WOMEN ENGINEERS: A STUDY OF PARTICIPATION IN EDUCATION AND EMPLOYMENT IN AMHARA REGION, ETHIOPIA

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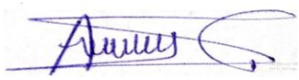
DECLARATION

I hereby, declare that the thesis work entitled "**Women Engineers: A study of Participation in Education and Employment in Amhara Region, Ethiopia**" is my original work carried out under the supervision of Prof. Seema Singh. This thesis has been prepared in conformity with the rules and regulations of Delhi Technological University, Delhi, India. The research work presented and reported in the thesis has not been submitted either in part or full to any other University or institute for the award of any other degree, diploma, or other qualifications.



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CERTIFICATE

This is to certify that the thesis titled, **“Women Engineers: A Study of Participation in Education and Employment in Amhara Region, Ethiopia”**, submitted to the Delhi Technological University, Delhi, in fulfilment of the requirements for the award of degree of Doctor of Philosophy in Economics is an original research work carried out by **Mrs. Addissie Melak Muluneh** with roll number 2K17/PhD/HUM/06 under my supervision. The matter presented in the thesis has not been submitted elsewhere in part or fully to any University or Institute for the award of any degree to the best of my knowledge.

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(Addissie Melak Muluneh)

ABSTRACT

According to African Development Bank (AFDB) data, the annual growth of Ethiopian GDP was very low before the year 2000 because of low production, drought condition, Ethio-Eretria war, low-level of infrastructure development, and inconsistent technological development. However, it increased remarkably and experienced a 7.9% annual growth rate since 2000 onward. Now, Ethiopia's main challenges is to sustain its positive economic growth for which the government has given enough attention on developing its higher education landscape besides other. Like other countries, higher education is valued in Ethiopia because it develops an appropriate human capital required for national development. Specifically, engineering education is key for the development of appropriate technology of enhancing productivity. Traditionally, women are underrepresented in engineering education and employment as in many other parts of the globe. In this background, the purpose of this study is to investigate the issue thread bear. The education aspect has been discussed at three level as, the factors which affect women's choice of pursuing engineering education, the factors which affect women's achievements in engineering. At the employment aspect, it has investigated the factors affecting women graduates' employability in engineering in Ethiopia, and analysing the challenges faced by them at the work place. An effort has also been made to examine the effect of economic growth on women human capital formation in engineering during 1997-2018. Both primary and secondary data has been used to justify arguments.

Secondary data for the study has been gathered from a variety of secondary sources as Annual reports from the Ethiopian Ministry of Education, UNESCO, the African Development Bank Group, the World Bank, and ILOSTAT. Reputable journals, books, various papers, periodicals, proceedings and other sources on women's involvement in engineering education and employment have also been considered. Primary data have been collected from 843 women students of engineering and science using well-structured questionnaires and detailed interviews through phone.

Appropriate statistical tools have been used for analysing the data. To check the stationarity of the secondary data, Augmented Dickey-Fuller unit root test has been used. The bound test was used to investigate whether there is co-integration in the short run and

long run. After checking through the bound test, the ARDL model with error correction term has been estimated. Logit and Probit binary regression models, and OLS (ordinary least square multiple linear regression estimation) have also been used. Spearman's Rank Correlation test of selected variables has also been computed. In addition, various post estimation tests were also computed in order to check the unbiasedness of estimated coefficients and model fitting.

Detailed analysis of secondary data has been made (chapter 4) in support of the first objective that women are underrepresented in engineering education and employment. Through ARDL model with error correction term, an effort has been made to verify the impact of economic growth and government expenditure on education on women's human capital formation through engineering education. The result shows a significant and positive impact in the long run for both government expenditure and economic growth on education but these are insignificant in the short run. The reason may be the small-time frame during, which it is difficult to expect significant result. The Logit regression has been used for analysing factors affecting women's choice of learning engineering, which reveals that expected salary is the most influencing factor. Other factors have been ranked on the basis of their influences are high school education performance (results of grade 12 exam), having an engineer in the family and accessibility of the role models. The family's annual income has least influence on the choice of learning engineering. The OLS multiple regression model has been used for the fourth objective on women's academic performance in engineering education. The result shows that students' capabilities to gather information about the institution before joining the university is the most influencing factor. The second one is university's infrastructure followed by institutions' support for women students and the least affecting factor is peer learning habits of students. However, sexual harassment and the presence of engineers in the family have negative impact. The reason for negative impact of sexual harassment is quite obvious. However, negative impact of engineers in the family on academic performance needs further investigation as it does not look very logical. The Probit model has been used for the fifth objective which is on factors affecting employability of the women graduate engineers. The dependent variable was unemployment among them and the independent variables are communication skills, academic performance (cumulative GPA), willingness to migrate from one place to another for searching jobs, and non-

technical skills. As unemployment was dependent variable, the reverse of results may be seen as factors for employability. The last objective was on challenges faced by working women. Out of 244 total respondents, 35.25% have mentioned major problems and challenges faced by women engineers at the work place. Two third of the respondent said that they do not face any problem. Among the rest one-third, most of them complained about conflict with customer, staff member and leaders as well as discrimination, undermining and discouragement on the basis of gender, race and religion.

Though on the basis of finding from a sample of a state, suggestion may not be generalised for the whole country. However, the government regulatory bodies of higher education and other stakeholders may be suggested to take affirmative measures to enhance women's enrolment and academic performance to reduce the gender gap. Engineering colleges must pay attention to students' psychological, economic, and educational wellbeing, improving and expanding infrastructure, and show zero tolerance for sexual harassment through strict implementation of regulations. The women engineering graduates must improve their communication skills and non-technical skills, record better grade points, and be ready for employment migration. They are also suggested for late marriage as they can concentrate on their career well. The government must create a channel between universities and firms through teaching with a work placement curriculum, more emphasis on practical works, and maintaining law and order situation for taking care citizens' peace and security, and expanding infrastructure.

Keywords: *Women Engineer; Economic growth; Women Education and Employment; ARDL model; Logit model; Probit model; Ordinary list square model; Amhara region, Ethiopia.*

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LIST OF ABBREVIATIONS

AFDBG	Africa Development Bank Group
ARDL	Autoregressive Distributed Lag Model
AUIF	Accessibility of University Infrastructure
CGPA	Cumulative Marks
CLET	Women Students' Choice of Pursuing Engineering Education
CS	Communication Skill
ES	Expected Salary
FEDUC	Educational Background of the Family
FINC	Annual Income of the Family
FP	Presence of Engineers in the Family
GDP	Gross Domestic Product
GPA	Academic Performance
HEB	High School Education Background (the Result of Grade12 Exam)
ILO	International Labor Organization
JP	Job Preference
LEVA	Log of Education Value Added
LGE	Log of Government Expenditure
LGDP	Log of Gross Domestic Product
LWHCE	Logarithm of Women Human Capital Formation through Engineering Education
LWHCS	Log of Women Human Capital Formation in Secondary School
MOE	Ethiopian Ministry of Education
MR	Marital Status
NTS	Non-technical Skills
OLS	Ordinary Least Square
PI	Students Prior Information About the University they Have Joined
PL	Peer Learning
PP	Peer Pressure
RM	Role Model
RP	Students Place of Residence
SH	Sexual Harassment
STEM	Science, Technology, Engineering and Mathematics
UN	United Nation
UNE	Unemployment
UNESCO	United Nations Educational, Scientific and Cultural Organization
Usport	Interventions Followed by Institutions for Supporting Women Students
WB	The World Bank
WM	Willingness to Migrate for Searching a Job
YD	Year Dummy Variable

CHAPTER- ONE

INTRODUCTION

1.1. Background

According to African Development Bank (AFDB) data, the annual growth of Ethiopian GDP was low before the year 2000. Some of the reasons were low production, drought conditions, Ethio-Eretria war, low-level infrastructure development, and inconsistent technological development. However, it increased remarkably and experienced a 7.9% annual GDP growth rate after the year onward. The higher economic growth brought positive trends in poverty reduction in both urban and rural areas. However, Ethiopia's main challenges for sustaining its positive economic growth and poverty reductions are limited competitiveness in manufacturing, creating jobs, and low-level exports (AFDB, 2019).

Now, the recent lockdown in Ethiopia from March 2020 due to COVID-19 has created devastating social, economic, and political crises on the Ethiopian Economy and will take many years to recover. There is also severe political instability. In such a situation, asset holding, especially household's stock of intellectual capital, is necessary to reduce the pandemic's negative impact on the economy (Yamauchi et al., 2009).

1.2. Education in Ethiopia

Education is a crucial mechanism to improve human skills and knowledge. Educational investment is more critical than any other infrastructure investments. As it helps enhancing productivity and ultimately ability earn more. With high income, people live according to their preferences and priorities; able to drive the desired outcome and improve broader thinking. However, there are time lag constraints between investment in education and its reward (Bengtsson et al., 2018).

Ethiopia has two types of traditional education. One is family education, and the other is religious education. Family and society are responsible for educating and shaping their children according to their social norms. The children have to learn according to their culture, customs, beliefs, attitudes, rules, regulations, etc. Thus, the children learn through interaction with the members of their family and the community. On the other hand, the church education system in Ethiopia started in the sixth century CBC; however, at the beginning of the 4th CAD, the church became a formal institution of education with the language of Geez (Mengistie, 2019).

The primary purpose of the Ethiopian church education was to groom religious persons to serve the church and later on, for the civil service and government bodies. The curriculum of the church education uses to include reading, writing, theology, history, poetry, art of painting, art of building, architecture, moral and ethical basis for maintaining society's culture. The education system of the Ethiopian Orthodox Churches has grown with the time and has changed as per the changing requirement of the society. Ethiopian Orthodox Church played a vital role in reducing illiteracy. The Muslim Koranic School Education is another system of formal education in Ethiopia since 16th CAD. In the traditional religious schools, education system, teaching is taught mostly by men and rarely by women (Endawoke, 1996).

The modern education system of Ethiopia may be divided longitudinally into three parts as (i) the Imperial regime, (ii) the Dergue regime, and (iii) the Federal Democratic Republic of Ethiopia. The modern education system was started in Ethiopia during the era of Menelik Second. The king was very optimistic about the outcome of the modern education and approved the first education official announcement during 1906, which allowed women participation. There was another proclamation prepared in 1929 by Empress Zewditu, who ruled Ethiopia after her father, Menelik II. In 1930 Emperor Haile Selassie came to power. He established the Ethiopian Ministry of education, and continued the Menelik II education proclamation legacy. However, education was discontinued due to the Italian invasion of Ethiopia from May 1936 to 1941. During this six-year war period, Italian soldiers destroyed education materials and schools. After defeating Italian invaders, education was started again to produce educated government bodies (Seyoum, 1996).

In 1974 the Dergue regime led by Colonel Mengistu H/Mariam started ruling the country with socialist ideology. At this time, priority was given to education as a source for development. A "campaign for Adult education" was initiated to reduce the illiteracy rate. During this regime, student enrollment was very high though the quality of education declined due to lack of quality teachers and shortage of educational materials (Seyoum, 1996). Following the regime's fall, the Federal Democratic Republic of Ethiopia (FDRE) changed and replaced this education policy in 1991. During this time also, education received its due place and was kept in the priority sectors as it is one of the significant ingradiatent for overall development. A new policy of education and training was adopted in 1994 for all levels of education. The procedure was quite detailed, incorporating five general objectives, 15 specific objectives, four strategies, nine educational structures including kindergarten and special needs education, and seven academic measurements and examination. This policy of article 3.7.7 is approved as special attention will be given to women (MoE, 1994). The Ethiopian education system is structured by different stages, i.e., kindergarten, alternative basic education, and first cycle primary education (grade 1-4). In addition, second cycle primary level from grade 5-8, first cycle secondary level grade 9 and 10, second cycle secondary education level (preparatory school grade 11 and 12), technical and vocational education and training (TVET), undergraduate degree, Master degree, and Ph.D. education level. Even though women are highly respected in the community, there are strong social and cultural pressures for early marriage. Hence, many girls do not go to school. Even if they go, they are dropped out of school because of various problems such as harassment, violence, and the natural phenomena of adolescence age. This situation leads to low education and professional labour force for national development (MoE, 1994).

1.3. Women Human Capital Formation through Higher Education in Ethiopia

Human capital formation is the fundamental determinant of economic growth. It is essential to create and improve high technology to increase labour productivity and income generation (Lavrinovicha et al., 2015). Many theories and empirical studies confirm this. Schultz argued that human capital investment with other factors has a non-replaced role for economic growth by enhancing skills and knowledge. Schultz strongly believes that developed countries increase their national output through this investment. When human capital assets increase, it induces productivity and leads to improved earnings of workers (Schultz, 1961). Schultz's idea is also supported by the endogenous growth model developed by Romer states that growth can be generated from endogenous, not from the outside force exerted (Romer, 1994).

Patrinos also extended the importance of human capital investment for promoting economic growth from the review of the new growth theory, which says human capital can create externalities that can induce endogenous technical change and increase return to scale. Human capital contributes substantially towards increasing labor productivity, stimulating innovations, and building the ability to absorb new technologies. This human capital formation and human development are achieved through education. Education is an essential and influential instrument for enhancing the earnings of workers, reducing poverty, empowering people, inspiring health and flexibility in the environment, and developing effectiveness in the economy that leads to improvement in economic growth. Education has been given significant importance during the development and growth strategy of many countries. It performs an essential role in the formation of human capital. Educated human capital accumulation with physical capital encourages and understands the use and importance of technology (Patrinos, 1994). Even technology takes place in societies due to educated people. It gives time to make people productive, contributing to the economy's development and growth (Lucas, 1988). In a given level of initial per capita GDP, higher investment in human capital that facilitates the absorption of new technology leads to more economic growth (Barro, 2001).

According to Azevedo & Nnadozie, human capital investment refers to any practices that enhance human capital or an individual's productivity in education (schooling and training), health, and other capacities (skills, abilities, and ideals) (Azevedo & Nnadozie, 2019). Investment in education has current costs and yields future benefits (Johnes & Johnes, 2007). Like other countries globally, education is valued in Ethiopia because it contributes to national development by providing an appropriate human capital that helps increase productivity and eliminate poverty. The teaching of females, in particular, contributes to various aspects of their lives, such as increased longevity, family health, and nutrition. Education is crucial for empowering women because it enables them to survive the challenges, has better access and opportunities in the workforce, reduces economic dependency on others, and be the best investment for the country's development.

Higher education is a significant educational level that helps to produce educated people, significantly affecting a country's economic development as qualified human capital and economic growth have a strong correlation (Nickolas, 2019). In Ethiopia, higher education started in the 1950s following the first higher education institution, Addis Ababa University. The number of higher education institutions before 1990s was only 5 Universities. Little progress was made in expanding higher education institutions until introducing the current education and training policy in 1994 (MoE, 1994).

Ethiopia has a central admissions system in which undergraduate placement criteria are set by the Federal Ministry of Education (MOE) for all public higher education institutions. MOE is responsible for students' placement in universities based on their grade 12 exam results, out of 700 and highly selective, given the scarcity of university seats. Students can select at least five universities they want to join and submit the reference to MOE. The MOE sets minimum grade requirements and quotas for different programs based on institutions' annual intake capacity. MOE is placing students in the priority of keeping the interest of top score students. That means high-score students can be admitted according to their choices, while lower-performing students tend to be admitted at the vacant seats in anywhere, whether students may have proposed or not. In this situation, students who have a low score on grades 12 exams will be placed in universities that can be newly established, very far away from the capital city, complex weather conditions, and so on without their interest (MoE, 1994).

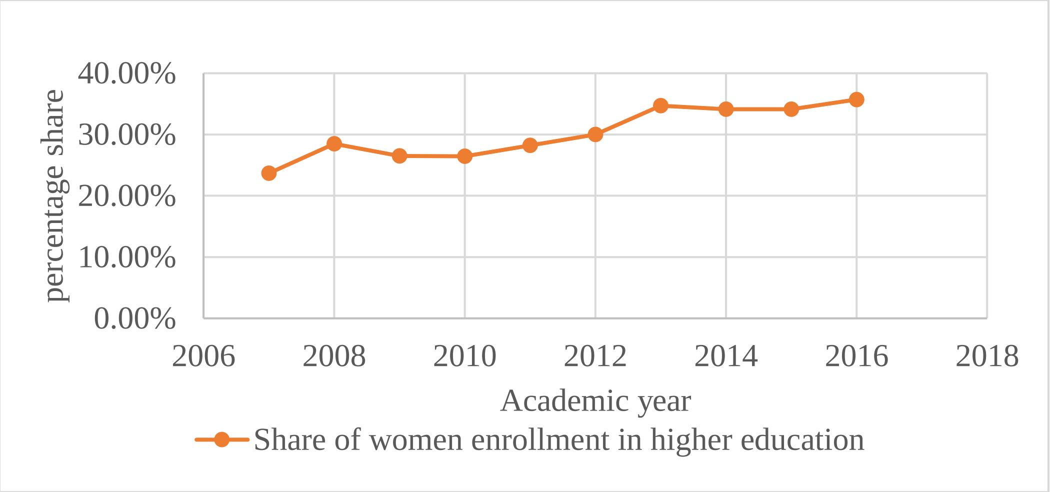

Figure 1.1 Women enrollment participation in higher education of Ethiopia. Source: MOE education annual abstract report 2007-2016

As women's education has been influenced by socio-cultural norms and attitudes, there is low participation of women in higher education. The Ethiopian government has designed and implemented various affirmative action policies to promote gender equality in the country's universities. This program also includes providing female-only tutorials, guidance and counselling services; academic support from capable senior students; and overall assertiveness training (Molla, 2013). Each university's so-called "gender office" is responsible for implementing and following this affirmative action policy. This leads to the improvement of women's enrollment in higher education. In Figure 1.1, the percentage share of women enrollment in higher education shows an increasing trend from 23.67% during 2007 to 35.71% in 2016 from the total enrollment.

1.4. Women Participation in STEM Education

The acronym STEM (Science, Technology, Engineering, and Mathematics) is defined as, "*science* is the systematic study of the nature and behaviour of the material and physical universe based on observation, experiment, and measurement, as well as the formulation of general laws to describe these facts. *Technology* is the branch of knowledge concerned with creating and applying technical means and interactions with life, society, and the environment. It includes subjects such as industrial arts, engineering, applied science, and pure science. *Engineering* is the art or science of putting pure science knowledge, such as physics or chemistry, into practical applications, such as constructing engines, bridges, buildings, mines, ships, and chemical plants. *Mathematics* is a collection of related sciences that includes algebra, geometry, and calculus. It is concerned with studying number, quantity, shape, space, and interrelationships through specialized notation" (White, 2014).

According to Xie et al., the abbreviation STEM usually stands for a set of educational and occupational fields related to science. STEM education is closely associated with the math and science curriculum that is required for all students. STEM education becomes more specialized and detailed at higher levels (Xie et al., 2015). According to Bybee, STEM education means only science and mathematics, even though technology and engineering products greatly influence everyday life. Since engineering is directly involved in problem-solving and creativity, which are high priorities on every nation's topic, STEM education should also incorporate more engineering and technology subjects (Bybee, 2010).

The engineering and technology profession makes essential contributions to the economy's GDP and high social value. The engineers create, improve, and protect the environment, provide living facilities, industry, and transportation, producing high economic values. Findings from various countries support the positive effect of technology on economic growth through job creation, providing new services and industries, workforce transformation, and business innovation (Kvochko, 2013). A study by Royal Academy also confirmed a positive correlation between GDP per capita and engineering and technology education (Academy, 2016).

The history of women in engineering & technology had started in the 11th century, and they contributed to the technological advancement of societies around the world. Ada Lovelace (1815 - 1852) was the first woman engineer who had published the first algorithm. She is one of the first computer programmers applicable by Charles Babbage's mechanical general-purpose computer Analytical Engine. Engineering and technology education helps women's empowerment through the knowledge of science and technology. Therefore, women in engineering and technology education have been given due importance in academic studies (SWE, 2019).

In the early 20th century, more significant numbers of women began to be admitted to the engineering & technology field. Still, they were generally under-represented in various countries of the world. There is evidence that women are less likely than men to study engineering and technology. These gender differences become noticeable in high school and at the university level. Although the percentage of bachelor's degree awards to women in engineering increased, they are still significantly underrepresented in the field (Science, 1998).

A study by Nguyen for the period 16th to the early 18th century, the participation of women in engineering was low, and the total enrollment in engineering was less than one percent during 1969 in Australia, later raised to 14.05% in 1996, even though they still represent less than 15% of the total engineering population (Nguyen, 2000). According to National Research Council, women accounted for one percent of engineering and technology education in the US in 1970, increased to 15% within ten years. The council added women account for 50% of the total population, but only 5.8% have engineering professions (Council, 1985). Schreuders et al., also support this under-representation

(Schreuders et al., 2009). In the UK, women's participation in engineering and technology at the undergraduate degrees was 14% in 1996 and 15% in 2010 (Powell et al., 2012).

In another paper, Mahajan has found male domination in other countries of the world. Engineering is considered a male profession, and women's participation is low. He has discussed gender stereotypes, social and cultural values of society, women's educational background in science subjects, lack of role models, women undermining employers' perception, etc., are reasons. Women are usually under-represented in engineering and technology's academic and professional fields, even though many of them have contributed once they join the area (Mahajan, 2017). This is also supported by UNICEF and ITU, that only 18% of women who are students in tertiary institutions throughout the world pursue STEM fields compared to 35% of men. The STEM education continues to be dramatically lacked in women's participation though there is some progression. However, gender equality, besides being a fundamental human right, is essential to achieve peaceful societies with full human potential and sustainable development (UNICEF & ITU, 2020).

According to Casallas et al., women's participation in undergraduate STEM education programs in Colombia has been declining, only about 11%. This phenomenon has been evidenced in many universities worldwide, and several collaborative projects and networks are trying to understand the causes to find mitigation actions in the future (Casallas et al., 2012). Wuhib and Dotger also conducted a study on why so few women in STEM at Syracuse University, New York. Even though there is a gradual increase in their participation, women are still underrepresented in science, technology, engineering, and mathematics (STEM) fields. In the 21st century, where the global economy and national security needs STEM expertise more than ever, the area is not benefiting from the talent of half of the world's population, i.e., women (Wuhib & Dotger, 2014).

The pattern of gender participation in technology is similar in Sweden to what has been reported globally. In the early years during which the modern engineering profession and education were developed and standardized, women were excluded from participation. However, in Sweden today, it is seen as good for women to become engineers, even necessary. The proportion of women students in engineering has grown below 10% in the early 1970s to about 30% in the early 2000s. Despite the gains in gender equality, however, it is apparent that ambivalence still surrounds `the woman engineer' today. The proportion of women is high in some programs and very low in others. The career paths of women and men who are engineers are not comparable either. Moreover, a cultural contradiction between being a woman and an engineer is mirrored in everyday language, where women are depicted as `soft' while technology is described as `hard' (Ude, 2002).

Another study by Marginson et al. argued that countries generally are grappling with the issue of the under-representation of women in STEM fields and pursue a variety of gender equity policies and strategies to address this (Marginson et al., 2013). Villa and Gonzalez investigated the percentage of women students in engineering and technology in Mexico. They found a lower rate of women enrollment in the field, which has achieved parity with male enrollment (García Villa & González y González, 2014). Vidal et al. also showed that the number of women enrollment in software engineering in Peru from 2010 to 2015 was only 20% compared to men (Vidal et al., 2020). Moreover, women in the U.K. also remain underrepresented in engineering and technology, that in 2010, women enrollment in these fields accounts for only 15%, from 57% of the total university students (Powell et al., 2012).

Hammout and Hosseini studied students' involvement in online master's engineering and science studies to minimize the gender gap in Mexico’s STEM education. They have collected data from 5,000 participants of online master's studies in business, engineering, and other fields to find the gender gap between the candidate's participation with a specific emphasis on science, technology, engineering, and mathematics (STEM). They found that lower participation of women in the field (Hammout & Hosseini, 2020). According to the UNESCO Institute for Statistics, women account for fewer than 30% of the world's researchers, and female representation in engineering and computer science is much lower, around 10%. A study from14 countries found that the probability for a female student graduating with a Bachelor's degree in a science-related field is 18%, compared to 37% for male students (UNESCO, 2016). This under-representation of women in engineering and technology education leads to gender inequality in this profession's workplace (Kitada and Harada, 2019).

Colomo-Palacios et al. also examine gender gap narrowing in higher education computing studies in the case of three countries (i.e., Norway, Spain, and Tunisia). They have collected data based on student enrollment and macroeconomic aspects such as gross domestic product, unemployment data, the quality-of-life index of the Organization for Economic Cooperation and Development (OECD), the gender equality index, and a set of information. They found the percentage of female students in 2018 was 12.7%in (Norway), 26.32%in (Spain), and 50% (Tunisia). Results show a gender gap in computing studies in these countries except Tunisia (Colomo-Palacios et al., 2020).

This is happening in Asian countries also; one study done in Pakistan by Malik and Courtney (2011) shows women are few in higher education participation. Parents prefer their son child to send school and spend money than their daughters. Their finding shows that 80% of respondents believe that parents do not spend similar amounts of money educating their daughters as they do on their sons. The percentage share of women in engineering and technology in India was 16.2% during 2000, as indicated by Parikh and Sukhatme (2004) though, it increases currently (Gupta, 2012). Another study conducted by Singh and Fenton (2014) founds women's participation is low in India and Australia. Another study by Abdullah et al. (2018) in Malaysia also shows women's participation in the engineering sectors is comparatively lower. Thus, women's representation in engineering and computer science is much lower (Abdullah et al., 2018).

There is also a significant imbalance in the two genders in Africa, as in other parts of the world. As a result, the women engineers are few and unable to participate in national development fully. Among the problems are the high isolation of women engineers in the profession and the absence of many prominent women who can serve as role models. To overcome this, the UNESCO regional office for science and technology in Africa embarked on a pilot project to prepare a directory of female engineers in a few African countries, including Ethiopia (UNESCO, 1995). Masanja indicates that education statistics in Sub-Saharan African countries show that women lag behind men in general, specifically in science, mathematics, and technology. He investigated examination results and the selection of students to tertiary level institutions from 10 countries. And found that fifty got a chance to go to a public university for every hundred males who passed the secondary school examination. In contrast, for every hundred females who passed the test and were eligible, only seven got a chance (Masanja, 2010).

Imasogie et al.'s study indicates that the total number of women engineering students enrolled in 2011-2016 was 15% in Nigeria. They suggest the possible reason that socio-cultural and labor market gender preconceptions, psychosocial influences, formulation and implementation of gender insensitive policies, and lack of awareness of engineering opportunities (Imasogie et al., 2018). Longe et al. also studied women's engineering education experiences in Nigeria using primary and secondary data (Longe et al., 2019). They found that female engineering students' enrolment has a decreasing trend from the 2011-2017 academic year.

UN (2020) annual report also shows that primary education girls continue to lag behind boys in mathematics achievement significantly in sub-Saharan Africa. This is also the case in South-eastern Asia. Women's under-representation is deeply rooted in unequal gender norms that require problem-solving and a curious mind. However, STEM education also can contribute to personal empowerment, the transformation of communities and nations, and building economies for the future. (UN 2019- 2020 annual report).

According to Rathgeber (2003), in Africa, women are not interested in studying sciences, and engineering results in low participation in academic positions in science-related subjects. Oanda and Akudol further claim that fewer female Sub-Saharan African students enrolled in STEM and their completion rates are lower than male students (Oanda and Akudol, 2010). In Ethiopia, Singh and Sarah have conducted a study by grouping all the world countries into four groups to discuss women participation based on similarity of characteristics. They found Ethiopia comes in the fourth group, which has developing countries with traditionally low participation of women in engineering education, recently the participation has increased (Singh and Peers, 2019).

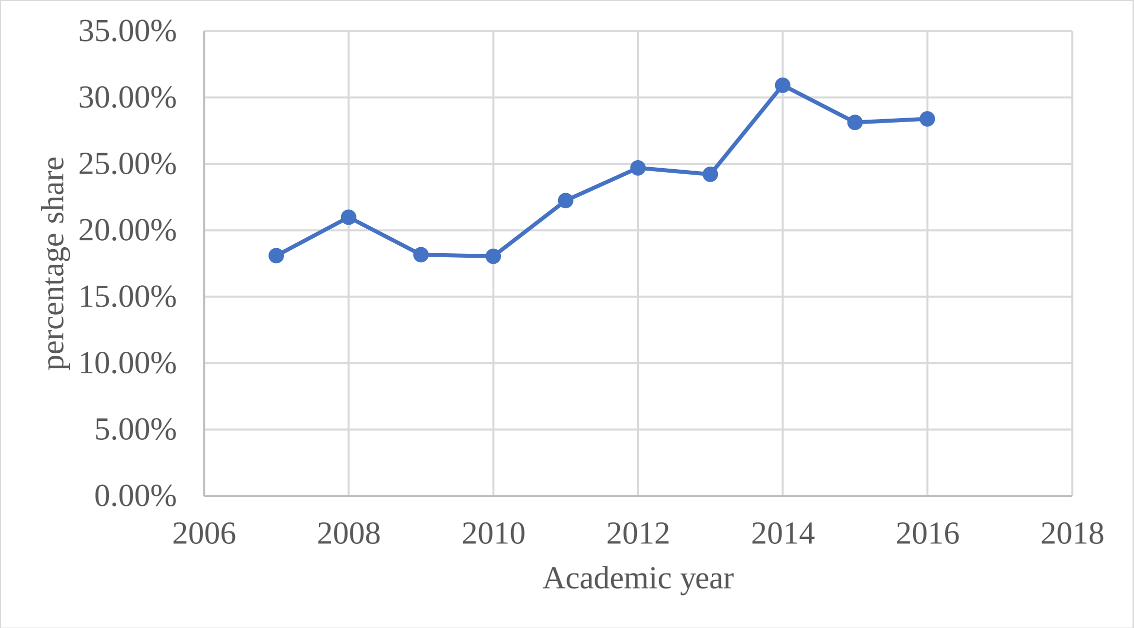

Figure 1.2 Women enrolment in engineering education in Ethiopia.
Source: MOE education annual abstract report 2007-2016

The currently available data in Figure 1.2 shows the percentage share of women enrolment from the total enrolled students in engineering and technology education in Ethiopia on an undergraduate degree program. The number of women enrolments in the field has progressed from 18% during 2007 to 28% in 2016, though it is still low.

1.5. Women Participation in STEM Employment

Employability is about being capable of getting work for earning (Hillage and Pollard, 1998) and education system is developed in such a way that the educated person becomes more appropriate for getting employment. However, the persistent unemployment during the last decade has become a matter of concern for academicians at the micro level and policymakers at the national level. Unemployment is often used as a reflection for poor health of the economy. The underutilisation of human capital or unemployment is a major challenge before many countries of the world. It negatively affects the economic development of the country (Batu, 2016). Unemployment is one of the major challenges the world facing today. Coupled with population growth and increased poverty, it has a significant impact on growth and development at large (Kassa, 2012). The inability of jobseekers to find gainful employment tends to create dissatisfaction and frustration among them which has very harmful consequences. It causes the youth to resort to social vices such as robbery, prostitution, and political unrest. Unemployment constitutes underutilization of human resources. there is underutilization of resources. As a result, the total productivity of the country is less than the potential level of output. If a country's unemployment persists for a long time, it may create financial hardship, crimes, poverty, homelessness, frustration, and social isolation, resulting in the erosion of a healthy society (Peshawar et al., 2015). In general, unemployment affects health, household income, government revenue, and GDP, and development. So, failure to prevent these resources from going to waste makes them vulnerable to poverty at the micro level and a loss of potential income tax revenue to the nation at the macro level (Baah-Boateng, 2013). A high unemployment rate distorts rate of economic growth, and as the number of unemployed people increases, there is loss of precious human resource in the short run and loss revenue collected through loss of output, export, and finally low collections of finances through direct taxes. Hence, studying unemployment helps to tackle these problems through some policy actions (Kassa, 2011).

Despite considerable progress in promoting gender equality and narrowing the gender gap in the workforce during the last 50 years, the labour market much of women’s work remains in sex-stereotyped occupations that are more precarious, vulnerable, and poorly paid than men. Consequently, women are disproportionately affected by the global financial and economic crisis and hence poverty than men (Maria, 2015). The unemployment rate has remained higher on women than men due to a higher prevalence of temporary contracts, differences in educational attainment, and labor market segregation. Women are more likely than men to exit and re-enter the labor market owing to family commitments and career interruption for child-rearing results in more extended periods of unemployment which lead to skills obsolescence and reduced employability, while men are more likely to move directly from one job to another (ILO, 2012)

Unemployment has several interconnected adverse effects on women through making their life unpleasant and hopeless**.** As a result, unemployed women experience many ups and downs because they face a scarcity of economic resources that determines their social life and psychological well-being. This unemployment problem is more severe for women than men(Dessie, 2015).

According to Meece, approximately only 63 women per 100 men have participated in the world's labour force. He also argued that women are less economically active in the Middle East, South Asia, North Africa, and other developing economies. Moreover, even though women in industrialized countries have made significant gains in paid employment, there is still considerable gender segregation in the workforce. For example, in the USA, he found 90% of women tend to be traditionally female jobs, such as lower and elementary class teaching, nurses, secretaries, etc. (Meece, 2006).

Women generally had a painful experience while working with their male peers. Specifically, women participated less and lost confidence by comparing with the men who appeared confident and competent. Women have less likely engagement in full-time employment and earn a lower salary than men after graduation. Webster argued that women's paid work has continued at a minimal range of jobs like banking, health, education, etc. (Webster, 2014).

The importance of engineering and technology to modern society for wealth creation and maintaining living standards has long been recognized. However, the accessibility of employment opportunities is an issue; specifically, women who graduate in engineering and technology have the challenge of getting the job. Several studies show that women's low employment status in engineering and technology graduates in most parts of the world (Salmon, 2015; Joseph, 2016). This supports the finding of Hosaka argued, engineering and technology workplaces continue to be uncertain environments for women graduates (Hosaka, 2014).

Another study states a smaller percentage of women engineering graduates than men who have jobs and offered women earnings are about 54% less than men in India (Choudhury, 2015; Singh and Peer, 2019). Female graduates in STEM majors have a lower unemployment rate and gender inequality in salary in the US during 2008. The annual income of men is $49,111 for full-time STEM employment and $37824 for females. 4.8% of males were unemployed from total STEM graduate male and 5% female were unemployed from complete graduate female in STEM (Xu, 2017). These show the inequality of women and men in annual income and employment participation.

In Ethiopia, the government bodies concentrated on expanding higher education without matching higher education and employment. There is no proper channel of communication between higher education and employer companies. Furthermore, employers were overlooking recent graduates and only employing those with five years of work experience. This leads to a severe unemployment problem., Figure 1.3 shows the average number of employed women in engineering and technology professions as teaching staff in Ethiopian universities from 2007 to 2016 is 7.6%. This is confirmed by Jote (2017), finding substantial variations observed between men and women, and women's employment status is consistently lower in Ethiopia.

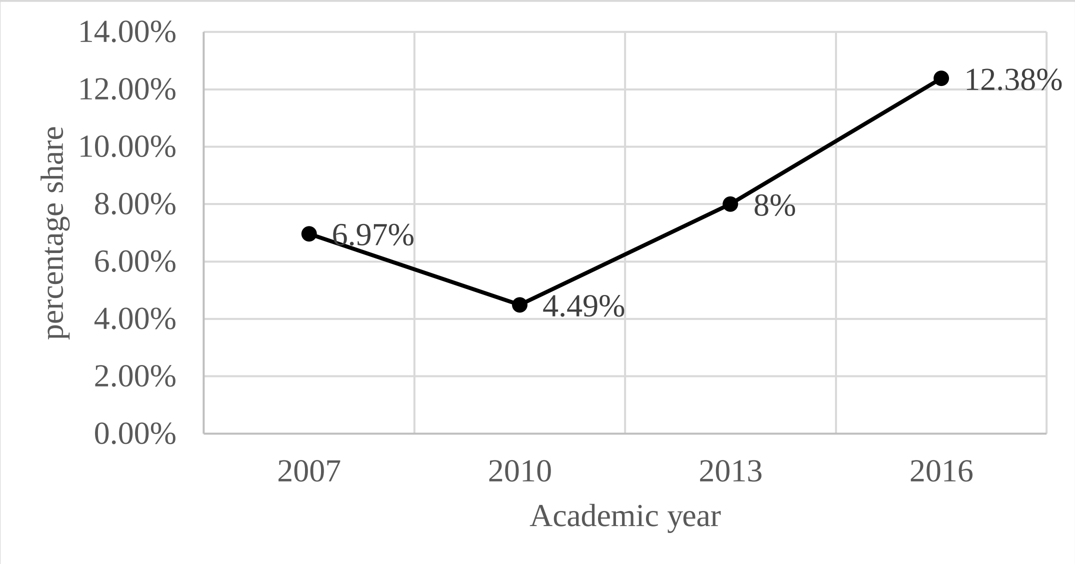

Figure 1.3 Share of women teaching staff in engineering education of Ethiopia.
Source: MOE education annual abstract report 2007-2016

In order to tackle women's under-representation, there are many organizations found in the world that encourage women's participation in engineering and technology education, as presented in Table 1.1. These organizations promote short and long-term scholarships and training; improve the participation, achievement, and continuation of women in STEM education and careers to reduce the gender gap in STEM professions. They also strengthen the capacity of countries to deliver gender-responsive STEM education through teacher training, educational contents, teaching methodology, and curriculum; and enhance awareness of the importance of STEM education for women (UNESCO, 2019).

Table 1.1 Organizations that are promoting the participation of women in engineering education.

Organizations	Country
African Women in Science and Engineering (AWSE)	Kenya, Tanzania, Uganda
Anita Borg Institute for Women and Technology	Global
Association of Francophone Women in STEM (AFFESTIM)	Canada
Association of Korean Women Scientists and Engineers	Republic of Korea
Association of Professional Women Engineers of Nigeria (APWEN)	Nigeria
Association of South African Women in Science and Engineering	South Africa
BC Women in Technology (BCWiT)	Canada
Canadian Coalition of Women in Engineering, Science, Trades and Technology (CCWESTT)	Canada
German Association of Women Engineers	Germany
Global Women Inventors and Innovators Network	Global
Grace Hopper Celebration of Women in Computing United States	United States
Institute of Electrical and Electronics Engineers (IEEE) Women in Engineering	Global
International Network of Women Engineers and Scientists	Global
Japan Network of Women Engineers and Scientists – JNWES	Japan
WISE-India	India, United Kingdom
WITEC EU (European Association for Women in Science, Engineering & Technology, etc.,	Europe

1.6. Purpose and Significance of the Study

As there is a need for women's representation in engineering and technology fields to solve today's problems through innovation to achieve women empowerment and sustainable development goals (SDGs) by 2030. Women professionals in engineering and technology are required to solve climatic change, accessibility of water supply, disease control, and renew energy. Moreover, sometimes lower-performing men are selected due to absence or low representation of women in these fields (Reuben et al., 2014). Creating diverse work-place environments with employees of different race, ethnicity, gender, disability status, age, or sexual orientation, is also widely linked to positive outcomes, such as more significant innovation and productivity (Nishii, 2013). In addition, women professionals in engineering and technology have an opportunity to engage in a high-quality job in the field, leading to a better salary than other fields (Carnevale et al., 2011).

According to UNICEF (2020), STEM education improves women's awareness and capacity to protect the environment, position them as leaders in their communities, and actively engage in activities which ultimately leads to a more sustainable society. Women who develop STEM skills are better prepared to contribute to scientific research and technology development initiatives for innovative solutions in the industrial sector. The STEM knowledge prepares women with skills which are high in demand in the market and hence, are better paying which ultimately improves their livelihoods and contribute to poverty reduction and economic growth. Technical, and vocational knowledge and skills learned during STEM education equip women for high end and digital employment, and entrepreneurship which ultimately, helps in women empowerment and elimination of gender disparities. This leads to women involvement as capable players in promoting sustainable development and gender equality in all spheres of life.

Out of the STEM field, the knowledge and skills of engineering is more important due to its applied nature and bigger scope than the technology. The engineering labour market offers a better job opportunity and a higher return on educational investment (Landivar, 2013) where, women remain less represented than in any other STEM field (Corbett and Hill, 2015). In the recent years, various stakeholders are taking up in many affirmative actions with limited success. So, it becomes imperative to discuss the matter in detail, in depth and rigorous.

Since Ethiopia is among low income and developing countries of the world, there is an urgent need for more women in engineering and technology professions to bring diversity in the technological innovation which will ultimately, lead to poverty reduction, social, economic, and environmental development. Hence, conducting detailed research in the field is a urgent need which may be used as a reference by policy makes and planner in the government and institutions of higher education to enhance women's number and quality in engineering and technology. Regarding this issue, the UNESCO has opined that the lack of women in the technology sectors has significant socio-economic consequences as women loses an essential tool for personal and economic empowerment. Moreover, according to the United Nations Women's Deputy Executive Director Lakshmi Puri, "estimates have shown that in energy and agriculture, 2.5 million engineers and technicians will be needed in sub-Saharan Africa to achieve improved access to clean water and sanitation" (UNESCO, 2016). So, there are sufficient reasons to carry on in-depth research on the participation of women in engineering and technology.

1.7. Organization of the Study

This study has been organized into six chapters. The description given in the following table:

Table 1.2 Chapters in the thesis

Chapters	Title	Discussion
1.	Introduction	Background, education in Ethiopia, women capital formation in higher education of Ethiopia, women participation in engineering and technology (STEM) education, women participation in engineering and technology employment, purpose and significance of the study, and organization of the study have been discussed.
2.	Review of Literature	the review of the literature regarding to the impact of economic growth on human capital formation in engineering and technology education, factors affecting women's choice of learning engineering and technology education, factors affecting academic performance of women students in engineering and technology education, factors affecting the employability of women graduates in engineering and technology, challenges faced by working women engineers and technologists, and research gaps of the study
3.	Objectives and research methodologies	The objectives of the study, research questions, hypothesis, statistical tools and sample size and socio-economic profile of the respondents have been discussed.
4.	Descriptive Analysis	The first objectives of the study have been discussed on the basis of descriptive statistics i.e., the status of women participation in engineering education and employment
5.	Inferential Analysis	regression analysis of the study regarding women in engineering education and employment has also presented in the chapter five. In this chapter, challenges faced by women engineers at the work place also discussed.
6.	Conclusion and recommendation	Chapter six concludes the discussion, limitation of the study and provides recommendation for various stakeholders.

CHAPTER -TWO

REVIEW OF LITERATURE

The review of literature has been done in five sections, i.e., regarding the impact of economic growth on human capital formation through engineering education among women, factors affecting women's choice of learning engineering education, factors affecting academic performance of women in engineering and technology education, factors influencing employability of women graduates in engineering education, and challenges of women working in engineering professions.

2.1. The Impact of Economic Growth on Human Capital Formation in Engineering Education

Human capital formation is the primary determinant of economic growth. It is essential to create and improve high technology to increase labor and income generation (Lavrinovicha et al., 2015). Many theories and empirical studies confirm this. Becker developed the idea of investment in human capital that influences future real income by embedding resources in people. The following assumptions have been used during the formulation of his theory. These are: (a) earnings typically increase with age at a decreasing rate, (b) unemployment rates tend to be negatively related to the level of skill, (c) employers in low-income countries are highly limiting the freedom of their workers than in high-income countries, (d) younger persons change jobs more frequently and receive more schooling and on-the-job training than older persons, (e) the distribution of earnings is positively skewed, especially among professional and other skilled workers; (f) skilled persons receive more education and other kinds of training than others, and (g) the extent of the market limits the division of labor. He also identified four variables on these assumptions, i.e., job training, schooling, other knowledge, and productive wage increases, which are fundamental for investing in human capital. First, he argued that investment in human capital ties closely with income inequality among people. Secondly, the total amount of investment in human capital and its rate of return can be determined by earnings and employment situation. This is because skilled workers have a higher probability of being employed than unskilled workers and earn more salary due to investing more in themselves (Becker, 1962).

The human capital theory promotes education as an" investment" that pays off in the long run for both the citizen and the state in terms of jobs and economic development. The human capital theory offers a compelling model for neoliberal education governance. As a result, the approach encourages state education systems as instruments for economic growth, subservient to the lauded information economy (Gillies, 2017).

According to Ployhart et al., there isn't just one human capital resource, but various types that can be combined in multiple potentially distinct ways. These points lead to many conclusions, including various human capital tools that are not limited to generic or unique categories. They conclude that the source of competitive advantage is primarily human capital resource combinations, even when those resources are plain, imitable, or tradable (Ployhart et al., 2014).

It is known that human capital formation is the fundamental determinant of economic growth. Improved public services with increased tax revenues, the government can spend more on education, an essential public service critical instrument for human capital formation. High educational standards can give the population a greater diversity of skills and literacy. This enables better opportunity and freedom. Similarly, engineering and technology education is essential for investing in socio-economic infrastructures such as health, transport, massive canals, dams for irrigation purposes, hydroelectric power, and increasing production (Chaaban and Cunningham, 2011). Engineers and technologists bring the creative and innovative process used to solve sustainability and prevent cyber-attack, massive energy consumption, and food production. The taking part of women in science, engineering, and technology are also essential for economic growth. They are observed as key factors of growth and development both in advanced and developing countries. Particularly in fast-growing countries, women's underutilization in science, engineering, and technology is associated with human resource damage. Therefore, investing in women and empowering them through education increases national income potential (Ojobo, 2008; Duflo, 2012; Dimitriadi, 2013). The Sustainable Development Goal five (SDGs) also emphasized gender equality in education and social and economic empowerment (UN, 2015).

Recent studies about the relationship between human capital and economic growth are also supporting the previous studies. Among these, Khorasgani carried out a study in

Iran using a dynamic ARDL model, indicating that the higher education variable had an encouraging effect on economic growth in both the short and long run (Khorasgani, 2008). Li and Liang also found that human capital in education significantly impacts East Asia's economic growth (Li and Liang, 2010). Moreover, Breton stated that increasing education directly affects national production and marginal productivity of physical capital indirectly (Breton, 2013). Neeliah and Seetanah also conducted an empirical study in Mauritius with the vector error correction model's help that shows human capital has a significant role in economic growth (Neeliah and Seetanah, 2016). But a study by Monteils argued that human capital returns are falling, and thus knowledge produced by education cannot be the device of endogenous economic growth (Monteils, 2002).

Researchers measure human capital by taking a proxy of school enrollment from primary to higher education and standard years of attainment. Benavot, one of the researchers, found no significant difference between the male and female impact of primary education on economic growth. However, female secondary educational level negatively and insignificantly while males in this level of education have a positive and significant impact on economic growth. Benavot also argued that the greater the investment in education, the more critical the improvement in society's human capital and the more significant national productivity and economic growth (Benavot, 1989). Barro also extends the idea by taking the school attainment as a proxy variable of human capital and found that growth is positively related to males' average year of school attainment. Because workers having educational backgrounds can quickly adopt the technology. However, female education at secondary and higher-level school attainment has become insignificant to growth. But indirectly significant at the primary level by reducing of bearing a child (Barro, 2001).

Kifle conducted a study via error correction model taking data from 1971-2005 and founds that human capital variable in the form of schooling has an insignificant impact on the level of output of Ethiopia due to lower education quality (Kifle, 2006). Borojo and Yushi (2015) disproved the finding of Kifle that primary and secondary school enrollment has a positive and statistically significant effect on economic growth both in the long run and short run. But this was invalidating by Ali et al.; Hanif & Arshed that higher education enrollment has a significant and positive impact on Pakistan's gross domestic product in the long run (Ali et al., 2016; Hanif & Arshed, 2016). Kanayo (2013) also examined the relationship between human capital and economic growth in Nigeria found that investment in human capital in the form of education significantly impacts economic growth (Kanayo, 2013).

Sehrawat and Giri also constructed a composite index for male and female human capital by taking education and health to proxy for human capital. The finding states that female human capital is significant and positively related to economic growth in the short and long run. In contrast, male human capital is positive but insignificant to economic growth (Sehrawat and Giri, 2017). Another study by Chang et al. from all BRICS countries exhibited a unidirectional statistical causality relationship. The result shows that higher education enrollment granger caused economic progress in China and South Africa. In addition, the impact from tertiary academic training is found to be positive for all BRICS nations (Chang et al., 2018). Moreover, a very recent study by Marquez-Ramos and Mourelle founds education at the secondary and tertiary levels has a positive impact on the economic growth of Spain (Marquez-Ramos and Mourelle, 2019).

There are also studies in line with the influence of economic growth on human capital. In this context, In & Doucouliagos conducted a study using cointegration regression and error correction mechanism, founds causality of US private sector GDP to human capital formation and the reverse is true (In & Doucouliagos, 1997). Freire-Seren confirms that income has a positive and significant effect on human capital improvement. In turn, it has a positive and significant impact on the growth of income in the Spanish economy (Freire-Seren, 2002). Oketch found that per capita growth causes investment in human resource development through education, which is a determinant of investment in physical capital, again leading to significant per capita growth in Africa with the help of two-stage least square estimation (Oketch, 2006). Islam et al. also found causality running from GDP (gross domestic product) to education and vice versa in Bangladesh (Islam et al., 2007). Ahmad and French also investigated the relationship between human capital stock and real GDP in the same country using vector error correction model and vector autoregressive techniques, which founds GDP granger causes human capita (Ahmad and French, 2011). Uneze also established bi-directional causality between capital formation and economic growth in the short and long run in thirteen Sub-Saharan countries (Uneze, 2013).

Gebrehiwot has done an empirical study of the impact of human capital development on Ethiopia's economic growth with the help of the ARDL model. The study's findings indicate a stable long-run relationship between real GDP per capita and education human capital, about 73.66 percent annual adjustment towards long-run equilibrium (Gebrehiwot, 2016). Chang et al. (2018) also obtained the result, which confirmed that the national economic expansion granger caused an increased tertiary enrollment in Russia and India.

Regarding women's human capital, Hill and King supporting the idea that women's education is essential for economic growth and social well-being, which is monetary terms cannot measure. Better education increases mother productivity in the house, increasing household living standards, reducing child mortality, and investing in children's human capital (Hill and King, 1995). Klasen estimated and found that gender inequality in education directly affects economic growth by lowering the average human capital level. Due to these gender gaps in education, East Asia and Sub-Saharan Africa, South Asia, and the Middle East have 0.4 to 0.9 percent differences in their annual per capita growth rates (Klasen, 2002). Bandara argued that women are not fully utilized in Africa to account for educational gender gaps and others. This leads to gaps in labor productivity resulted in a negative effect on output per worker. His finding indicates that output per worker declined by 0.43% to 0.49% due to a 1% increase in gender gaps ineffective labor (Bandara, 2015).

Shafuda and De studied the impacts of government spending on human capital development (education achievements) and increased national income in Namibia using time series data. The findings reveal a significant long-run positive relationship between government spending on education and the gross tertiary enrollment rate (Shafuda and De, 2020). Megawati also examined the effects of government spending on education on school enrollment in Indonesia. The findings show that government education spending has a positive and significant impact on school enrollment in Indonesia. It also shows that government education spending is associated with a greater probability of school enrollment for poor children and girls (Megawati, 2020). The reviewed studies regarding to impact of economic growth on human capital formation has given in Table 2.1

Table 2.1 List of reviewed papers related to the impact of economic growth on the human capital formation (education).

Researchers	Discussions
Lavrinovicha et al. (2015); Becker (1962); Gillies, 2017; Ployhart et al., 2014; Chaaban and Cunningham, 2011); Kanayo (2013);	Investment in human capital through education and training leads to improve income generation.
\Ojobo, 2008; Duflo, 2012; Dimitriadi, 2013; UN, 2015; Hill and King, 1995	Investing in women and empowering them through education increases national income potential and equality in education.
Khorasgani, 2008; Li and Liang, 2010; Breton, 2013; Neeliah and Seetanah, 2016; Monteils, 2002; Borojo and Yushi (2015); Ali et al., 2016; Hanif & Arshed, 2016; Chang et al., 2018; Marquez-Ramos and Mourelle, 2019	Higher education variable had an encouraging effect on economic growth
In & Doucouliagos, 1997; Freire-Seren, 2002; Oketch, 2006; Islam et al., 2007; Ahmad and French, 2011; Uneze, 2013; Chang et al. (2018)	GDP has an impact on human capital formation, and Human capital formation has a positive impact on economic growth (income)
Benavot, 1989; Barro, 2001	Male secondary education has a significant positive impact on economic growth, while female secondary education negatively affects.
Sehrawat and Giri, 2017	Female human capital is significant and positively related to economic growth in the short and long run. In contrast, male human capital is positive but insignificant to economic growth.
Kifle, 2006	Human capital variable in the form of schooling has an insignificant impact on the level of output.
Gebrehiwot, 2016	The stable long-run relationship between real GDP per capita and human capital formation
Klasen, 2002; Bandara, 2015	Education gender gap leads to decline of output per worker (economic growth) and human capital level.
Shafuda and De, 2020; Megawati, 2020	Government spending on education and the gross tertiary enrollment rate (Human capital formation) have positive relationship.

2.2. Factors Affecting Women's Choice of Pursuing Engineering Education

The previous studies identify the factors affecting women students' choice of learning engineering and technology fields in higher education.

2.2.1. The nature of scientific queries, socio-cultural, and economic factors

Based on traditional socialization and traditional roles of the sexes, young women in many parts of the world view engineering and technology as a masculine field populated with males (Ross and Thomas, 2008). Kolmos et al. studied motivational factors, gender and engineering education based on survey data covering the entire population of students enrolled in Danish engineering education in 2010 in Denmark. The whole population included 3630 students, out of which 1675 (46%) completed the questionnaire. They explore the motivational factors behind an educational choice, aiming to compare male and female students' reasons for choosing a career in engineering. They found that mentors than men significantly more influence women.

In contrast, men tend to be more motivated by intrinsic and financial factors and by the social importance of the engineering profession. Parental influence is low across all programs. By differentiating between specific clusters of engineering programs, researchers further show that these gender differences are subtle and that motivational factors are unequally important across the different educational programs. The findings confirmed that social motivations are the most important motivational factors for attracting students to engineering and technology education (Kolmos et al., 2013).

Bossart and Bharti also conducted a study on women in some engineering departments who have more success in recruiting and graduating women than others. Data have been collected from the year 2000-2016 of undergraduate engineering department data from the University of Florida (UF) and the National Science Foundation (NSF). Women earn more undergraduate degrees in engineering disciplines to perceive a societal benefit (Bossart and Bharti, 2017).

Another study by Casey et al. studied motivating STEM+C learning with the social impact of cybersecurity and digital forensics in the US. The finding shows young women appear to be more motivated by social issues such as safety and privacy, whereas young men seem to be more motivated by career choices (Casey et al., 2020). Moreover, Melak and Singh found that sexual harassment harms women students' academic performance in STEM education, which leads to gender gaps in this field (Melak and Singh, 2021). Vidal et al. also believe that stereotypes, cultural barriers, lack of confidence, lack of knowledge of career opportunities, and lack of vision of possibilities are more than enough reasons for students who do not pursue university studies in engineering or drop out from university (Vidal et al., 2020).

Longe et al. also studied women's engineering experiences in Nigeria using primary and secondary data. Participants have been taken from 79 women students enrolled in engineering at Rufus Giwa Polytechnic. They found that 69 participants agreed on the question "wrong perceptions about engineering limit women participation in engineering." Fifty-two respondents agreed that "women's participation in engineering is limited by the dominance of men in the field," and 57 participants also agreed that "women's participation in engineering is limited by lack of career awareness (Longe et al.,2019)."

A study by Wuhib and Dotger conducted why few women in STEM using 296 participants in New York. They consider the chilly climate of STEM fields and present social perception's role as the factors affecting undergraduate women's STEM education success. Their findings show that undergraduate women reported greater use of social supporting than did men. They also found that social support is a better predictor of commitment for women than men. Therefore, they suggest that STEM fields should create a more collaborative and comfortable environment for women to participate better, retain and succeed in these fields (Wuhib and Dotger, 2014). Sulaiman and AlMuftah conducted a study on women in the engineering pipeline using secondary data from Qatar University in 2008 and 2009 female undergraduate engineering students. This article aims to reveal the barriers to progress, tracking the performance and the emerging trend of success at the undergraduate level of women in engineering in a different cultural dimension. Findings show that successful economic development and access to modern education are the key drivers that change the position of women in Qatari society (Sulaiman and AlMuftah, 2010). Powell et al. agreed that women facing various cultural and structural barriers in entering and developing engineering and technology in the UK, which leads to this sector being controlled mainly by men (Powell et al., 2011).

Beddoes examine feminist scholarship in engineering education. This article investigates the current state of feminism in the emerging field of engineering education. It identifies barriers, challenges, and tensions experienced by scholars and educators who have been involved with feminist engineering education initiatives. Using data from fifteen educators and researchers interviewed conducted through email, in-person, and Skype selected from the US and Australia to show international perspective. The participants worked in several different institutions, and Snowball sampling was used to determine 2 Australian participants and conducted the semi-structured interviews between April 2009 and December 2010. She founds engineering knowledge, culture, and training; engineering education as an emerging research field; publishing; institutional constraints; productive, non-alienating critique and the feminist label, legitimacy, and risk are barriers to women carrier choice (Beddoes, 2012).

2.2.2. Role model and encouragement

The lack of female engineering faculty role models and the failure to account for women's different cognitive styles are cited as contributing factors to the shortages of women students pursuing engineering degrees. Ross and Thomas argued that one of the most effective ways to accomplish this is a composite mentoring activity. Developing a mentoring relationship can be a challenge. The mentor can advise the mentee on career, academic, psychosocial, and role model functions and positively influence underrepresented students in the STEM discipline. They also argued that country's public and private sectors need to establish and maintain incentives for students to pursue high technology carer. They suggested providing opportunities to gain research experience is one of the more fundamental ways to retain students from underrepresented groups in the STEM areas (Ross and Thomas, 2008).

Vidal et al. also studied closing the gender gap in Peru's engineering. Their objective was to create a community of female students who became role models who share their motivation to STEM with new female students and participate in the recruitment process. The main activities were divided into two branches: a) exposure to role models at the student level and b) participation in the international community Django girls. Implementing exposure to role models and participating in the international community Django girls from 2016 to 2019 increase women's interest in the software engineering. A study by Simmonds et al., 2021 examined the impact of affirmative action on female computer science/software engineering undergraduate enrollment using 10% of students enrolled in all Chilean universities. They found that affirmative action programs, such as the gender equity program (GEP), successfully attract more young women to study in STEM fields (Vidal et al., 2020).

Marginson et al. reported international comparisons of science, technology, engineering, and mathematics (STEM) education. They showed that mentoring programs were positively evaluated as improving women's STEM participation. Examples of mentoring programs include: bringing together young women and successful female STEM professionals (including scientists, engineers, mathematicians, and computing specialists) to provide an authentic understanding of STEM careers and access to female role models (Marginson et al., 2013).

Powell et al. investigate gender stereotypes among women engineering and technology students in the UK, using quantitative and qualitative data were collected from 656 engineering and technology students at a UK university. They found that school teachers had a strong influence on the choices of engineering and technology students. By gender, 43.4% of women surveyed agreed that they were encouraged to study engineering and technology by a school teacher, compared to only 33.7% of men. A teacher's ability to engage students in a subject can help motivate interest (Powell et al., 2012).

2.2.3. Accessibility of awareness about field selection and intervention by stakeholders

Singh studied women in engineering education in India using secondary data from the year 1980 – 2005. Affirmative action as reservation and hostel facility for women students, which has already been taken, needs to expand for women students to join STEM education at a higher level (Singh, 2013). However, Powell et al. examine women engineering and technology students in the UK, using data from 53 women engineering and technology undergraduate students. The gendered help women receive is shown to be short-term benefits. This is likely to hinder women from progressing in their careers at the same rate as their male peers (Powell et al., 2011).

According to Watermeyer, science outreach programs and informal learning for young women help develop an ability to celebrate gender differences and women's multiple roles in science (Watermeyer, 2012). Rover studied improving student participation in electrical, computer and software engineering in the USA using different intervention programs to increase women's participation in STEM education. The program's interventions include weekly seminars, leadership studies, cohort and group activities such as discipline-based outreach, participation in seminars, faculty and peer mentoring, participation in discipline-based learning groups and student organizations, and other events. Through these programs in three years, from 2016 to 2019, the number of undergraduate women in electrical, computer, cybersecurity, and software engineering increased by 28% (Rover, 2020).

Another study by Sauer et al. conducted a study in Brazil to promote student enrolment in engineering and technology, based on workshops, a science and astronomy club, science and technology, and others. The results show how the activities are being promoted by encouraging women's participation and training for careers in the exact sciences, engineering, and information technology. These reduce the impact of gender inequalities on students' elementary and high school career choices (Sauer et al., 2020). Großgkreutz et al. also argued that media is essential to create women's awareness about STEM education. They found from the literature that active and successful females in technology regarded as positive by society should be introduced through media, increasing women's choice of STEM education (Großkreutz et al., 2017).

Aeschlimann et al. also studied how to improve women's interest in holding science, technology, engineering, and mathematics. They found that classroom assistants of learners' motivation can increase the possibility of choosing STEM education (Aeschlimann et al., 2016). Akcaoglu et al. also stated that promoting student preservation, presentation, and careers in science, technology, engineering, and mathematics (STEM) is suitable progressively essential due to STEM education's domestic and global importance (Akcaoglu et al., 2018).

2.2.4. Self-perception and interest of women students

Baytiyeh studied the status of women engineers in the Middle East, considering women engineers in Lebanon as a case study. The author investigated the following questions: What are the influences behind females' decisions to choose engineering as their major course of study? What are the motives behind this decision? What are the perceptions of females regarding the essential skills for a successful engineering career? An online survey consisting of Likert-scale items was completed by 327 female engineers who graduated from universities in Lebanon and now work in various locations worldwide. Exploratory factor analysis (EFA) and one-way ANOVA tests were employed to determine which items formed related subsets. The study's finding shows a genuine interest in the field appeared to be the primary influence in the participants' decisions to choose the engineering field. Besides, the potential for professional growth was the leading motivator for choosing to engineer (Baytiyeh, 2013).

Balakrishnan and Low also reveal that learning experience is directly related to female students' intention to pursue engineering and technology careers (Balakrishnan and Low, 2016). Abdullah et al. also studied women's participation in engineering professions in Malaysia. Their study explored the factors affecting women's participation in engineering sectors and the future intention to choose engineering degrees using 161 participants. They found that learning experience, educational choice, and opportunity inequality are the top factors affecting women's engineering education choice (Abdullah et al., 2018). Their finding is also confirmed by Jayawardena et al. argued that the most influential factor was the learners themselves (Jayawardena et al., 2020). Sheldrake et al. also found that student's attitude about the application and relevance of science is essential in choosing the field stream (Sheldrake et al., 2017).

Main and Schimpf reviewed the literature on women's underrepresentation in computing fields across four life levels, i.e., pre-high school, high school, primary college choice, and employment after graduation. Gender disparities in interest and attitudes toward computers correlate with access to and usage of computing tools at the pre-high school and high school levels. Environmental context (classroom architecture, experiences with peers and role models, cues from stereotypical images) determines whether students want to major in computing in college. In contrast, psychosocial factors (e.g., sense of belonging and self-efficacy) and departmental culture play a role in persistence in computing fields (Main and Schimpf, 2017).

Schreuders et al. conducted a study on pipeline or personal preference of women in engineering in the US. This study examines data collected from engineering students using an online survey from the fall of 2005 through the spring of 2007. A total of 969 men and women students from 21 US universities participated in this online survey. The finding indicates that women are less interested in specific engineering activities (Schreuders et al., 2009).

Smith and Dengiz studied women in engineering in Turkey using data were collected from 671 female students who attended Middle East Technical University (METU) (Ankara), Bilkent University (Ankara), Gazi University (Ankara), Hacettepe University (Ankara), Bogazici University (Istanbul), Marmara University (Istanbul), and Istanbul Technical University (Istanbul). The methods include surveys and facilitated focus groups. Their finding shows that women in Turkey choose engineering fields mainly because they enjoy the underlying mathematics and science. There is no gender bias on the part of teachers or fellow students; however, women students believe that they have fewer opportunities than male peers and acutely feel the lack of role models (Smith and Dengiz, 2010).

2.2.5. The role of families on women student's choice of learning

Rankin et al. conducted a study on familial influences in African American women's persistence in STEM education in the USA using 34 African American women participants. The finding reveals that 20 (59%) women participants believe that families play a positive role in African American women's persistence in STEM education through early exposure and access to computing, support for women's self-efficacy, education as a family value, career guidance, and advice, etc. They also argued that parents become mentors who offer career advice to help their daughters succeed in male-dominated workplaces. They function as role models and a source of inspiration (Rankin et al., 2020).

Zamora-Hernández et al. explore strategies for attracting more women into engineering in Mexico taking official data from the Mexican government of student enrolment from 2009-2019. They found that 93% of women participants positively responded from their families on learning engineer education. In contrast, 63% of female students were influenced by negative social perceptions when choosing the study's engineering field. On the other hand, 46% of participants answered that peer pressure is the most crucial factor affecting women's decision to study engineering, 41% said low job opportunity was the factor affecting women's choice of engineering. They also found that 52% of women participants agreed that there should be more information regarding women in engineering and their success story to reduce negative social and cultural perceptions about women's engineering education. They conclude that family and successful stories of women in engineering are the most important factors encouraging women's choice of engineering education. They also suggest strategies to attract more women in engineering; these are: organize ongoing communication events such as women in engineering, create a discussion with women lecturers in engineering and students and the families, continuous assessment and follow up by the faculty, establish associations who encourage women in engineering education, women faculty members can be the best cooperates to encourage women students in engineering education (Zamora-Hernández et al., 2020).

Großkreutz et al. also studied the influence on career choice to increase female students' participation in STEM. They noticed that family, career, and income are crucial factors in advancing women in engineering. They also argued that girls, who had contact with technology through their father in their parents' house from early childhood, significantly more often choose a technical career path. Therefore, it is safe to presume that developing an interest in technology during childhood can increase women's technical fields percentage (Großkreutz et al., 2017).

Talley and Ortiz studied women’s interest development and motivations to persist as college students in Science, Technology, Engineering, and Mathematics from a Hispanic-Serving Institution. The purpose of this study was to gain a deeper understanding of the experiences of women credited for influencing the development of their career interest goals and the sources of motivation they attribute to success in their academic course outcomes in their fields of study. Data have been collected through questionnaires, conducting focus groups, and through email from the larger group of students’ samples of > 50 and to gain in-depth responses from a smaller group of students’ samples of < 25.

Respondents were from Latina and African American women from Computer Science, Engineering Technology, Engineering, and Physics in Texas, USA. The sampling method for this study was non-probability sampling based on a voluntary sample from a targeted population group. The population of interest was women. The finding indicated that students identify early participation in STEM activities and family socializing behaviour as ones that contributed the most towards influencing their interest in STEM and motivated them to persist in their studies and pathways as future STEM professionals (Talley and Ortiz, 2017).

2.2.6. Recruitment and retention

Krasnov et al. women's participation in engineering has been an issue worldwide for many years. They identify the factors contributing to women's education in engineering and computing in Jordan, Malaysia, Saudi Arabia, Tunisia, and the USA. Their research questions were: (a) What motivates women's engineering choice as an educational path? (b) How do women perceive professionals in these fields and the work they do? (c) What societal, cultural, legal, and policy factors are perceived to support or constrain women's participation in engineering or computing fields of study and occupations? They found that the recruitment and retention of women in these fields continue to face substantial challenges (Krasnov et al., 2014).

Sulaiman and AlMuftah also discussed that recruitment were the reason behind the under-representation of women undergraduate engineering students (Sulaiman and AlMuftah, 2010). However, Haworth et al. investigated no difference between boys and girls when selecting courses (Haworth et al., 2010). Findings by Semali and Mehta reveal many students' barriers to joining science, technology, engineering, and mathematics education. These factors include overcrowding number of students, insufficient access to education material, inappropriate curriculum, poor learning performance, and the problem of unemployment after graduation (Semali and Mehta, 2012).

Carnasciali et al. investigate factors influencing students’ choice of engineering major, a case study at the University of New Haven. This research focuses on evaluating engineering students' decisions to choose or change their field of engineering study. A survey was conducted from 97 voluntary participants from eight undergraduate programs within the College of Engineering in the spring semester of 2012 through questioner and interviews. The finding indicates that only 66% of engineering students stated that they had determined their specific major before visiting potential universities during their search. This should indicate to the University's engineering programs that there is a significant opportunity to influence student decisions during the recruitment process of their first years of study (Carnasciali et al., 2013).

Makarova et al. also studied the experiences of young women in STEM vocational education and training. The paper investigates young women's perceptions during their vocational education and training (VET) in traditionally male-dominated science, technology, engineering, and mathematics fields by analysing mechanisms. Qualitative and quantitative data were collected from semi-structured interviews from 71 young women who had chosen a STEM career and were enrolled in Vocational education and training in Swiss secondary schools in the year 2012 in Germany. The interview was conducted by telephone. The finding indicates different processes of gendering in Vocational education and training, uncovering various mechanisms and symbolic actions which contribute to the reproduction of masculine culture in STEM professions (Makarova et al., 2016).

Clark et al. investigate psychosocial pathways to STEM engagement. Data for this study were collected in the context of a larger, longitudinal study of graduate students in STEM fields in US citizens. Three hundred thirty-two doctoral students in social science and STEM programs completed the online survey. Two hundred five of those students were enrolled in postgraduate programs in STEM, and 102 of those students were enrolled in doctoral programs in the biological sciences. 49.3% of the sample was female. The finding shows that perceived support from one's advisor may promote STEM engagement among women by predicting greater gender STEM identity compatibility, indicating greater STEM importance among women (but not men). STEM importance further predicts a higher sense of belonging and self-efficacy in STEM for women (Clark et al., 2016).

2.2.7. *High school educational background of students*

J. Gill et al. studied women, education, and the engineering profession by using data from women and man engineers in Australia. The finding shows that the success in math and science at high school is relevant to their enrolling in engineering at the university level (J. Gill et al., 2008).

Many papers are reviewed related to factors impacting women's choice of learning engineering and technology education in several countries worldwide. Hence, we found that the previous studies did not investigate these factors empirically. Consequently, we want to analyse factors affecting women's choice of engineering and technology education through regression analysis of primary data gathered in the Ethiopian context. These can add value to the scope of the literature on women's participation in STEM. There is also a need for more women's participation in engineering and technology in Ethiopia's development and poverty reduction. These reviewed previous studies are summarized in Table 2.2.

Table 2.2 List of reviewed previous studies about factors affecting women students' choice of pursuing engineering.

Researchers	Discussion
Ross and Thomas, 2008; Kolmos et al. 2013; Bossart and Bharti, 2017; Casey et al., 2020; Melak and Singh, 2021; Vidal et al., 2020; Longe et al., 2019; Wuhib and Dotger, 2014; Powell et al., 2011; Beddoes, 2012	The nature of scientific queries and sociocultural factors affecting women's choice of learning engineering and technology
Vidal et al., 2020; Simmonds et al., 2021; Marginson et al, 2013; Powell et al., 2012; Ross and Thomas, 2008	Role models and encouragement can affect women's choice of learning engineering and technology
Singh, 2013; Watermeyer, 2012; Sauer et al.2020; Großkreutz et al., 2017; Aeschlimann et al., 2016, Rover, 2020, Akcaoglu et al., 2018	The factor accessibility of awareness about field selection and intervention by stakeholders affecting women's choice of learning engineering and technology
Baytiyeh, 2013; Balakrishnan and Low 2016; Abdullah et al., 2018; Jayawardena et al., 2020; Sheldrake et al., 2017; Main and	Self-perception and interest of women students are also other factors.

Schimpf, 2017; Schreuders et al., 2009; Smith and Dengiz, 2010	
Rankin et al., 2020; Zamora-Hernández et al., 2020; Großkreutz et al., 2017; Talley and Ortiz, 2017	Studied the role of families on women students' choice of learning engineering and technology.
Kranov et al., 2014; Sulaiman and AlMuftah, 2010; Haworth et al., 2010; Semali and Mehta, 2012; Carnasciali et al.,	The author investigated recruitment and retention are also factors.
J. Gill et al., 2008	High school education background of students: Success in math and science at high school is relevant to their enrolling in engineering at the university level

2.3. Factor Affecting Academic Performance of Women in Engineering Education

Here, we deal with reviewing papers on factors that affect women's academic performance in higher education.

2.3.1. Socio-cultural factors

Women's enrolment in education is better today than ever before. Still, they do not always have the same opportunities as boys to complete and benefit from an education of their choice. Dench investigates a comparative study of factors affecting male and female engineering students by taking data from 89 female and male students through interviews and questionnaires. The finding shows that even if there are many identities between female and male engineering students, females are more disadvantaged that declines females' probability of success in this area of discipline (Dench, 1990). Women are held back by biases, social norms, and expectations that influence their educational performance. They are particularly underrepresented in science, technology, engineering, mathematics education, and, consequently, STEM careers (UNESCO, 2019). According to Almukhambetova and Kuzhabekova, most women are challenged by various socio-cultural factors, labor markets, and regional differences, contributing to under-representation in STEM fields in Kazakhstan (Almukhambetova and Kuzhabekova, 2020).

The finding of Hanson and Krywult also shows that country-level socio-economy, cultural and political factors, number of women in parliament, gender inequality, overall equality, and religion are examined as possible factors of girls' achievement in STEM education in Poland (Hanson and Krywult, 2020). A study by Mamo & Hailu confirms the idea. They studied female students' academic performance and competency in Ethiopia by collecting data from 135 female students at Dire Dawa University. They found that student behaviour and commitment-related factors were significant reasons for their poor academic performance and competency (Mamo & Hailu, 2017). Balakrishnan & Low also examine socio-cultural influences on female engineering students' perspectives on engineering courses and careers. The study was focused on the Japanese female students' perception of learning by looking at their intention to pursue careers in engineering fields. The findings revealed that socio-cultural values greatly influence students' motivation to pursue careers in engineering (Balakrishnan & Low, 2016).

2.3.2. High school educational background and university infrastructure

Mersha et al. studied factors affecting women students' academic achievement at Bahir Dar University using data collected from 200 male and 400 female students studying in 6 faculty, including engineering. The finding shows that high school academic background is the main factor for their low academic performance. They also found that personal factors and the university environment contribute to their insufficient understanding (Mersha et al., 2013). Mamo & Hailu also examine that related institutional factors can affect women's academic performance and competency (Mamo & Hailu, 2017).

Another study by Muhammed Hussen found that university entrance exam scores are the primary determinant of students' academic performance (Muhammed Hussen, 2016). Yigermal also proved a significant relationship between former educational background (measured by university entrance exam) and students' academic performance (Yigermal, 2017). A recent study by Raquel et al. also confirms other studies that students' academic performance and motivation can be obtained by knowing the student's educational background (Raquel et al., 2020).

2.3.3. The teaching methodology followed by teachers and peer learning habit of students

Riegle-Crumb and Moore examine 2000 students who enrolled in challenge-based engineering courses in Texas. The finding reveals that females reported lower interest in engineering and expressed less confidence in their engineering skills compared to males. Additionally, female students felt that the classroom was less inclusive. These findings relate to the teaching methodology instructors and students' learning habits that can affect their academic performance in engineering education (Riegle-Crumb and Moore, 2013).

Hosaka also studied women's experiences in the engineering laboratory in Japan. This qualitative study examines Japanese undergraduate engineering students' experiences interacting with departmental peers in the laboratory setting. Findings show that women generally had a painful experience while working with their male peers. They participated less and lost confidence by comparing with men who appeared to be confident and competent. According to Hosaka's findings, women were not interested to learn in groups with their friends, which is an essential factor for experience and knowledge sharing that leads to low academic performance (Hosaka, 2014). Balakrishnan and Low also conducted on the Japanese female students learning experience in engineering programs. The findings revealed that learning experience was directly related to female students' intention to pursue their engineering careers (Balakrishnan and Low, 2016).

2.3.4. Academic curriculum and sexual harassment

Garcia Villa studied women students in engineering in Mexico. The study found that academic curriculum was a crucial problem of women's academic performance in engineering. When the duration of the engineering program is so long, that discourages learning motivation which leads to low performance (Garcia Villa, 2014). Molla and Cuthbert investigate women's higher education experience in Ethiopia by taking qualitative data from 2 government universities. The finding shows that sexual violence and bias contrary to women indicate inequality in the university. The result indicates that this violence and discrimination can affect women students' psychological and academic performance (Molla and Cuthbert, 2014). World Economic Forum and UN also identified reasons women and girls participate in STEM fields at lower rates, such as lack of encouragement, active discouragement, lack of role models, negative peer pressure, and harassment. Studies show that it is not an ability issue. Women from under-represented groups face prejudice twice over, both against their gender and their race. In some countries in the developing world, girls still struggle for primary access to education and then for acceptance into the workplace (World Economic Forum 2017; UN, 2020).

2.3.5. Interventions followed by institutions for supporting women students

Van den Hurk et al. (2019) studied the effectiveness of interventions applied in STEM education and found that some effective interventions prevent the dropout of initially motivated and most intelligent students in STEM areas of study. Making institutions a conducive environment for learning can lead to better achievement rather than a dropout (Van den Hurk et al., 2019). In some countries, including Ethiopia, girls have an affirmative action policy to support their educational achievement. However, there is an argument about this affirmative action offered to females at the university level. For example, Molla and Cuthbert argued that affirmative action policies slightly benefit females at the entry point only, not in academic achievement (Molla and Cuthbert, 2014).

2.3.6. The annual income of the family and residence place

Family income situation is an essential factor in determining the academic performance of children. Muhammedhussen found family economic situation, sleep time, and habit of study are the main determinants of students' academic performance, while the residential place was found insignificant (Muhammedhussen, 2016). Lin and Lv also found family income have a significant influence on child education. According to their finding, increasing family income does play a more substantial role in enhancing children's education in China (Lin and Lv, 2017). Tomul and Çelik carried out a study and found that family income affects academic performance (Tomul and Çelik, 2009). A recent study by Li & Qiu also finds that a family's socioeconomic status affects more urban students' academic performance than rural students (Li & Qiu, 2018).

On the other hand, Gobena carried out a study by taking data from Education and Behavioural Science students in Harmaya University, Ethiopia. The finding indicates there is no effect of family income on students' academic performance (Gobena, 2018). There is a controversy about whether family income affects students' academic performance, which needs further investigation from these reviewed studies.

2.3.7. Educational background of the family and the role model

Learners will need the full support of their families and other stakeholders to maximize their academic performance potential. Buchmann and Diprete found female superior academic performance in college completion remains the largest in families with a low-educated, but it currently extends to all family types (Buchmann and Diprete, 2006). Li and Qiu also find families who have a high-quality educational background and understanding educational opportunities lead to better academic performance. Besides, parental education support for their children encourages children's learning behaviours and affects academic performance (Li and Qiu, 2018). Tomul and Çelik also conducted a Turkey study and confirmed parent education affects students' academic achievement (Tomul and Çelik, 2009).

Similarly, Gobena obtained a positive and significant relationship between family educational level and students' academic achievement (Gobena, 2018). Carnasciali et al. also found parental educational achievement levels affect students' performance (Carnasciali et al., 2013). Choudhury argued that since children mostly follow their family, educated parents (also other educated adults in the household) are more aware of the benefit of education and invest more in providing quality education (Choudhury, P. K., 2015).

There are also studies regarding role models has an impact on women's academic performance. Corbett and Hill argued that women role models strengthen young women's mathematics attitudes and self-concepts and increase women's abilities to consider STEM fields as career options (Corbett and Hill, 2015). Sjaastad studied and found teachers are models by displaying how STEM might bring forward someone's success by providing a positive experience with the field (Sjaastad, J., 2012). Leavey also reports that women in STEM prefer to have women mentors (Leavey, 2016). This supports a study that indicates women were more interested in STEM after reading biographies of successful STEM role models and reading letters of encouragement from women role models (Shin, Levy, and London, 2016; Herrmann et al., 2016). The precise summary has provided in Table 2.3.

Table 2.3 List of reviewed papers related to factors affecting women's academic performance in engineering education.

Researchers	**Discussion**
Dench, 1990; UNESCO, 2019; Almukhambetova and Kuzhabekova, 2020; Hanson and Krywult, 2020; Mamo & Hailu, 2017; Balakrishnan & Low, 2016	Socio-cultural factors affecting women academic performance of engineering and technology education

Mersha et al., 2013; Mamo & Hailu, 2017; Muhammed Hussen, 2016; Yigermal, 2017, Raquel et al., 2020	High school educational background is a factor affecting women academic performance of engineering and technology education
Mersha et al., 2013; Mamo & Hailu, 2017	University infrastructure is a factor affecting women academic performance of engineering and technology education
Riegle-Crumb and Moore, 2013	Teaching methodology followed by teachers is a factor affecting women academic performance of engineering and technology education
Hosaka, 2014; Balakrishnan and Low, 2016	Peer learning habits of students is a factor affecting women academic performance of engineering and technology education
Garcia Villa, 2014	Academic curriculum or duration of is a factor affecting women academic performance of engineering and technology education
Molla and Cuthbert, 2014; World Economic Forum 2017; UN, 2020	Sexual harassment is a factor affecting women academic performance.
Van den Hurk et al., 2019; Molla and Cuthbert, 2014;	Interventions followed by institution for supporting women students
Muhammedhussen, 2016; Lin and Lv, 2017; Tomul and Çelik, 2009; Li & Qiu, 2018;	Annual income of the family has a positive impact on women's academic performance.
Gobena, 2018	The annual income of the family does not affect women students' academic
Muhammedhussen, 2016	Residence place is a factor that is not affecting the academic performance of women in engineering and technology education
Buchmann and Diprete, 2006; Li and Qiu, 2018; Tomul and Çelik, 2009; Gobena, 2018; Carnasciali et al., 2013; Choudhury, P. K., 2015	The educational background of the family is a factor affecting women's academic achievement in engineering and technology.
Corbett and Hill, 2015; Sjaastad, J., 2012; Leavey, 2016; Shin, Levy, and London, 2016; Herrmann et al., 2016	The role model has an impact on women's academic performance in engineering and technology education.

2.4. Factors Influencing Employability of Women Graduates in Engineering Education

Unemployment is a circumstance in which an individual actively searching for employment is incapable of securing one. There are two broad classifications of unemployment: voluntary (when a person is willing to leave his work to search for a new job) and involuntary unemployment (a situation in which a person is willing to continue to work but unable to do so). Again, there are more specific types of unemployment. These are structural, frictional, and cyclical unemployment (Mathew, 2018). Let us discuss some theoretical explanations about what factors will cause unemployment.

2.4.1. Existence of market forces such as the presence of legal minimum wage (government interventions)

The classical theory of unemployment believes that government intervention or imposition of some restriction in the market can create less probability of employability. This theory of unemployment is formulated based on the following assumptions.

- The market behaves as described by the idealized supply and demand model.
- The labor market is regarded as perfect competition, and advert transactions
- Quantity of labor service is measured by the number of workers working full days over a given period.
- The price of labor is real wage per day.
- Every unit of labor service is the same
- Every worker in this market will get precisely the same wage
- The equilibrium wage is WE, and the equilibrium quantity of labor supply is LE

The technical explanation of this theory argued that in the free market, which is adjustable, there is no involuntary unemployment since everyone who wants a job at the given wage gets a job. In the supply curve beyond equilibrium point Le, many people may want to work at a higher wage. However, given the presently existing wage rate, these people have made a rational decision not to take part in this labor market. In this theory, the only way actual involuntary unemployment can occur is if there are market forces such as legal minimum wage.

As presented in Figure 2.1, if employers are required to pay a minimum wage of 'Wb' above the equilibrium wage, they will appoint fewer workers. At that level of artificially high wage 'Wb,' employers want to hire only 'Ld' workers, but at that wage, 'Ls' amount of people wishes to jobs that create surplus labor since the market is prevented from adjusting to equilibrium legal restrictions on employers. At the same time, some people want a job at that level of wage, but they cannot find hence, they become unemployed. Therefore, the classical theory of unemployment concludes that unemployment is the consequence of legal restriction and interference in the labor market (Neva R. et al., 2006).

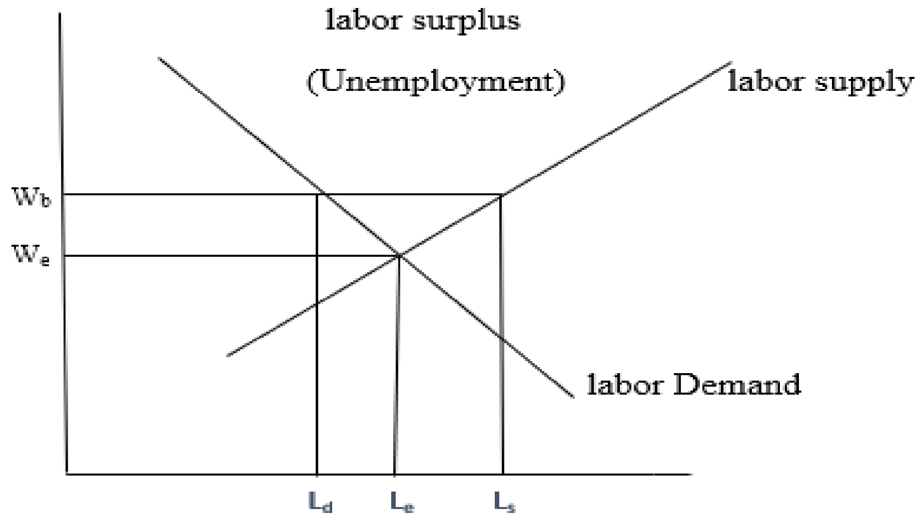

Figure 2.1 Presentation of the classical theory of unemployment

2.4.2. The decline of aggregate demand during the period of boom and recession of business cycle in the economy

Unlike the classical theory of unemployment, Keynesian theory of unemployment argued that unemployment occurs due to the decline of aggregate demand during the boom and recession of the business cycle in the economy. The fall of demand for goods and services leads to the decline of production resulted in a reduction of employment level and incensement in unemployment. This can be adjusted by government interference (Keynes, 1936).

2.4.3. Contractual agreement turns out

Implicit Contrasts Theory of Unemployment developed based on assumptions that firms are risk-neutral act as employers and insurers of homogeneous risk-averse laborers. The argument is that unless there are small changes in the product's price, wide labor demand above-average economy, and high risk-averse labor leads to deduction of employees. In addition, mall unemployment compensation, and highly competitive product market, lead to firms lay off parts of the workforce during the law state of demand through random choice at the time of prevailing for the specification of full employment during contractual agreement turn out (Azariadis, 1975).

2.4.4. Education level, socio-cultural perceptions, economic factors, and gender stereotypes

Cooke examined Asian women's employment participation by taking India, China, Japan, and South Korea. The finding reveals that education level, traditional societal value, employer strategies, and discrimination contribute to gender inequality in employment across these four countries. He also stated that institutional structures, persistent male-controlled gender norms and stereotypes, and ineffective representation limit women's bargaining power in the labor market and hold down their financial reward and career progression (Cooke, 2010). Dasgupta and Stout also argued that there are gender gaps in STEM jobs. The answer for what drives these gender disparities in STEM are: learning environments, peer relations, and family characteristics, which become obstacles to STEM achievement, leads to the low opportunity of women graduates in STEM employment (Dasgupta and Stout, 2014).

Clem Herman investigated gendered factors affecting employability for mature women students in STEM. Data in this paper are drawn from a longitudinal study of 167 women graduates in science, technology or mathematics in 2011 and 2012, through a postal survey who participated in a UK government-funded online program to support them to return to work. Twenty-three of the 66 respondents were then interviewed by telephone. The interview transcripts were analysed to identify individual, personal and external factors that had contributed to career outcomes since completing the course. The paper examines three gendered factors identified as being of particular influence on outcomes gender role normativity, locality and mobility, and structural and institutional barriers (Clem Herman, 2015).

According to ILO, science, technology, engineering, and mathematics jobs are experienced with the gender gaps worldwide. This is due to gaps in education fuelled by gender stereotypes and expectations, male-dominated STEM workplaces against prejudice, a lack of women role models, provision of low salaries than their male co-workers, and bias that pushes women out of STEM careers (ILO, 2020).

Islam also discussed that graduate woman attempting to pursue a career or postgraduate degrees are often excluded because of their gender and marginalized, leading to much less entering the job market. He also argued that there are equal opportunities for both genders in principle, but social perception and prejudice determine which employment types are particularly suitable for whom (Islam, 2017).

Sharma et al. indicate that wage, progression, security, unconscious biases, stereotypes, societal, cultural, and institutional issues are barriers for women to have science and technology job opportunities. Studies also show women were found to be underrepresented in STEM fields. This under-representation resulted from gender stereotypes, spatial skills differences, hierarchical and territorial segregation, and job allocation discrimination (Sharma et al., 2019). O'Leary identified factors such as women graduates in science and engineering suffer from job insecurity, the absence of expanding new businesses, and in many countries manufacturing economy is substituted by the knowledge economy, which creates short positions available for the number of graduates (O'Leary, 2012). Ong et al. argued that this under-representation of women in STEM jobs represents human capital's under-utilization and the financial loss of training qualified workforce in engineering & technology.

It is known that; a higher level of education is essential for joining the labor market and increasing public standing (Ong et al., 2011). However, Bryan and Guccione found bias in research financing grants, which favours men and culturally male-dominated fields (mainly engineering and technology) that exacerbate gender inequality. Even though women have a higher degree level of education, they face painful experiences to work in a top position from a diverse source of obstacles (Bryan and Guccione, 2018).

The study by Torres-Guijarro and Bengoechea also reveals a gender issue in the engineering college of Span. Women criticize themselves severely, indicating that they lack confidence in engineering and technology education, leading to low job opportunities (Torres-Guijarro and Bengoechea, 2017). Bowen also explores women's gender-biased experience in work-integrated learning internship placement or other jobs, particularly in the STEM sector, due to women and work's assumption. This leads to the low participation of women opportunities in terms of employment perspective. However, creating employment opportunities for women graduates in the engineering and technology field is essential for national development. Workplace environments, structures, and traditions often impose sets of male-dominated expectations on women graduates that limit their range of job opportunities (Bowen, 2020). Xiaohao and Changjun also found that the financial crisis has negatively influenced student employment growth and has aggravated the already severe imbalance of supply and demand in the Chinese job market for university graduates (Xiaohao and Changjun, 2013).

A study by Bryan and Guccione found a higher level of education is essential for joining the labor market and increasing public standing (Bryan and Guccione, 2018). But Crabb and Ekberg argued that women's academic career interests were reduced than men's, especially after holding post-graduate degrees (Crabb and Ekberg, 2014). As Blackmore (2014) discussed, even though women have computed higher degree levels of education, they face discouraged experience working in higher positions from diverse sources of obstacles. Himmelweit et al. (2019) also confirmed bias in research financing grants that favour men and culturally male-dominated masculine positions (mostly engineering and technology areas) and fields, which exacerbates gender inequality. Related to this (Dobele et al. 2014) stated that gender imbalance deserves higher education regarding salary and position even though it is achieved through the workload. (Edwards and Coates, 2011) found that women have experienced less likely engagement in full-time employment and earn lower salaries than men after graduation. (Kandiko Howson et al., 2018) explored women usually sense that men have the opportunity to access the status and figure of honors more quickly than they do.

Another study stated that education is basic for developing knowledge economy and innovation when implemented in practical work. So university graduate schools have to link with institutions and industries (Boud and Tennant, 2006). Wilson and Wilson also show that work-integrated learning and collaborative practice is essential for women to intensify confidence, improve social interaction, develop knowledge about their chosen professional, thoughtful, and prospective principal to employment after graduation (Wilson and Wilson, 2019). Smith also confirmed that professionally work-ready learning and teaching curriculum is essential for supplying university graduates who are well prepared for the occupation to government, companies, and professional citizens (Smith, 2012). Jackson showed that working in a team, being given duty, and joint learning in work placement have significantly generated skill development and actual knowledge, vital to getting employment after graduation (Jackson, 2016). Bridgstock argued that recently employability involves far more than possession of graduates, since there is promptly changing facts and information demanding economy. So that graduates must be taking the initiative and improve entrepreneurial skill (Bridgstock, 2009).

However, Bowen explores that women face gender-biased experience in work-integrated learning internship placement or other jobs, particularly in the STEM sector, due to the assumption of women and work (Bowen, 2019). A study argued that men receive more sponsorship and mentoring accessibility in the STEM profession than women. This leads to low participation of women in employment opportunities in terms of employment perspective (O'Connor et al., 2019).

2.4.5. Academic performance (cumulative GPA)

As educational attainment becomes increasingly essential in employment settings, the undergraduate grade point average (GPA) will be an attractive selection. Many positive findings lend credence to using GPA in applicant screening as a cost-efficient proxy for applicant mental ability and motivation. However, organizations should consider many factors and limitations in the selection process to ensure fairness and accuracy (Imose and Barber, 2015). Another study by Li and Zhang conducted a study in China and found that other things being equal, graduates with better college GPA were more likely to be employed (Li and Zhang, 2010). Drydakis also confirmed this finding by conducting a UK study and finding a positive relationship between GPA obtained from university and invitations to interviews for job allocation (Drydakis, 2016).

2.4.6. Communication skills and non-technical skills

Ting et al. revealed that employers regard language proficiency and communication skills as separate attributes in the Malaysian private sector. If they have strong communication skills, employers are willing to accept hiring applicants with average English proficiency. The findings also showed that solid communication skills would improve employability and career development opportunities (Ting et al., 2017). Baytiyeha and Naja also explored perceptions of engineering graduates regarding the difficulties of obtaining a job after graduation in Lebanon. Their finding reveals that communication skills, responsibility, and self-confidence were the main challenges facing engineering graduates in obtaining a job (Baytiyeha and Naja, 2012). Matthews et al. found that graduates with service-learning experience have a significantly shorter time getting a job Matthews et al. According to Lowden et al., there is a broad understanding of what qualities, characteristics, skills, and knowledge constitute employability both in general and specifically for graduates. Employers expect graduates from their degrees to have academic and disciplinary abilities. Still, they often need graduates to show a variety of broader skills and qualities, including teamwork, communication, leadership, analytical thinking, and problem-solving (Lowden et al., 2011).

Humburg et al. argued that employers look at the essential characteristics when recruiting higher education graduates, the skills that graduates should possess to be employable, and how higher education institutions can best enable students to develop employable profiles. The analyses show that interpersonal skills (communication skills, teamwork skills, etc.) are almost as essential as professional expertise. To be employable, a graduate needs interpersonal skill, and below-average levels cannot be compensated for even by the best grades or the most relevant study field (Humburg et al., 2013). Pan et al. also considers a proactive personality as a non-technical skill. The finding reveals that the indirect effect of bold nature on job search success is a variety of skill development to acquire job-related knowledge and skills and help achieve rapid job obtaining (Pan et al., 2018).

2.4.7. Marital status and job preference

Previous studies have used this variable who found that 35.7% of the unmarried female with undergraduate education level has obtained more than three years agreement singed jobs, whereas 15.7% were currently married (Roy and Mukherjee, 2013). Another study found that employment preferences are heterogeneous according to graduates' ideal employment expectations Schuster et al. leading to lower job opportunities (Schuster et al., 2020). A short summary of reviewed papers related to the employability issue has given in Table 2.4.

Table 2.4 List of revised papers related to factors affecting the employability of women graduates in engineering fields of study.

Researchers	Discussion
Cited by Neva R. et al., 2006	The classical theory of unemployment conclude that unemployment is the consequence of legal restriction and interference in the labor market
Keynes, 1936	Keynesian theory of unemployment argued that unemployment occurs due to the decline of aggregate demand during the period of boom and recession of the business cycle in the economy.
Azariadis, 1975	Implicit Contrasts Theory of unemployment which concludes the cut off an agreement between employers and workers can create unemployment
Cooke, 2010; Dasgupta and Stout, 2014; Clem Herman, 2015; ILO, 2020; Islam, 2017; Sharma et al., 2019; O'Leary, 2012; Ong et al., 2011; Bryan and Guccione, 2018; Torres-Guijarro and Bengoechea, 2017; Bowen, 2020; Xiaohao and Changjun, 2013; Bryan and Guccione, 2018; Crabb and Ekberg, 2014; Blackmore, 2014; Himmelweit et al., 2019; Dobele et al. 2014; Edwards and Coates, 2011; Kandiko Howson et al., 2018; Boud and Tennant, 2006; Wilson and Wilson, 2019; Mith, 2012; Jackson, 2016; Bridgstock, 2009; Bowen, 2019; O'Connor et al., 2019	Education level, socio-cultural perceptions, economic factor, and gender stereotypes are factors affecting the employability of women graduates.
Imose and Barber, 2015; Li and Zhang, 2010; Drydakis, 2016	Academic performance (cumulative GPA)
Ting et al., 2017; Baytiyeha and Naja, 2012; Lowden et al., 2011; Humburg et al., 2013; Pan et al., 2018	Communication skills and non-technical skills
Roy and Mukherjee, 2013; Schuster et al., 2020	Marital status and job preference

2.5. Challenges Faced by Women Working in Engineering Professions

Although many national and international policies and programs have been implemented to promote and increase gender equity in science and technology, there is a significant gender gap in women's participation in higher science academic careers.

According to Sharma et al., Minimum wage, progression, security, unconscious biases, stereotypes, societal, cultural, and institutional issues are barriers to women reaching the higher levels of science and technology professions (Sharma et al., 2019). Rosser found the most considerable challenges women engineering and technology professionals face are balancing carriers and their families (Rosser, 2004; Rosser, 2018). Bastalich et al. also founded the interviewed women engineers and stated that cultural stereotypes about women as under-confident or unsuited to engineering work starkly is the major challenge (Bastalich et al., 2007).

Subri analysed studies on Job Issues Factors, Gender Discrimination, and Conflicts of Life Balance in her literature analysis on challenges experienced by women engineers. Anything that inhibits skilled women engineers from moving up the career ladder is referred to as a challenge or a barrier. These difficulties may even be viewed as a roadblock in their professional development. Some difficulties may be verbal, physical, or mental in nature (Singh, 2021). Another form of prejudice is working in a dangerous workplace or traveling to foreign countries (off-site work). She also mentioned that one of the issues facing female engineers is that their bosses have little faith in their abilities, questioning their ability to perform off-site or travel to a foreign place. Furthermore, the manner of women's inquiry contributes to their employer's scepticisms of their talents. Additionally, even some employers or co-workers, may have doubts on women capability to lead which have an impact even on job distributions, and ultimately on wage distribution (Subri, 2018).

Seema Singh has found that women engineers are subject to the following types of bullying. These are: (1) discrimination at the time of appointment as considering male candidate first, (2) their salary may be same but more additional work is given, (3) fault finding, (4) by saying not qualified for promotion, may not be considered at the time of promotion, and (5) in private sector where salary is neglected, women engineers may be given lower salary (Singh S., 2019). Few studies have been done regarding this specific topic, as given in Table 2.5.

Table 2.5 List of reviewed papers regarding to challenges faced by women engineers at the work place

Researchers	Discussion
Sharma et al., (2019); Subri, (2018) Rosser (2004); Singh (2019); Singh (2021) Bastalich et al. (2007)	They are focused on the challenges of women working in the engineering and technology profession.

2.6. Research Gap of the Study

Extensive paperers have been reviewed related to women's participation in science, technology, engineering, and mathematics (STEM) education and employment worldwide. From this literature, there are few studies conducted in Ethiopia about women's participation in engineering and technology education and jobs, even though many studies are available in many countries. In addition, the previous studies did not empirically investigate the factors affecting women's choice of learning engineering and technology education. Even though the earlier studies studied the relationship between economic growth and human capital formation in general (i.e., primary level education enrolment, secondary, tertiary, or in the three cases together), this study focuses on engineering and technology education specifically. The previous studies did not study a family profession, year of university establishment, and students' accessibility of information about universities before joining. So, we want to research factors affecting women's academic performance in engineering and technology education, including these three factors with primary data collected from Ethiopia. The previous studies did not study the variable willingness to migrate for searching for a job. Consequently, we want to research factors affecting the employability of women graduates in engineering and technology education, including this factor with primary data collected from Ethiopia.

In addition, there are no studies about the challenges of women graduates in the engineering and technology field of study in the case of Ethiopia, as well as few studies available in other countries. In this study, we want to identify these challenges in the context of Ethiopia. Hence, this study differs from the existing work and significantly contributes to the literature on women's participation in STEM education and employment. There is also a need for more women's participation in engineering and technology in Ethiopia's development and poverty reduction.

CHAPTER- THREE

OBJECTIVES AND RESEARCH METHODOLOGY

As discussed in the previous chapter, there is an existing research gap in women's participation in engineering education and employment. Thus, the present study intends to explore some of the issues. This chapter discusses the objectives, research question, hypothesis, and research methodology.

3.1. Objective of the Study

This study has general objectives and six specific objectives.

3.1.1. General Objective

This study's general objective is to analyse the formation and participation of women's human capital in engineering education and employment in the Amhara Region of Ethiopia.

3.1.2. Specific Objectives

The specific objectives of this study are:

I. To analyses the status of women in engineering education and employment with the help of enrollment and graduation data

II. To examine the effect of economic growth on women human capital formation in engineering education in Ethiopia;

III. To investigate factors affecting women's choice of pursuing engineering education, using variables (a) high school education background of students, (b) existence of engineering and technology professionals in the family, (c) family suggestion to study engineering education, (d) peer pressure, (e) duration of the program or curriculum, (f) accessibility of role model, (g) annual income of the family, and (h) expected salary.

IV. To explore factors affecting academic performance of women in engineering education, with the help of variables (a) peer learning habits of students, (b) interventions followed by institutions for supporting women students, (c) accessibility of university infrastructure, (d) sexual harassment, (e) students having prior information about the university, (f) teaching methodology followed by teachers, (g) accessibility of role model, (h) family educational background, (i) duration of the program or curriculum to study engineering and technology, (j) residence place of students, (k) year of establishment of universities, (l) annual income of the family, and (m) existence of engineering professionals in the family.

V. To analyses factors affecting women graduates' employability in engineering education, using variables academic
performance, communication skill, willingness to migrate for a job searching, job preference, non-technical skill, and marital status.

VI. To identify challenges faced by working women engenderers.

3.2. Research Questions

1. What is the status of women enrollment and employment participation in engineering education in Ethiopia and worldwide?
2. What is the impact of economic growth on women's human capital formation in engineering education in Ethiopia?
3. Do (a) high school education background of students, (b) existence of engineering professionals in the family, (c) family suggestion to study engineering education, (d) peer pressure, (e) duration of the program or curriculum, (f) accessibility of role model, (g) annual income of the family, and (h) expected salary are factors affecting women's choice of pursuing engineering education?
4. Whether (a) peer learning habits of students, (b) interventions followed by institutions for supporting women students, (c) accessibility of university infrastructure, (d) sexual harassment, (e) students are having prior information about the university, (f) teaching methodology followed by teachers, (g) accessibility of role model, (h) family educational background, (i) duration of the program or curriculum to study engineering, (j) residence place of students, (k) year of establishment of

universities, (l) annual income of the family, and (m) existence of engineering professionals in the family are factors affecting academic performance of women in engineering education?

5. Do factors (academic performance, communication skill, willingness to migrate for a job searching, job preference, non-technical skill, and marital status) affecting women graduates' employability in engineering education?
6. What are the challenges faced by women engineers at the work place?

3.3. Research Methodology

The study has quantitative approaches through primary and secondary sources to discuss the main research objectives. This section went through the research subject, data sources, and sampling techniques.

3.3.1. The hypothesis of the study

Based on the specified objectives, the study has the following hypothesis. These are:

$H2_0$: Economic growth has not an impact on women's human capital formation in engineering and technology education in Ethiopia,

$H2_1$: Economic growth has an impact on women's human capital formation in engineering education in Ethiopia.

$H3_0$: The factors (a) high school education background of students, (b) existence of engineering professionals in the family, (c) family suggestion to study engineering and technology education, (d) peer pressure, (e) duration of the program or curriculum, (f) accessibility of role model, (g) annual income of the family, and (h) expected salary have not an impact on women's choice of pursuing engineering education.

$H3_1$: The factors (a) high school education background of students, (b) existence of engineering professionals in the family, (c) family suggestion to study engineering education, (d) peer pressure, (e) duration of the program or curriculum, (f) accessibility of role model, (g) annual income of the family, and (h) expected salary have an impact on women's choice of pursuing engineering education.

$H4_0$: The factors such as (a) peer learning habits of students, (b) interventions followed by institutions for supporting women students, (c) accessibility of university infrastructure, (d) sexual harassment, (e) students are having prior information about the university, (f) teaching methodology followed by teachers, (g) accessibility of role model, (h) family educational background, (i) duration of the program or curriculum to study engineering, (j) residence place of students, (k) year of establishment of universities, (l) annual income of the family, and (m) existence of engineering professionals in the family have no an impact on academic performance of women in engineering education.

$H4_1$: The factors (a) peer learning habits of students, (b) interventions followed by institutions for supporting women students, (c) accessibility of university infrastructure, (d) sexual harassment, (e) students are having prior information about the university, (f) teaching methodology followed by teachers, (g) accessibility of role model, (h) family educational background, (i) duration of the program or curriculum to study engineering, (j) residence place of students, (k) year of establishment of universities, (l) annual income of the family, and (m) existence of engineering and technology professionals in the family have an effect on women students' academic performance in engineering education.

$H5_0$: The factors, such as academic performance, communication skill, willingness to migrate for a job searching, job preference, non-technical skill, and marital status are not affecting women graduates' employability in engineering education.

$H5_1$: The factors such as, academic performance, communication skill, willingness to migrate for a job searching, job preference, non-technical skill, and marital status are affecting women graduates' employability in engineering education.

3.3.2. Description of the study area

Ethiopia is found in the Eastern parts of Africa. The country is a land of multicultural and multilingual diversity of populations. Ethiopia has around 112 million people (WB, 2019). From this total population, 23 million are living in the urban area. Christianity and Islam are the major religion in the country. The annual growth of Ethiopian GDP experienced a 7.9% average for the last 20 years, given in Figures 3.1. However, this economic growth will be harmful due to a lack of good governance and political disruption (AFDB, 2019).

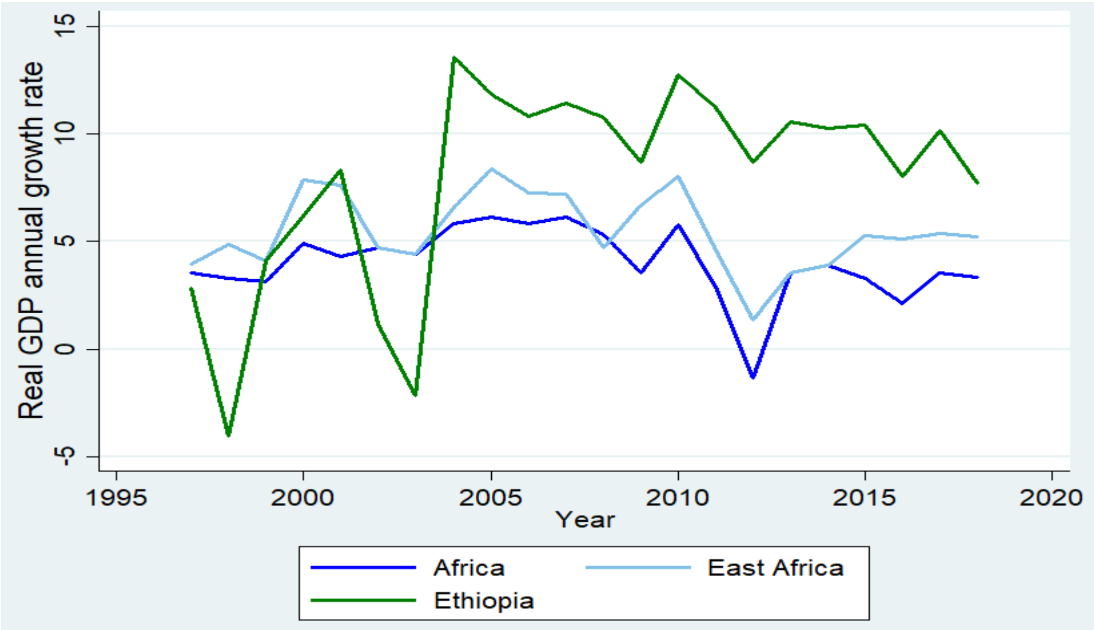

Figure 3.1 Annual growth rate of GDP in Africa, East Africa and Ethiopia
Source: AFDB (Note: Data for 2017 and 2018 are estimated

The Amhara is one of the regions located in the north-western part of Ethiopia between 9°20' and 14°20' North latitude and 36° 20' and 40° 20' East longitude. Its land area is estimates at about 170000 square kilometres. Amhara borders the Tigray Region in the North, Afar in the East, Oromiya in the South, Benishangul-Gumuz in the Southwest, and Sudan in the west. Amhara is divided into 11 zones and 140 districts. There are about 3429 kebeles[1]. "Decision-making power has recently been decentralized to district, and thus the community is responsible for all development activities in their areas. The 11

[1] Kebele is the smallest administrative unit of Ethiopia, similar to a ward, a neighbourhood or a localized and delimited group of people. It is part of district, itself usually part of a Zone, which in turn are grouped into one of the Regions based on ethno-linguistic communities that comprise the Federal Democratic Republic of Ethiopia. Each kebele consists of at least five hundred families, or the equivalent of 3,500 to 4,000 persons. There is at least one in every town with more than 2,000 populations.

administrative zones are North Gonder, South Gonder, West Gojjam, East Gojjam, Awi, Waghemra, North Wollo, South Wollo, Oromo nationalities, North Shewa, and Bahir Dar City special zone. According to the Central Statistical Agency, population projection of 2014- 2017, the total population of the Amhara region is 21,134,988, of which 10,585,995 are male, and 10,548,993 are female population. The language is Amharic (CSA, 2013).

The historic Amhara region in Figure 3.2 contains much of the highland plateaus above 1500 meters with rugged formations, gorges, and valleys and millions of settlements for Amhara villages surrounded by subsistence farms and grazing fields. In this region are located the world-renowned Nile River and its source, Lake Tana, and historical sites including Gonder and Lalibela. Interspersed on the landscape are higher mountain ranges and cratered cones, the highest of which, at 4,620 meters, is Ras Dashen Mountain northeast of Gonder Millennia of erosion have produced steep valleys, in places 1,600 meters deep and several kilometres wide.

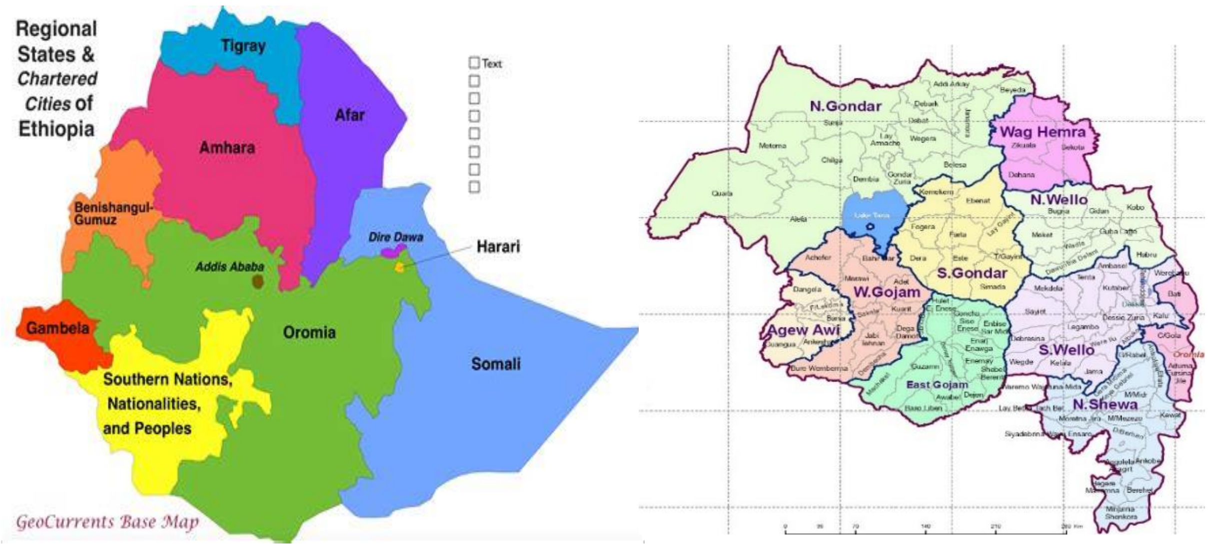

Figure 3.2 Map of Ethiopia and Amhara Region.

3.3.3. Research design

To collect information on the main variables of the study, well-structured questionnaires has been used for students and recent graduates. The information thus, gathered has been supplemented by formal interviews with employees from different companies to learn about the problems they face at work. The study used descriptive and econometrics research design which is presented in figure 3.3

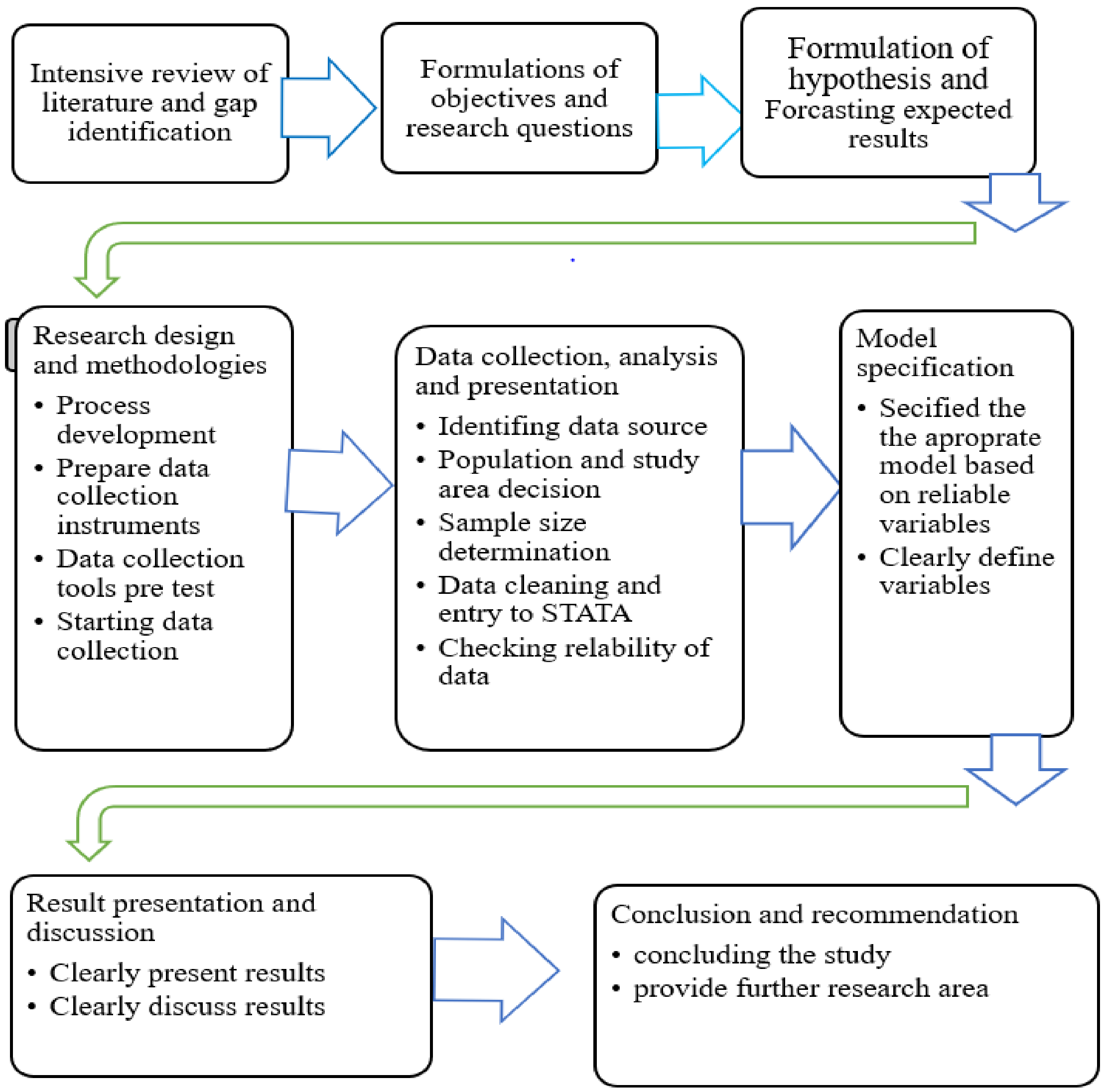

Figure 3.3 The research design of the study.

3.3.4. Sources of data

This study has been conducted based on primary and secondary data on women in engineering and technology education and employment from Ethiopia. The secondary data has been collected to analyse women's participation in STEM education and employment and investigate the impact of economic growth on women's human capital formation in engineering and technology. And the primary data was collected from selected

Universities of Amhara Region, Ethiopia. The universities were selected based on their established year. The period of collection of data is from May 2018 to December 2018.

3.3.4.1. Primary Data Source

It was collected from the original information source. The primary data were more accurate and had a higher degree of decision-making confidence, with the trusted study providing a direct link to the event's occurrence. University students and alumni are the primary data sources, which are collected by questionnaires and interviews.

3.3.4.2. Secondary Data Source

Secondary data was gathered from a variety of secondary sources as Ethiopian Ministry of Education, UNESCO, the African Development Bank Group, the World Bank, and ILOSTAT. Reputable journals, books, various papers, periodicals, proceedings, and other sources on women's involvement in STEM education and employment were considered for the study.

3.3.5. The procedure of data collection and sample size determination

For primary data have been collected through some procedures. Firstly, the Amhara region was selected as a sample state, one of nine states in a country. The state has ten higher institutions given in Figure 3.4. Secondly, these ten public higher institutions were divided into four groups based on the establishment year. The first group includes Bahir Dar University and Gondar University, established as a college in 1954 and recognized as a university in 2000. The second group comprises Debre Birhan University, Debre Markos University, and Wollo universities, which were founded in 2005. The third category includes Debre Tabor University and Woldia University, established in 2008. Finally, Injibara University, Mekdela Amba University, and Debark University, established in 2015, are included in the fourth category. Thirdly, we select three universities from each group except the fourth category. These are Bahir Dar University, Wollo University, and Debre Tabor University.

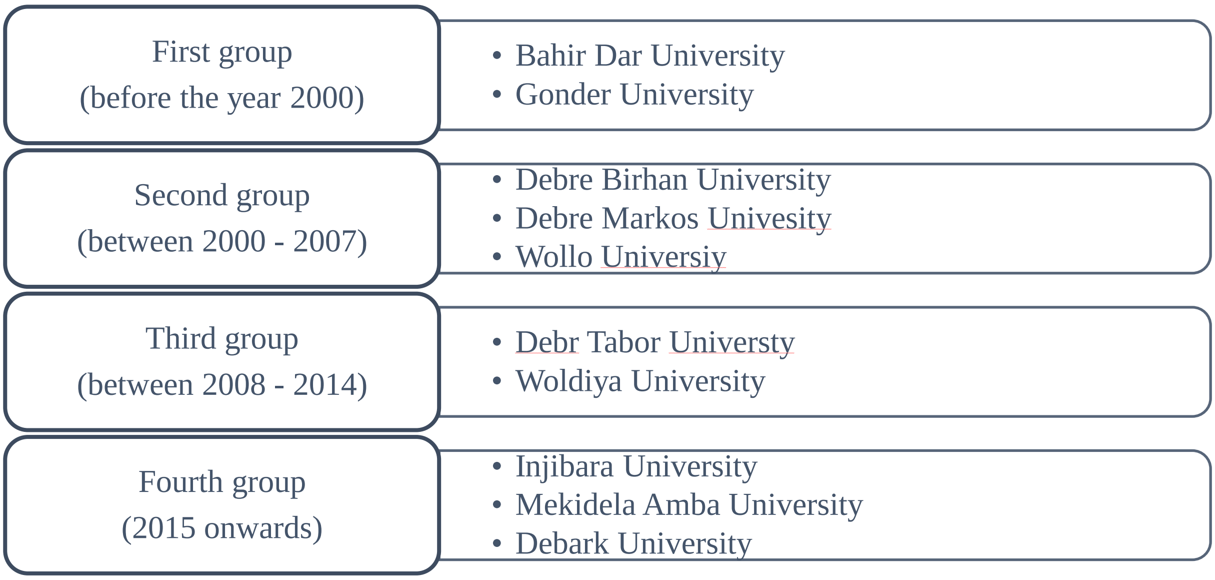

Figure 3.4 Classification of universities dealing with STEM education

Considering year of establishment as the base for selection of sample universities has been done purposively. Since universities established at different years can have different experiences. However, selection of universities within the group was random. Data was not collected from universities of 4^{th} group as they were new and were not have required data for the study. In Ethiopia, higher education costs such as hostel fees, food, etc., are covered by the government via cost-sharing agreements. Most students are placed to go to university according to their grade 12 marks through placement by the education ministry. Due to such selection procedure, one can find students in any university of across the country representing different economic statuses, religions, cultures, languages, etc. Hence, the sample is representative. The next step is determining the sample size from the total population of women students in STEM faculty from the selected universities.

Sample Size Determination of Students

From the population of 4679, a sample of 384 has been selected on the bases of following equation for determining sample size *to* identifying factors affecting women student's choice of pursuing engineering education (Del Águila and González-Ramírez, 2014).

$$n = \frac{z^2.p.q.N}{e^2(N-1)+z^2.p.q} \qquad (1)$$

where n = is the sample size, N = 4679 (the total population), Z^2 = is ***z***-score at a specified confidence level of 95.5% = $(2.01)^2$. The value e = 45% (0.045) is the desired level of precision (acceptable error), the range in which the population's true value is estimated. The (P = 30%) has a characteristic proportion, and q is $(1\text{-p})^2$. Finally, proportions according to universities have been provided in Table 3.1, i.e., 218 (56.6%) respondents from Bahir Dar University, 99 (26%) respondents from Debre Tabor University, and 67(17.4%) respondents from Wollo University. Based on this sapling procedure, primary data were collected from 301 women students enrolled in engineering and technology faculty and 83 students from other science departments (i.e., physics, chemistry, mathematics, biology, and statistics) using the specified questions.

Table 3.1 Sample size for factors affecting women students' choice of engineering education

	Bahir Dar University		Debre Tabor University		Wollo University		Total
	engineering	natural science	engineering	natural science	engineering	natural science	
No.of students	2212	451	935	272	521	288	679
No.of respondents	181	37	77	22	43	24	384
Percentage	47%	9.6%	20%	6%	11.2%	6.2%	100%

Source: Author own calculation

For this determination of the number of respondents for identifying factors affecting women academic performance in engineering education, we follow procedures. Thus, the total population of women students in engineering in the selected universities during 2018

[2] This approach is capable of giving a mathematical solution, and as such, is a frequently used technique of determining sample size. If the items of the universe are homogeneous, a small sample can serve the purpose. The less variable (more homogeneous) a population, the smaller the sample size. A proportion of 50% indicates a greater level of variability than either 20% or 80%. These approaches of determining sample size have assumed that a simple random sampling design. Sample size such as 200-500, is better for multiple regression, analysis of covariance, or log linear analysis, which might be performed for more rigorous state impact evaluations. On the other hand, for descriptive analysis any sample size is possible (Israel 2003).

was 3668. From these entire populations, we have determined 376 sample respondents based on equation one. Where n is the sample size, N = 3668 (population size), Z^2 is standard variate at the desired confidence level of 95.5% = $(2.01)^2$, e = 45% (0.045) is the desired level of precision (acceptable error), the range in which the actual value of the population is estimated to be. Whereas p is the estimated proportion of an attribute present in the people taken as 30% and q is $(1 - p)$. Then, we did proportions according to the total women students in each sample university. Hence, 227 (60%) respondents from Bahir Dar University, 96 (26%) respondents from Debre Tabor University, and 53 (14%) respondents from Wollo University, a total of 376 respondents have been selected for the study as given in Table 3.2. Based on this procedure, primary data have been collected from 376 women students enrolled in engineering and technology faculty through structured questionnaires. These students, study from first year to fifth year during May 2018.

Table 3.2 Sample for identifying factors affecting women academic performance in engineering education.

	Bahir Dar University	Debre Tabor University	Wollo University	Total
	Engineering	Engineering	Engineering	
No. of students	2212	935	521	3668
No. of respondents	227	96	53	376
Percentage	60%	26%	14%	100%

Source: Author own calculation

Sample Size Determination of Women Engineering Graduates

To determine the number of respondents, we have a total population of 1840 women graduates in engineering and technology in the selected universities during 2016 and 2017. We have determined 384 sample respondents based on equation one. Where n is the sample size, N = 1840 (population size), Z^2 (95.5%) = $(2.01)^2$, e = 45% (0.045), p is taken as 42%, and q is (1- p). Then, we did proportions according to the total number of women students in each sample university. Hence, 251(65.3%) respondents from Bahir Dar University, 46(11.9%) respondents from Debre Tabor, and 87(26.6%) respondents from Wollo University, a total of 384 respondents have been selected for the study as given in Table 3.3. Based on this procedure, primary data have been collected from 384 women graduates from 2016 and 2017 in engineering and technology during May 2018.

These selected respondents were asked through telephone interviews with a structured questionnaire. Our research questions were telephone surveys as closed-ended questions (Arnon and Reichel, 2009). We have received graduates' phone numbers from the universities registrar's office by taking responsibility for our respondent's security guarantee. If a call was not answered or by agreement with the interviewees, the sample was entirely used by repeat calls. Before asking them, we explain ourselves legality and objectives of the study. The interviews were conducted through the language of Amharic, translated from English. The listed sample respondents are from two different years that some are from the 2016 graduating batch, and some are from 2017 graduates. Therefore, this data's nature is two-year cross-section data. Since these have been collected from two different years and different independent observations, we pooled these two-year cross-sectional data together that makes many observations.

Table 3.3 Sample size for identifying factors affecting employability of women graduates in engineering based on year of graduation and universities.

Graduation Year	Bahir Dar University			Debre Tabor University			Wollo University			Total		
	No. of Graduates	No. of Respondents	Percentage	No. of Graduates	No. of Respondents	Percentage	No. of Graduates	No. of Respondents	Percentage	No. of Graduates	No. of Respondents	Percentage
2016	411	86	22.4%	26	5	1.3%	214	45	1.7%	651	136	35.4%
2017	790	165	42.9%	195	41	10.6%	204	42	10.9%	1189	248	64.6%
Total	1201	251	65.3%	221	46	11.9%	418	87	22.6%	1840	384	100%

Source: Author own survey data

In this employment data collection, valuable information has been gathered from 244 employed respondents. These data were used to analysis the challenges of women working in engineering and technology fields. The total sample respondents are given in Figure 3.5.

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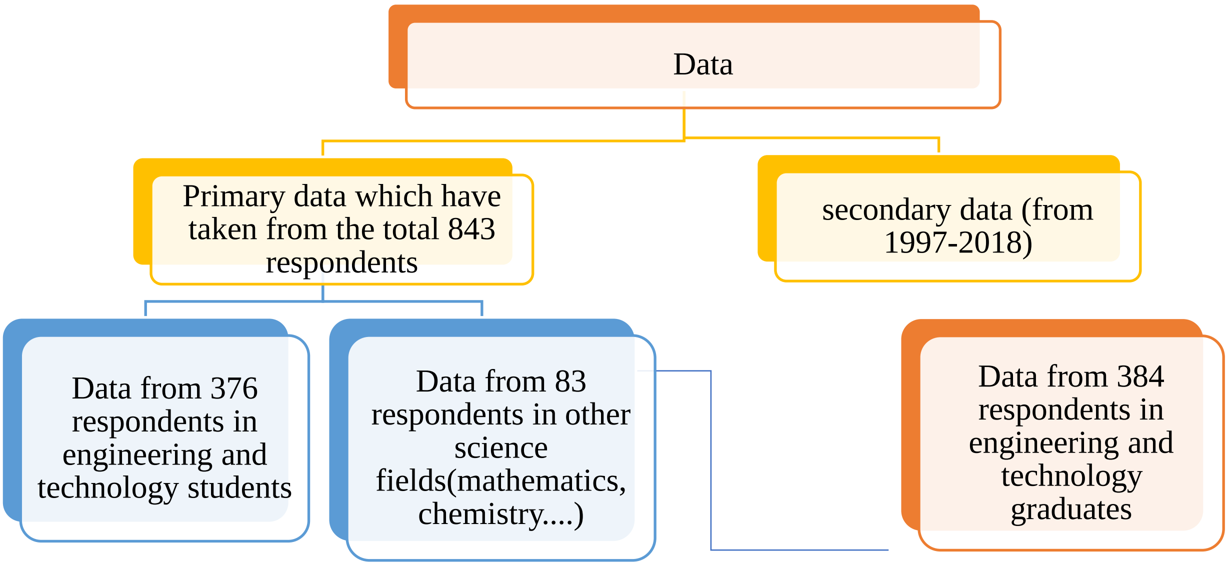

Figure 3.5 Data used in the study

3.3.6. Sample description

As shown in Table 3.4, out of 384 samples, 301 respondents are female students from the engineering and technology departments. The remaining 83 sample respondents are from other science (biology, chemistry, physics, mathematics, and statistics). One hundred sixty-nine respondents have engineering and technology professionals in their family members, but 215 respondents do not have such professionals. From the total sample, 228 respondents have access to a role model, and 246 respondents are not affected by the program's duration. Only 99 and 54 respondents have been influenced by family and friend suggestions (peer pressure) to select a field of study, respectively. Regarding the place of residence of respondents, 254 are living in urban areas. On the other hand, 262 respondents have a family educational background.

Most of the respondents have six to ten family members, while 100 respondents have less than six members in their family. Respondents from natural science have on average 358.6 marks in the grade 12 entrance exam. Similarly, respondents in engineering and technology have 392.9 scores on average in the same grade. When we see the family of respondents' annual income in natural science, their family income is birr 51522.9 on average, and family income of engineering and technology students is birr 73823.9. Similarly, out of the total of 384 sample respondents, 250 (65.1%) respondents were decided to study engineering and technology education, whereas only 6 (1.56%) respondents chose to study natural science via expecting higher salary income.

Table 3.4 Demographic and socio-economic status of respondents on factors affecting women's choice of pursuing engineering.

Variables	Responses	
Existence of engineering and technology professionals in the family	No = 215	Yes = 169
Access to role model	No = 156	Yes = 228
Effect of duration of the program	No = 246	Yes = 138
Family suggestion for selection of fields	No= 285	Yes = 99
Peer pressure for selection of filed	No = 330	Yes= 54
Place of residence	Rural = 130	Urban = 254
Family educational background	No = 122	Yes = 262
Number of family members	Less than six = 100 More than ten = 8	Six to ten = 213 Unknown = 1
Expected salary	No = 128	Yes = 256
High school education performance	Respondents from natural science	mean =358.6
	Respondents from Engineering and technology	Mean =392.9
Income of the family	Respondents from natural science	Mean = 51522.9
	Respondents from Engineering & technology	Mean = 73823.9
Number of respondents who chose to study engineering and technology		301
A number of respondents chose to study natural science		83

Source: Author own calculation

The statistical results in Table 3.5 also show, 39.32% of respondents who have engineering and technology professionals in the family decided to study engineering and technology. This effect is because most students adapt to the experience of their families. Intrinsically, in this study, 51.82% of respondents who have the accessibility of role models in their surroundings decided to study engineering and technology. Only 7.55% of respondents were decided to study natural science even though they have role models. In this study, respondents in engineering and technology have 392.9 marks on average, whereas respondents from natural science have 358.6 marks in the grade 12 entrance exam. Hence, students who have results of entrance exam 392.88 score marks and above could decide to study engineering and technology education. The mean difference of the effects of entrance exam results between women's decision to study natural science and the decision to study engineering and technology is -34.3 score marks.

Expected salary is one of the main factors that can determine a student's choice of department. Out of 384 sample respondents, 250 (65.1%) respondents were decided to study engineering and technology education, whereas only 6(1.56%) respondents chose to study natural science via expecting higher salary income. On the opposite, 77(20.05%) and 51(13.28%) respondents decided to study engineering & technology education and Natural science fields, respectively, without expecting a higher salary. In this study, from the total respondents, 28.65% of respondents were affected by the program's duration to study engineering and technology.

The family suggestion is another important factor for women to decide which department they have to choose. Otani (2019) studied the positive relationship between students' education achievement and parental involvement. In this study, 25.78% of respondents chose their field based on family suggestions with other influences. From this, 25.78%, 79 (20.57%) students decided to study engineering and technology, and the remaining 20(5.21%) samples chose natural science. Peer pressure can also influence women students' selection of fields. Such that, 12.76% of students have decided to study engineering and technology by the influence of their peer pressure.

Table 3.5 Factors affecting women's choice of pursuing engineering (in %).

		Decided to study Natural Science		Decided to study engineering		Total	
Variable	Response	Frequency	%	Frequency	%	Frequency	%
Family professions	No	65	16.93	150	39.06	215	55.99
	Yes	18	4.69	151	39.32	169	44.01
	Total	83	21.61	301	78.39	384	100
Access of role model	No	54	14.06	102	26.56	156	40.63
	Yes	29	7.55	199	51.82	128	59.38

	Total	83	21.61	301	78.39	384	100
Duration of the program	No	55	14.32	191	49.74	246	64.06
	Yes	28	7.29	110	28.65	138	35.94
	Total	83	21.61	301	78.39	384	100
Family suggestion	No	63	16.41	222	57.81	285	74.22
	Yes	20	5.21	79	20.57	99	25.78
	Total	83	21.61	301	78.38	384	100
Peer pressure	No	78	20.31	252	65.63	330	85.94
	Yes	5	1.30	49	12.76	54	14.06
	Total	83	21.61	301	78.39	384	100
Expected salary	No	77	20.05	51	13.28	128	33.33
	Yes	6	1.56	250	65.10	256	66.67

Source: Author own calculation

As shown in Table 3.6, the respondents' cumulative GPA is categorized into three levels since CGPA is standardized from zero to four in the Ethiopian grading system of students' academic results. In this background, 64 respondents have below 2.5 scores; 139 students have scored 2.5 and above but below 3; most respondents have 3-grade points and more. Students' high school performance is a proxy of grades 12 exam results from those 40 respondents who obtain below half out of 700 marks from around seven subjects, whereas 336 respondents have 350 and above. Out of 376 samples, 241 have family educational background while 135 respondents have not such family. Out of the total sample, 183 respondents rate accessibility of adequate university infrastructure (i.e., laboratory, library, hostel, etc.) as suitable, whereas 48 respondents rate it as below satisfaction. Of the total respondents, 234 have got the chance of university support directly and indirectly.

Regarding sexual harassment, most students, especially women, are affected by this problem in any direction from the staff, their peers, but they do not want to talk due to fear and feeling dishonour. Thus, the sample's response shows only 111 students said, "yes, I am harassed." However, we believe that the actual figure will be more than this number.

Table 3.6 Demographic and socio-economic status of respondents on factors affecting academic performance of women in engineering education.

Demographic & socio-economic variables		Responses
	<2.5	64
	≥2.5 & <3	139
Cumulative GPA	≥3	173
High school education performance	<350 =40	≥350=336
Family educational background	No = 135	Yes= 241
Availability of university infrastructure	low = 48	medium =145 good= 183
Affirmative action given for girls in the university	No = 142	Yes = 234
Sexual harassment	No = 265	Yes = 111
Having engineering professionals in the family	No = 189	Yes = 187
Number of family members	Less than five = 85 Between 5 &10 =283	≥10 = 8
Income of the family	< 50000 = 184	≥ 50000 = 192
Place of residence	Rural = 133	Urban = 243
Access of role model	No = 143	Yes = 233
Effect of duration of the program	No = 227	Yes = 149
Teaching methodology	Partly = 119	Yes = 257
Peer learning	No = 118	Yes = 258
Peer pressure	No = 287	Yes = 89
Pre-informed about the university they have joined	No = 124	Yes = 254

Source: Author own survey data

In Table 3.7, 28.46% of respondents have engineers and technologists in their family and a cumulative GPA of three and more than three points. 40.96% of students with more than 350 points in the grade 12 exam also have three and more than three-point CGPA in university. Similarly, 33.51% of respondents having an educational background, and 35.37% of respondents with good accessibility of university infrastructure have scored three and above cumulative GPA. 38.56% of respondents have an opportunity to obtain university support, scores three and more, while 39.63% of respondents don't have such opportunity scores between 2.5 and 3 cumulative GPA, excluding 2.5 and 3 (for the detailed explanation, see Table 3.7).

Table 3.7 Factors affecting academic performance of women in engineering education (in %).

Variables	Responses	Cumulative GPA						Total	
		Less than 2.5		≥ 2.5 & <3		≥ 3			
		Freq	%	Freq	%	Freq	%	Freq	%
Family profession	No	39	0.37	84	2.34	66	7.55	189	0.27
	Yes	25	0.65	55	14.63	107	28.46	187	49.73
	Total	64	7.02	139	36.97	173	46.01	376	100
High school performance	< 350	8	2.13	13	3.46	19	5.05	40	10.64
	≥ 350	56	4.89	126	33.51	154	40.96	338	89.36
	Total	64	7.02	139	36.97	173	46.01	376	100
Family education background	No	24	38	64	7.02	47	12.50	135	35.90
	Yes	40	10.64	75	19.95	126	33.51	241	64.10
	Total	64	17.02	139	36.97	173	46.01	376	100
Accessibility of university infrastructure	Low	28	7.45	18	4.79	2	0.53	48	12.77
	Medium	26	6.91	81	21.54	38	10.11	145	38.56
	Good	10	2.66	40	10.64	133	35.37	183	48.67
	Total	64	17.02	39	36.97	173	46.01	376	100
universities support	No	57	15.16	1	39.63	24	6.38	142	37.77
	Yes	7	1.86	78	20.74	149	38.56	234	62.23
	Total	64	17.02	139	36.97	173	46.01	376	100
Sexual harassment	No	25	6.65	78	20.74	162	43.09	265	70.48
	Yes	39	10.37	61	16.22	11	2.93	111	29.52
	Total	64	17.02	139	36.97	173	46.01	376	100
Number of families	<5	20	5.32	28	7.45	37	35.11	85	22.61
	≥ 5 &≥ 10	43	11.44	108	28.72	132	34.31	283	75.27
	> 10	1	0.27	3	0.80	4	1.06	8	2.13
	Total	64	17.02	39	36.97	173	46.01	376	100
Annual income of the family	< 50000	35	9.31	64	17.02	85	22.61	184	48.94
	≥ 50000	29	7.71	75	19.95	88	23.40	192	51.06
	Total	64	17.02	139	36.97	173	46.01	376	100
Place of residence	Rural	19	5.05	40	10.64	74	19.67	133	35.37
	Urban	45	11.97	99	26.33	99	26.33	243	64.63

	Total	64	17.02	139	36.97	173	46.01	376	100
Role model	No	32	8.51	66	17.55	45	11.97	143	38.03
	Yes	32	8.51	73	19.41	128	34.04	233	61.97
	Total	64	17.02	139	36.97	173	46.01	376	100
Duration of program	No	45	11.97	88	23.40	94	25.00	277	60.37
	Yes	19	5.05	51	13.56	79	21.01	149	39.63
	Total	64	17.02	139	36.97	173	46.01	376	100
Teaching methodology	Partly	24	6.38	41	10.90	54	14.36	119	31.65
	Yes	40	10.64	98	26.06	119	31.65	257	68.35
	Total	64	17.02	139	36.97	173	46.01	376	100
Peer pressure	No	47	12.5	92	24.47	148	39.36	287	76.33
	Yes	17	4.52	47	12.50	25	6.65	89	23.67
	Total	64	17.02	139	36.97	173	46.01	376	100
Peer learning	No	48	12.77	41	10.90	29	7.71	118	31.38
	Yes	16	4.26	8	6.06	144	38.30	258	68.62
	Total	64	17.02	39	6.97	173	46.01	376	100
Having prior information	No	37	9.84	80	1.28	65	17.29	182	48.40
	Yes	27	7.18	9	15.69	108	28.72	194	51.60
	Total	64	17.02	39	6.97	173	46.01	376	100

Source: Author own calculation

As shown in Table 3.8, from the total sample of 384 respondents, 244 got a job, and the remaining 140 were unemployed. It shows that more than half of the respondents are employed. 53 employed and 27 unemployed respondents have less than five family members, whereas 185 employed respondents have five to ten family members. Only six respondents have more than ten family members. Two employed respondents are not interested in talking about their number of families. Out of 384 respondents, 272 live in an urban area; 186 are employed, and 86 are unemployed. The remaining 112 come from the origin of the rural regions. Of 384 respondents, 241 students have the educational background of their family, of which 160 respondents are employed while 81 are unemployed. The family's annual income of the majority of respondents is below 50,000

Ethiopian currency (Birr)[3]. The respondents are graduate students in the field of ten departments. Out of 384 representative samples, 46 are from chemical engineering, 99 from civil, 72 from textile, 40 are from the garment, etc. Only six respondents are from electrical engineering. However, there are no unemployed respondents from electrical engineering, garment, and leather technology graduates.

Table 3.8 Demographic and socio-economic status of respondents regarding the employability of women graduates in the engineering

Demographic and socio-economic variables		Number of respondents		
		Employed	Unemployed	Total
Number of family members	Less than five	53	27	80
	Five to ten	185	111	96
	More than ten	4	2	6
	Unknown	2	0	2
	Total	244	140	384
Place of residence	Urban	186	86	72
	Rural	58	54	12
	Total	244	140	84
Educational background of the family	No	84	59	43
	Yes	160	81	41
	Total	244	140	84
Family income	50000 <	118	93	211
	50000 and <100000	78	32	110
	≥ 100000	48	15	63
Department of the respondents	Electronics engineering	10	18	28
	Fashion design technology	28	2	30
	Garment engineering	40	0	40
	Hydraulics engineering	12	20	32
	Leather technology	16	0	16
	Mechanical engineering	2	13	15
	Textile technology	60	12	72
	Total	244	140	384

Source: Author own calculation

In Table 3.9, out of the total respondents, 86.98% are unmarried, and only 1.56% of respondents are married unemployed. Good communication skills are necessary for

[3] Birr refers to the name of Ethiopian currency denoted by ETB which is 1 US$ is exchanged by around 35 Ethiopian Birr ETB.

getting a job since it is the basis for recruiting workers. Of the total employed respondents, 53.65% have good communication skills. From this data, we can see that employed respondents with good communication skills take a higher proportion.

The variable willingness to migrate has been taken by considering the possibility of people can move from one place to another to search for a job or not. It could be a factor to increase or decrease the unemployment problem. The result shows that 34.64% of respondents couldn't move from one place to another to search for a job. As respondents said, this is due to some factors (i.e., political instability, shortage of money, and residence preference). Inter-industry labor mobility is low because of moving costs or industry-specific skills, leading to voluntary and involuntary unemployment.

Job preference of respondents has been taken as a dummy variable. Out of a total of 36.46% unemployed respondents, 33.07% had preferred jobs. This data shows that most unemployed respondents have preferred employment, and almost all employed respondents had no job preference. Of the total of 63.54% employed respondents, 41.15% have better non-technical skills. A higher proportion of unemployed graduates, 16.41% respondents, have aggregate marks in the range of 2.5 and 3. It is possible to see that around 37% of respondents whose score above 3 points are employed.

Table 3.9 factors affecting the employability of women graduate in engineering (in %).

Variable		Employed		Unemployed		Total	
		Respondents	%	Respondents	%	Respondents	%
Marital status	Unmarried	200	52.08	134	34.9	334	86.98
	Married	44	11.46	6	1.56	50	13.02
	Total	244	63.54	140	36.46	384	100
Communication skill	Not good	38	9.9	134	34.9	172	44.79
	Good	206	53.65	6	1.56	212	55.21
	Total	244	63.54	140	36.46	384	100
Willingness to migrate	No	99	25.78	133	34.64	232	60.42
	Yes	145	37.76	7	1.82	152	39.58
	Total	244	63.54	140	36.46	384	100
Job preference	No	240	62.5	13	3	253	65.89
	Yes	4	1.04	127	33.07	131	34.11
	Total	244	63.54	140	36.46	384	100
Non-technical skill	Not good	86	22.40	95	24.74	181	47.14
	Good	158	41.15	45	11.72	203	52.86
	Total	244	63.54	140	36.46	384	100
Aggregate	< 2.5	23	5.99	46	11.98	69	17.97

marks	≥ 2.5 &< 3	79	20.57	63	16.41	142	3.9
	≥ 3	142	36.98	31	8.07	173	45.05
	Total	244	63.54	140	36.46	384	100
Family education background	No	84	21.88	59	15.36	143	37.24
	Yes	160	41.67	81	21.09	241	62.76
	Total	244	63.54	140	36.46	384	100

Source: Author own calculation

From Table 3.10, 75.8% of employed women respondents have five family members. 185(76.22%) respondents living in urban areas and 5.57% employed women have educational background in their family. Similarly, 51.64% of respondents are working in government organizations, and 52.08% are unmarried employed 58.61% of respondents have 5000 ETB (Ethiopian Birr) and above. 80.74% employed have maternity leave opportunities in their working organization (see Table 3.10).

Table 3.10 Demographic and socio-economic status of employed engineers.

Variables		Response	Percent
Number of the family members	Less than five Five to ten More than ten Unknown	53 185 4 2	21.72% 75.8% 1.64% 0.8%
Place of residence	Urban Rural	186 58	76.22% 23.77%
Educational background of the family	No Yes	84 160	34.43% 65.57%
Family income	< 50000 ≥ 50000 ≥ 100000	118 78 48	48.36% 31.96% 19.67%
Department of the respondent	Electronics Engineering Fashion design technology Garment Engineering Hydraulics Engineering Leather Technology Mechanical Engineering Textile Technology	10 28 40 12 16 2 40	4.098% 11.475% 16.39% 4.92% 6.55% 0.82% 16.39%
Work place	Government Private	126 118	51.64% 48.36%
Marital status	Unmarried Married	200 44	52.08% 11.46%
Communication skill	Not good Good	38 206	9.9% 53.65%
Willingness to migrate	No	99	25.78%

	Yes	145	37.76%
Job preference	No Yes	240 4	62.5% 1.04%
Non-technical skill	Not good Good	86 158	22.40% 41.15%
Aggregate marks	< 2.5 ≥ 2.5 &< 3 ≥3	23 79 142	5.99% 20.57% 36.98%
Monthly salary	< 5000 ETB ≥ 5000	101 143	41.39% 58.61%
Maternity leave	No Yes	7 197	19.26% 80.74%

Source: Author own calculation

3.3.7. Discussions on variables and instruments

I. *Discussion of variables for regression on the impact of economic growth on women human capital formation*

Women's human capital formation in engineering and technology education (WHCE) is the proxy variable of women's engineering and technology education enrolment in an undergraduate program. It is available at the Ethiopian Ministry of Education in annual reports (MOE, 2016). The previous studies in Ethiopia conducted by Kifle (2006), Borojo & Yushi (2015); Gebrehiwot (2016) used total men and women human capital, but we have taken women human capital in engineering and technology in this study.

Government expenditure on education (GE) is an investment in human capital formation measured by current US$ and is collected from the African Development Bank Group database (AFDB, 2019). The previous studies Megawati (2020); Shafuda & De (2020) also used this variable to investigate the effects of government spending on education in human capital development.

Gross domestic product (GDP) measured by local currency, called Ethiopian Birr, is denoted by (ETB) based on constant price during 2010. It has been taken from the African Development Bank Group database (AFDB, 2019). These collected data have transformed into a natural logarithm to make stationary. Chang et al. (2018) also used to show the relationship between national economic growth and tertiary enrolment in Russia and India.

Women's human capital formation in secondary school (WHCS) is a proxy of the number of women enrolments in secondary school. Ali et al. (2016) has also used education enrolment as a proxy of human capital formation. ***Education value-added (EVA)*** is a measure of quality in terms of how the educational experience enhances students' knowledge, abilities, and skills that impact the national output (Harvey & Green, 1993). It is measured by current US$, which is available at African Development Bank Group.

II. *Discussion on variables used for regression to identify factors affecting women student's choice of learning engineering and technology*

Women students' choice of learning engineering and technology education is the dependent variable. It is measured by 1= women students who decided to study engineering and technology, and 0=if not, using the questionnaire "Are you studying engineering and technology education or not?"

The availability of engineering and technology professionals in the family is an explanatory variable valued as 1=' yes I have engineering and technology professionals in my family, and 0= if not by asking the question "Do you have engineering and technology professionals in your family?"

Accessibility of role model is also an explanatory variable valued as 1=' yes, I have role model, and 0 = I have no role model' using the questionnaire "Do you have a role model to choose your department?" Kolmos et al. studied motivational factors of gender and education and found that women are significantly more influenced by mentors (role models) (Kolmos et al., 2013). Smith and Dengiz also support the idea of the impact of role models for the study area's choice that women students believe that they have fewer opportunities than male peers and acutely feel the lack of role models (Smith and Dengiz, 2010).

The grade 12 Entrance Examination, which is offered for all Ethiopian universities in natural science subjects, is used to measure high school education performance. Exam results are evaluated on a zero-to-hundred-point scale, with a maximum score of 700 possible in seven subjects. Ethiopia's Ministry of Education sets the minimum standards for university entry. Consequently, high school educational performance is a continuous variable measured by the grade 12 exam with the questionnaire "How much was your grade 12 final exam result?"

Family suggestion to study engineering and technology is also an independent variable measured through 1 = yes if the students were affected by their family during course selection, and 0 = if not, by asking the question "Whether your family suggested, you join the courses which are pursuing or not?" Talley and Ortiz (2017) argued that early participation in STEM activities and family socializing behaviour contributed the most to shaping their interest in STEM and encouraging them to continue their studies and seek careers in STEM as future professionals (Talley and Ortiz, 2017).

Peer pressure is an explanatory variable valued as one = yes if women students are affected by their peer pressure during course selection, and 0 = if not using the questionnaire "Do you have selected your field of study because of peer pressure?"

Expected salary is also a dummy and regressor variable valued as 1= yes if female field selection is affected by expected future salary, and 0= if not. The participants were asked the question, "Do you think that the salary you are expecting after graduation pushes you to join the course you are pursuing?"

The family income is also a continuous independent variable measured by Ethiopian Birr obtained through the questionnaire "How much is your family's annual income?"

If there is an educated person in the respondent's family, the score is one, and if there isn't, the score is zero. Riegle-Crumb and Moore (2013) divided family education into four categories: secondary school, vocational training, college-level, and advanced degree. This analysis used the family's educational background as a dummy variable to determine if all family members are illiterate or educated (Riegle-Crumb and Moore, 2013). Other studies also argued a positive relationship between students' parental educational background and academic achievement (Campbell et al., 2017; Humble and

Dixon, 2017; Jhang and Lee, 2018). Hu et al. also found that higher paternal education levels possessed more positive attitudes towards science (Hu et al., 2018).

The duration of the program or curriculum in Ethiopia takes five years to complete engineering and technology learning. It has measured 1= yes if students' choice of learning engineering and technology education were affected by the duration of the program or curriculum, and 0= no if not using the questionnaire "Do the duration of the program or the curriculum bothers you at the time of course selection?"

III. Definition of variables used for regression to identify factors affecting academic performance of women students in engineering

Academic performance has been measured by cumulative marks of women obtained from the faculty of engineering and technology in the duration of a five-year study period. Cumulative marks in higher education are ranging from zero to four scale awards A = 4, B = 3, C = 2, D = 1, and F for 0 with a “plus” or “minus” grade awarded. A and A + have the same grade point, and 2 points average score is a minimum graduation criterion. Hence, academic achievement is measured by the student’s average score mark. Witherspoon and Christian also examine gender differences in educational attainment by taking this GPA to measure academic performance (Witherspoon and Christian, 2020).

Student's peer learning habits are also measured as one = “yes, I have an experience of learning with other students outside the classroom,” and 0 = if not. Riegle-Crumb and Moore measured this variable through five Likert scales from strongly disagree to agree through the questionnaire strongly. Such as “would you relate yourself with the people around you in this class,” and “could you think that most of the skills learned from outside the class would be useful to you in engineering?” (Riegle-Crumb and Moore, 2013). Based on these previous studies, this study also incorporated peer learning habits of the student, which will impact women students' academic performance.

Interventions for supporting women students were also measured by yes = one if students obtain university support and 0 = if not. Van den Hurk et al. measured this variable by investigating research literature that “What kind of interventions should be taken to raise interest and sense of belonging in STEM education among women and men?” (Van den Hurk et al., 2019).

Accessibility of university infrastructure is also valued in three levels; low, medium, and good, using the questionnaire "How do you rate infrastructural accessibility and services provided in your university?" (Eccles and Wang, 2016). Sexual harassment is another variable considered dichotomous and measured by asking whether students experience any sexual harassment or not (United Nations, 2020; World Economic Forum,2017).

Students having prior information about the university is also considered and measured using a questionnaire "Do you have gathered general information about the institution which you have joined before entering?".

T***he existence of engineering and technology professionals in the family*** has been measured using the questionnaire, "Do you have a person in your family who graduated in engineering and technology field of study?"

Riegle-Crumb and Moore measured teachers' ***teaching methodology*** via a Likert scale with the question of "Do you think that your instructors are encouraging you in engineering class? (Riegle-Crumb and Moore, 2013)". Patall et al. also measured teachers' encouragement of students in daily class by five Likert scales. It is also estimated as one = "yes I am comfortable with teaching methodology followed by the teacher," and 0 = "I am partly comfortable (Patall et al., 2018)."

High school education performance is measured through the final semester of the grade 12 Entrance Examination, provided for countrywide Ethiopian University in seven natural science subjects. Exam performance is graded as a zero-to-hundred-point scale with a total possible scoring of 700 in seven subjects. The Ministry of Education of Ethiopia decides minimum scores for university admission. Therefore, high school educational performance is a continuous variable measured by the grade 12 exam (Muhammedhussen, 2016; Gilar-Corbi et al., 2020).

Family educational background is measured as one = yes, there is an educated person in the respondent's family, and 0 = if not. Riegle-Crumb and Moore measured family education background by four groups: secondary school level, special occupational training, college level, or advanced degree (Riegle-Crumb and Moore, 2013). In this study, family education background has been taken as a dummy variable for illiterate or educated family members.

Access to role models is also a variable valued as one = yes; 0 = I have no role model (Corbett, 2015). The previous studies by Muhammed hussen, measured the residence place by kilometres from students' homes to universities. However, in this study, residence place is categorized into two. Students who belong to rural areas are denoted by 0, and 1 represents students from urban areas. The family's annual income is another continuous variable measured in thousands of Ethiopian Birr (Muhammedhussen, 2016).

The duration of the program or curriculum to study engineering and technology has been measured through the questionnaire "Have you feeling tired with staying five-year study to complete your degree in engineering and technology?" (Villa and González, 2014). This study also considers the establishment of universities as a factor affecting the academic performance of students. It is measured whether students are studying in first group universities since senior educational institutions are more experienced and have a better learning environment.

IV. *Discussion on variables used for regression to identify factors affecting the employability of women graduates in the engineering*

Unemployment is a dependent variable measured by asking, "Are you unemployed or not?". Unemployed women who graduate in engineering and technology were denoted by 1, and 0 = otherwise. Drydakis (2016) measures in the same way that the probability of an applicant receiving a job interview takes the value one if the applicant gets an interview invitation for job allocation and 0 otherwise. Li and Zhang (2010) also calculated unemployment = one and 0=otherwise.

Academic performance has been measured by the cumulative GPA of women obtained from the faculty of engineering and technology in the duration of a five-year study period. Cumulative marks in higher education are ranging from zero to four scale awards A = 4, B = 3, C = 2, D = 1, and F for 0 with a "plus" or "minus" grade awarded. A and A + have the same grade point, and 2 points average score is a minimum graduation criterion. Hence, academic achievement has been measured by a student's average score mark. (Li and Zhang, 2010; Xu, 2017) also measure students' academic performance by cumulative GPA taken from their official transcript, which can determine the probability of women graduates getting a job.

Communication skills are required for graduates to deal with the information exchange in workforce settings, considered a dummy variable and valued 1= "I am right in communication skill, and 0 = other, using the questionnaire "How is your communication skill? We have taken these variables in the literature (Teijeiro et al., 2013; Humburg et al., 2013; Osmani et al., 2015).

Marital status *(MR)* refers to whether graduated women have got married or not, which will impact the probability of obtaining a job. It is a dummy and explanatory variable measured by denoting 1 for married respondents and 0= unmarried participants by asking, "Are you married or not?" Roy and Mukherjee (2013) were also adopted the exact mechanism.

Willingness to migrate has been taken by considering that people can move from one place to another place for searching jobs that could be a factor to increase or decrease the unemployment problem. It has been measured as 1 = able to migrate for searching jobs, and 0 = otherwise, using the questionnaire "Are you ready to go to another place for searching a job?"

Job preference is considered a dummy variable valued as 1 = unemployed because of not getting the job they are looking for, and 0 = otherwise using the question "Are you unemployed because of not getting the job you are looking for?" The scarcity of jobs that a woman would like to do increases the chance of being unemployed.

The non-technical skills *also have* been measured by 1 = observations who had good non-technical talent, and 0 = not good, by asking the participants, "How are you in skills like working in groups, able to negotiate things, searching information through media, etc.?". Pan et al. (2018) considers proactive personality as a non-technical skill and measured through asked the participants to indicate the extent to which they agreed with statements regarding proactivity using five Likert scales (from 1 = "strongly disagree," to 5 = "strongly agree").

The year 2017 dummy variable has denoted as one = the respondents in 2017 graduates and 0 = observations in 2016. Since data has been collected from two different (2016 and 2017) batch pass-out graduates, we added a year dummy variable in the regression (Wooldridge, 2010).

3.3.8. Method of data analysis and data reliability

Checking the reliability of data is an essential issue during data analysis. One of the most used reliability estimators is the Augmented Dickey-fuller unit root test of stationary of secondary data. This reliability test has computed that shows data are stationery. Bound cointegration test of the variables has also been conducted, and the result shows a level relationship among the variables.

Women students' choices of learning engineering and technology education is a dependent variable affected by independent factors. Expected wage, family pressure to study engineering and technology, peer pressure, the availability of engineering and technology professionals in the family, access to a role model, the family's annual income, students' high school education success, program length (curriculum), and family educational history are all factors to consider.

During primary data analysis, testing the data's reliability is essential. One of the most commonly used reliability estimators is Cronbach's Alpha (Mohamad et al., 2015). This reliability test has been computed with a scale reliability coefficient of 0.6, indicating that the data is accurate. Table 3.11 displays Spearman's rank correlation coefficient for each independent factor and the dependent variable (women students' choices of engineering and technology education). The correlation coefficients of program length (curriculum) ($p = 0.6377$) and family suggestion to study engineering and technology education ($p = 0.6928$) can be found insignificant in Table 3.11.

Logit regression analysis was also conducted to analyse the most important factors affecting women students' choices of learning engineering and technology education, which are the reason for the gender imbalance in STEM education. Diagnostic tests, such as multicollinearity, constant variance, and Hosmer-Lemeshow test of the model specification were computed. A Pseudo R^2 and Wald chi^2 were also used to verify the estimated coefficients' unbiasedness and model fitting. Descriptive approaches have also been used to evaluate secondary data.

Table 3.11 Spearman's rank correlation coefficient test of variables regarding factors affecting women's choice of pursuing engineering.

Variables	Corr.coff	Sig.level	Mean
Expected salary	0.6621	0.0000	0.6666667
Family profession	0.2362	0.0000	0.4401042
Accessibility of role model	0.2613	0.0000	0.59375
Duration of program(curriculum)	0.0241	0.6377	0.359375
Family suggestion	0.0202	0.6928	0.2578125
Peer pressure	0.1214	0.0173	0.140625
High school education performance	0.3753	0.0000	385.4714
Annual income of the family	0.1518	0.0029	69003.65

Corr.coff= correlation coefficients, Sig.level = significant level (p-value).

Source: Authors own calculation

The pairwise correlation of the selected independent variable is also given in Table 3.12, which shows a very weak correlation coefficient (< 0.3), indicating no severe multicollinearity problem.

Table 3.12 Spearman's pairwise correlation coefficient test of independent variables used to identified factors affecting women's choice of pursuing engineering.

Variables	FP	RM	PP	HEB	FINC	ES
Family profession	1.0000					
Accessibility of role model (RM)	0.1779	1.0000				
Pear pressure (PP)	0.1092	0.0753	1.0000			
High school education performance (HEB)	0.1057	0.0419	0.2401	1.0000		
Annual income of the family (FINC)	0.0493	0.0087	0.1023	0.1791	1.0000	
Expected salary (ES)	0.1039	0.1575	0.1112	0.2470	0.1389	1.0000

Source: Authors own calculation

Women students' academic performance in engineering and technology education is a dependent variable affected by independent factors. These are peer learning habits of students, interventions followed by institutions for supporting women students, accessibility of university infrastructure, sexual harassment, students having prior information about the university, existence of engineering and technology professionals in the family, role model, the annual income of the family, high school education performance of students, duration of the program(curriculum), family educational background, and year of establishment of universities.

The reliability test has been computed that shows reliable data with a scale reliability coefficient of Cronbach's Alpha =0.7. The correlation of each independent factor with women students' academic performance in engineering and technology has also been computed using Spearman's rank correlation coefficient as given in Table 3.13. From this table, the correlation coefficient of family income (p = 0.6), duration of the program (p = 0.07), teaching methodology (p = 0.3), high school educational performance (0.2), and year of establishment of universities (p = 0.29) are more than standard significant level $p \leq 0.05$ and being insignificant. Ordinary Least Squire Multiple Linear Regression Analysis was also conducted to analyse the most important factors affecting women's academic performance in engineering and technology, which are the reason for the gender imbalance in STEM education. Diagnostic tests, such as multicollinearity, heteroscedasticity, and link test of the model specification, were computed. Moreover, a normality test of residuals is conducted to check the estimated coefficients and model fitting unbiasedness. Secondary data have also been analysed through descriptive methods.

Table 3.13 Spearman's rank correlation coefficient test of independent variables with academic performance and statistical summary of variables

Variable	Correlation coefficient	Sig.level	Mean	Std. Dev.
Family educational background	0.1254	0.0150	0.6409574	0.4803589
Family profession (FP)	0.2267	0.0000	0.4973404	0.5006591
Role Mode (RM)	0.2096	0.0000	0.19680	0.4861121
Residence Place (RP)	−0.1281	0.0129	0.6462766	0.4787617
Family Income (INC)	0.0231	0.6558	73357.98	105802.1
Duration of the program (DP)	0.0908	0.0728	0.3962766	0.4897749
Teaching methodology (TM)	0.0527	0.3084	0.6835106	0.465726
Peer Learning (PL)	0.4253	0.0000	0.6861702	0.4646664
Accessibility of university infrastructure (AUIF)	0.6045	0.0000	1.359043	0.6976709
Sexual harassment (SH)	−0.5487	0.0000	0.2952128	0.4567461
University support (Usport)	0.5628	0.0000	0.6223404	0.4854478
Pre informed about the institution	0.6942	0.0000	0.6702128	0.4707622
High school education performance	0.0628	0.2243	391.9707	42.80644
Year establishment of universities	−0.0542	0.2948	0.6037234	0.4897749

Sig.level = significant level (p-value), Std. Dev. = standard deviation.
Source: Authors own calculation

The unemployment of women graduates in engineering and technology education is a dependent variable affected by independent factors. Checking the reliability of data is an essential issue during primary data analysis. The reliability test has been computed that shows reliable data with a scale reliability coefficient of Cronbach's Alpha of 0.7991. The correlation of each independent factor with the unemployment of women graduates in engineering and technology has also been computed using Spearman's rank correlation coefficient as given in Table 3.14. From this table, all variables' correlation coefficient is less than the standard significant level $p \leq 0.05$ and significant, which shows a strong correlation with the dependent variable.

Probit Regression Analysis was performed to examine the most important factors influencing the unemployment of women graduates in engineering and technology, which explain the gender gap in STEM jobs. In addition, all diagnostic tests such as multicollinearity, heteroscedasticity, and the Hosmer-Lemeshow test were calculated. Furthermore, a normality test of residuals was performed to verify the estimated coefficients and model fitting impartiality. Descriptive approaches have also tested secondary data. All analyses were performed with the program STATA 14.

Table 3.14 Spearman's rank correlation test result on factors affecting employability of women graduates in engineering.

Variable	Correlation coefficients of variables with unemployment of graduates	P-value (significance level)
Marital status	-0.1966	0.0001
Communication skill	-0.7757	0.0000
Willingness to migrate	-0.5357	0.0000
Job preference	0.9043	0.0000
Non-technical skills	-0.3144	0.0000
Academic performance	-0.4152	0.0000

Source: Authors own computation

3.3.9. Model specification

In this study four types of models i.e., Autoregressive Distributed lag model, Logit, Probit, and Ordinary Least Square models have been used for data analysis.

3.3.9.1. Autoregressive Distributed Lag Model

Stationary test of the time series data

If the statistical property of data does not vary with time, the data is said to be stationary. This is the basis for obtaining realistic estimates of a model, which is the driver of a meaningful forecast and policy implementation (Nkoro et al., 2016). If time series is stationary, its mean, variance, and auto-covariance (at various lags) remain the same no matter at what point we measure them. The unit root is specified by Dickey and Fuller (1979):

$$Y_t = \rho Y_t - 1 + e_t, -1 \leq \rho \leq 1 \quad (2)$$

$$Y_t - Y_t - 1 = \rho Y_{t-1} - Y_{t-1} + e_t$$

$$\Delta Y_t = (\rho - 1) Y_{t-1} + e_t$$

$$\Delta Y_t = \delta Y_{t-1} + e_t \quad (3)$$

where, $\delta = (\rho - 1), \delta = 0 \Rightarrow \rho = 1$ refers to Y_t is the unit root, $\delta < 0$ refers to Y_t is stationary. Time series data with unit roots may have negative consequences. There will be the problem of auto-correlation, maximum R^2 without the relationship between the two-time series, which is called spurious or nonsense regression. It is impossible to do forecasting. This study detected the problem in the usual augmented dickey fuller (ADF) unit root test method. Dickey and Fuller have developed this test by extending the dickey fuller (DF) test. ADF test has been estimated in three ways.

1. Suppress constant term in regression: $\Delta Y_t = \alpha Y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta Y_{t-1} + e_t$ (4)
2. Include intercept term in regression: $\Delta Y_t = \delta_1 + \alpha Y_{t-1} + \sum_{i-1}^{p} \beta_i \Delta Y_{t-1} + e_t$ (5)
3. Include intercept and trends in regression: $\Delta Y_t = \delta_1 + \delta_2 t + \alpha Y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta Y_{t-1} + e_t$ (6)

After the stationary condition of the time series has been tested with the help of the Augmented Dickey-Fuller unit root test, the proposed model has specified as:

$$LWHCEt = \alpha_0 + \beta_1 LGDPt + \beta_2 LGEt + \beta_3 LWHCSt + \beta_4 LEVAt + \epsilon_t \quad (7)$$

where $LWHCE$ refers to the logarithm of women human capital formation in engineering and technology education; t is the year of study; $LGDP$ is the log of GDP; LGE is the log of government expenditure on education; $LWHCS$ is a log of women human capital formation in secondary school; $LEVA$ is the log of education value-added; α_0 is a constant term; β_1 , β_2 , β_3 ,β_4 are coefficients and ε_t= error term. In recently, emphasis has been given to testing for the existence of relationships in levels among variables. The techniques for cointegration are Engle and Granger's (1987) two-step error correction procedure for testing the null hypothesis of no level relationship.

However, this is used when the variables become stationary after the first difference, which is not applicable for the variable, which is the non-unit root at a level I (0) and the first order of integration I (1) but not I (2). Therefore, when the data is stationary at a level I (0) and at the first order of integration I (1), the autoregressive distributed lag (ARDL) bound test approach is suitable (Pesaran et al., 2001). Using the ARDL method of cointegration analysis is the best alternative from others as far as; (i) it can distinguish dependent and explanatory variables; (ii) removing problems associated with serial correlation; (iii) it estimates the long-run and short-run components of the model at the same time; (iv) the method can be applied to studies that have a small sample, and (v) ARDL model with error correction term can determine model stability with cumulative sum square method and hence, the coefficients are unbiased and efficient. Therefore, the dynamic econometric model is specified in equation (8) derived from equation (7) with appropriately selected lag orders. The proper lag order can be obtained by the Akaike information criterion (AIC), Bayesian information criterion (BIC), Hannan-Quinn (HQ), and others. In this study, Akaike's information criterion has been used via the command of maxlags (2) (Nkoro et al., 2016).

ARDL (m, n, p, q, r) lag orders

$$LWHCEt = \alpha_0 + \sum_{i=1}^{m} \alpha_1 LWHCE_{t-i} + \sum_{i=0}^{n} \beta_1 LGE_{t-i} + \sum_{i=0}^{p} \beta_2 LGDP_{t-i} + \sum_{i=0}^{q} \beta_3 LWHCS_{t-i} + \sum_{i=0}^{r} \beta_4 LEVA_{t-i} + \epsilon_t \quad (8)$$

where,

$LWHCE_t$ is a dependent variable which refers to the log of women human capital formation in engineering and technology education,

LGE_t is government expenditure on education, taken as log form

$LGDP_t$ is the log of gross domestic product considered as an independent explanatory variable; $LWHCS_t$ is the log of women human capital formation in secondary school; $LEVA_t$ = the log of education value added; t is an error term, α and β are parameters; $m \geq 1$ lag for dependent variables, $(n, p, q \; and \; r \geq 0)$ is the number of lags in independent variables. The bound test of cointegration estimation among the variable shown in equation (9) has been formulated based on equation (8) by taking one variable as a dependent at a time.

Bounds Cointegration Test

$$\Delta LWHCEt = \alpha_0 + \sum_{i=1}^{m} \alpha_1 \Delta LWHCE_{t-i} + \sum_{i=0}^{n} \beta_1 \Delta LGE_{t-i} + \sum_{i=0}^{p} \beta_2 \Delta LGDP_{t-i} + \sum_{i=0}^{q} \beta_3 \Delta LWHCS_{t-i} + \sum_{i=0}^{r} \beta_4 \Delta LEVA_{t-i} + \delta_1 LWHCE_{t-1} + \delta_2 LGE_{t-1} + \delta_3 LGDP_{t-1} + \delta_4 LWHCS_{t-1} + \delta_5 LEVA_{t-1} + \epsilon_{1t} \quad (9)$$

where Δ is the change of the variable (difference), α_0 is the constant term, α_1, β_1, β_2 , β_3 and β_4 short-run coefficients; δ_1 , δ_2 , δ_3 , δ_4 and δ_5 are long-run coefficients; $t - i$ is lagged period, ϵ_{1t} = errors from each equation, and the rest are already defined above. The null hypothesis of no cointegration from each equation is specified as: H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ and H_1 : $\delta_1 \neq 0$, $\delta_2 \neq 0$, $\delta_3 \neq 0$, $\delta_4 \neq 0$, and $\delta_5 \neq 0$. Since H_0 is rejected and H_1 is accepted, ARDL model with error correction term can be computed to identify the long-run and short-run adjustment speed. Hence, the model is formulated in equation (10).

$$\Delta LWHCEt = \alpha_0 + \sum_{i=1}^{m} \alpha_1 \Delta LWHCE_{t-i} + \sum_{i=0}^{n} \beta_1 \Delta LGE_{t-i} + \sum_{i=0}^{p} \beta_2 \Delta LGDP_{t-i} + \sum_{i=0}^{q} \beta_3 \Delta LWHCS_{t-i} + \sum_{i=0}^{r} \beta_4 \Delta LEVA_{t-i} + \varphi ECM_{t-1} + \varepsilon_t \quad (10)$$

$$where \; ECMt = LWHCEt - \alpha_0 - \sum_{i=1}^{m} \alpha_1 LWHCE_{t-i} - \sum_{i=0}^{n} \beta_1 LGE_{t-i} - \sum_{i=0}^{p} \beta_2 LGDP_{t-i} - \sum_{i=0}^{q} \beta_3 LW\,HCS_{t-i} - \sum_{i=0}^{r} \beta_4 LEVA_{t-i} \quad (11)$$

ECM is the short-run error correction model, and φ in equation (10) is the speed of adjustment running from short run to long run. The model has estimated on the base of STATA 14 software. After the ARDL model with ECM regression estimation, many diagnostic tests of model fitting have been computed to check the significance and unbiasedness of the estimated coefficients. Among these, test of serial correlation and residual stability were included.

3.3.9.2. The Logit Model

Factors affecting women's choice of learning engineering and technology education analysed through binary Logit regression analysis. According to Damodar et al. (2004), the cumulative logistic probability function is specified as follows.

$$P_i = \frac{1}{1+e^{-(Zi)}} \quad (12)$$

By computing some steps and taking into account the disturbance term, the Logit model becomes as follows;

$$Z_i = \alpha + \sum \beta_i x_{ij} + \mu_i \quad (13)$$

Zi = dependent variable, α is the intercept (constant term), β_i is parameters associated with variables, and μ_i - is a disturbance term that is not observable but can affect a dependent variable.

$$CLET = \alpha + \beta_1 ES + \beta_2 FP + \beta_3 RM + \beta_4 PP + \beta_5 HEB + \beta_6 FINC + \mu_i \quad (14)$$

Where CLET = women students' choice of learning engineering and technology education or other, ES = expected salary, FP= existence of engineering and technology professionals in the family, RM= accessibility of role model, PP = peer pressure, HEB = high school education background (the result of grade 12 exam), and FINC = annual income of the family.

3.3.9.3. Ordinary Least Square Model

The factors affecting academic performance were analysed through Multiple Linear Regression Analysis, allowing many elements in the model. According to Wooldridge (2016), the variable’s linear function is specified in equation two, and regression estimation has been conducted based on this equation.

$$CGPA = \beta_0 + \beta_1 Usport + \beta_2 SH + \beta_3 PL + \beta_4 AUIF + \beta_5 PI + \beta_6 FEDUC + \beta_7 FP + \beta_8 RM + \beta_9 RP + e_i \quad (15)$$

where CGPA = cumulative marks, Sport = interventions followed by institutions for supporting women students, SH = sexual harassment, PL = peer learning, AUIF = accessibility of university infrastructure, PI = students prior information about the university they have joined, FEDUC = is family educational background, FP = existence of engineering and technology professionals in the family, RM = role model, RP = residence place of students, β_0 is the intercept(constant term), $\beta_1, \ldots, \beta_9$ are parameters associated with variables, and e_i A disturbance term that is not observable but it can affect a dependent variable.

3.3.9.4. Probit Models

Two key issues were considered to construct a valued model; first, the data are pooled cross-section. Second, a dependent variable used is binary. Having these issues, we have employed the Probit model for the dependent variables' binary nature (Li and Zhang, 2010; Drydakis, 2016). And fortunately, the same methodology used for cross-section analysis can apply to pooled cross-section data. Using pooled cross-sections, we should usually include the year dummy[4] variable (Wooldridge, 2010). Let Y* is an unobserved or latent variable that can take all values of $(-\infty, +\infty)$ (Gujarati, 2004):

$$Y = \begin{cases} 1, & Y^* > 0 \\ 0, & Y^* \leq 0 \end{cases} \quad (16)$$

Given $Y^* = \beta_0 + X^T\beta_i + \epsilon_i$ where β_0 is constant, X is vector regressor variables, β_i is slope coefficients and ϵ_i is approximated to standard normal

[4] Since data is from two different years, a very general way of modeling (and testing for) differences in intercept terms or slope coefficients between periods is the use of time dummies. Including time dummies (for all but one, omitted date in the sample to avoid the dummy-variable trap) alone allows the intercept to have a different value in each period. The estimated intercept term in the model with time dummies is the estimated intercept in the period with the omitted dummy. The estimated coefficient on an included time dummy corresponding to a particular period is an estimate of the difference between the intercept in that period and the intercept in the omitted period.

distribution N (μ, δ_2), μ (mean) = 0 and δ (standard deviation) = 1. Then Probit model is constructed based on this latent variable.

$$P\ (Y\ =\ 1|X)\ =\ P\ (Y^*\ >\ 0|X)$$

$$=\ P\ (\beta_0 + X^T\beta_i + \epsilon_i > 0|X)$$

$$=\ P\ (\epsilon_i > -(\beta_0 + X^T\beta_i)\ |X)$$

$$=\ 1\ -\ F\ (-(\beta_0\ +\ X^T\beta_i))$$

with the assumption of ϵ_i is normally distributed. This gives

$P(Y\ =\ 1|X)\ =\ 1 - \phi\left(\frac{-(\beta_0+X^T\beta_i)}{\delta}\right)$ since $\delta\ = 1$, due to symmetry, the function becomes

$$P(Y\ =\ 1|X)\ = \phi\ (\beta_0 + X^T\beta_i) \tag{17}$$

$P(Y\ =\ 1|X)$ is a probability that an event occurs given the value of X, β_i is slope parameter estimated, and ϕ is the standard normal cumulative distribution function (CDF):

$$\mathrm{P(Y\ =\ 1|X)} = \phi(\mathrm{Y}) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{Y} e^{-\frac{x^2}{2}}dx$$

Having these procedures, we have the Probit model formulated as:

$$P\ (Y\ =\ 1|X_i)\ = \phi(\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7) \tag{18}$$

Where, $Y\ =$ Unemployment (UN), $X_1 =$ Marital status (MR), $X_2 =$ Academic performance (GPA), $X_3 =$ Communication skill (CS), $X_4 =$ willingness to migrate for searching a job (WM), $X_5 =$ Job preference (JP), $X_6 =$ non-technical skill (NTS), and $X_7 =$ Year dummy variable (YD). By substituting these variables into equation 18, we can formulate equation 19 :

$$P(UNE = 1|x) = \phi(\beta_0 + \beta_1 MR + \beta_2 GPA + \beta_3 CS + \beta_4 WM + \beta_5 JP + \beta_6 NTS + \beta_7 YD) \quad (19)$$

Since the data are from two different years, we have to interact[5] explanatory variables with the year dummy Wooldridge (2003) and compute the effects of the variables in 2016 and 2017. Why because we cannot find real interaction effects directly from the Probit estimation of the coefficients (Norton et al., 2004). It is done through marginal computing effects of variables at different values of the other variable and taking the difference, which gives the interaction effect. The interaction effect changes the marginal impact of one variable induced by changes in another variable's value (Karaca-Mandic et al., 2012). This interaction effect is performed based on the following procedure (Norton et al. 2004):

$$F(Y|X_1, X_2, X\beta) = \phi(\beta_1 X_1 + \beta_2 X_2 + \beta_{12} X_1 X_2 + X\beta) \quad (20)$$

where a given Probit model $F(.)$ the simple normal cumulative distribution function; X_1 and X_2 are interacted variables, which are dummy, β's are slope parameters, and ϕ is a probability function. In the scope of this paper, two types of interacted models are specified.

[A] when the interacted variables are both dummy variables, the interaction effect is the discrete double-difference formulated as equation 21 derived from equation 20.

$$\frac{\Delta^2 F(y|x_1, x_2, X)}{\Delta x_1 \Delta x_2} = \frac{\Delta^2 \phi(u)}{\Delta x_1 \Delta x_2} = \phi(\beta_1 + \beta_2 + \beta_{12} + X\beta) - \phi(\beta_1 + X\beta) - \phi(\beta_2 + X\beta) + \phi(X\beta) \quad (21)$$

---

[5] Including interactions between time dummies and another variable Z allows the coefficient on (effect of) Z to vary across periods. The estimated coefficient on non-interacted Z is the estimated effect in the period for which the dummy is omitted. The estimated coefficient on the interaction between Z variables and the dummy for period t is the calculated difference between the effects of Z in period t and the effect in the omitted period. The joint test of the interaction terms tests the hypothesis that the coefficients (effect) of Z are the same in all periods. The simple analysis of the interaction term for the period t dummy tests whether the effect of Z in period t differs from the impact in the omitted period (Wooldridge 2003, 2010).

$$where \quad u = \beta_1 x_1 + \beta_2 x_2 + \beta_{12} x_1 x_2 + X\beta$$

[B] when the interacted variables are one continuous and one dummy variable, the interaction effect is the discrete difference concerning a single variable formulated as equation 22 derived from equation 20.

$$\frac{\Delta\left(\frac{\partial F(u)}{\partial x_1}\right)}{\Delta x_2} = (\beta_1 + \beta_{12})\phi\big((\beta_1 + \beta_{12})X_1 + \beta_2 + X\beta\big) - \beta_1\phi(\beta_1 x_1 + X\beta) \quad (22)$$

Where X_1 is a continuous variable, X_2 year dummy Δ is the difference and ∂ is a representation of partial derivative of $F(u)$ concerning X_1.

CHAPTER- FOUR

DESCRIPTIVE ANALYSIS

As already discussed, that engineering education is a basic instrument to sustain and accelerate the overall development of a country, and it has a direct impact on productivity and earnings. Thus, the first objective of the study is to analyses the status of women in engineering education and employment with the help of enrollment and graduation data (page-52). This objective has been discussed based on secondary data under following.

4.1. Human Capital Formation in Engineering Education among Women

Since secondary school enrolment is the base for women enrollment in higher education, the study started with analysing secondary school data. The following Figures 4.1 show the number of women and men enrollment in secondary education. The number of secondary school students in Figure 4.1 shows that the average percentage share of women enrollment in secondary school is 37.38% during 1997-2018. In the same year average percentage share of men enrollment in secondary school is 62.62%, indicating gender disparity. The figure also shows decreasing gender disparity after 2000 which was the period of higher economic growth rate for Ethiopia (ref: first paragraph of the Chapter-1Introduction).

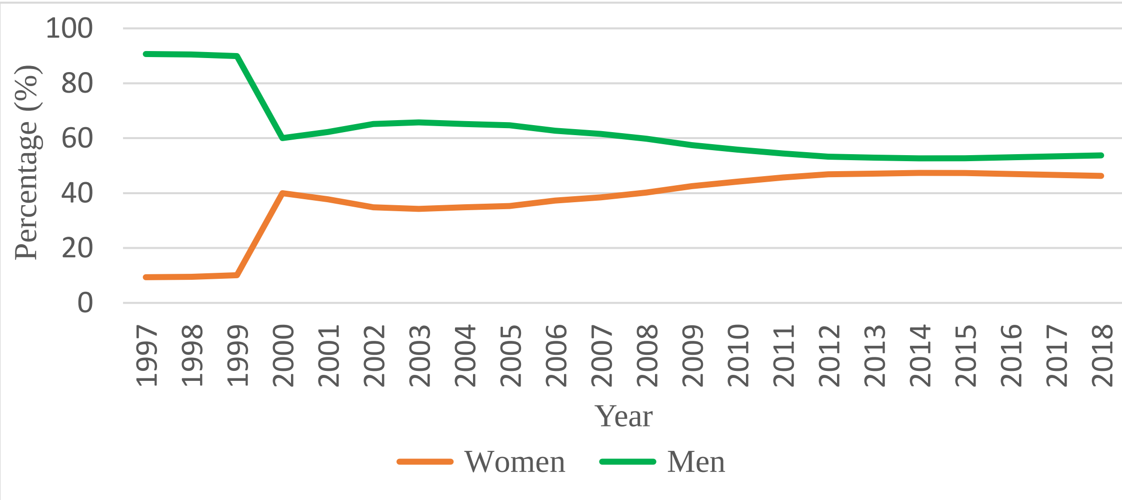

Figure 4.1 The status of women participation in secondary school in Ethiopia.

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

Table 4.1 also shows that women's enrolment in engineering and technology in regular undergraduate educational programs is improving based on data from 2007 to 2016. In 2007, women's enrolment in engineering and technology was 18% out of the total enrolled students of 13070. In the year 2008, there was better enrolment than in 2007. Out of the total enrolled 9570 students, women accounted for almost 21% in 2008. However, this number failed again in 2009, which is 18.16%. This happened in 2010 also. But starting from 2011, the percentage of women enrolling in engineering and technology fields of study increases from 22.24% to 28.4%. In 2014, their enrolment was 31% which is better from 2007 to 2016 than the remaining. But in 2015 and 2016, their enrolment declined to 28%. In general, when we see the average enrolment of women for ten consecutive academic years, the figure shows there is significant underrepresentation in the area. This is due to various social, cultural, and economic factors. Besides, women undermine themselves as they cannot perform science subjects.

Table 4.1 Trends of women students' enrollment in engineering education in a regular undergraduate program

Year	Man	Women	Total	% Women from the Total
2007	10676	2394	13070	18.087%
2008	7561	2009	9570	20.99%
2009	25437	5647	31084	18.1669%
2010	43958	9679	53637	18.045%
2011	68276	19523	87799	22.236%
2012	91742	30145	121887	24.7%
2013	91192	29794	120986	24.23%
2014	118078	52881	170959	30.93%
2015	127837	50025	177862	28.125%
2016	125171	49657	174828	28.4%

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

A statistical summary of Table 4.1, shows on average, 25175 women are enrolled within the last ten years, while 70993 men are enrolled. This indicates women enrolment in engineering & technology in regular under graduate is one third of man enrolment. The maximum number of women was enrolled in 2014, which is 52881, whereas the minimum has happened in 2008 which was only 2009 women students. In the same statistical summary, the maximum number of man enrolment is 127837 which was recorded in 2015, and the minimum is 7561 students which was seen in 2008 academic year of study. The average difference between man and women enrolment in engineering and technology regular undergraduate degree within ten years is 45817. Similarly, the enrolment variation of them within the year is increasing from year to year. This again implies there is a non-proportional gender balance in engineering & technology education regular undergraduate programs.

Table 4.2 Women enrollment in engineering education in evening under graduate program.

Year	Man	Women	Total	% Women from the total
2007	4157	551	4708	11.7%
2008	1297	375	1672	22.42%
2009	5740	717	6457	11.1%
2010	6145	905	7050	12.83%
2011	9945	1987	11932	16.65%
2012	12797	2725	15522	17.6%
2013	13186	3032	16218	18.7%
2014	22606	8467	31073	27.25%
2015	18211	4500	22711	19.8%
2016	16917	4478	21395	20.93%
Average women% from the total = 17.898%				

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

In Ethiopia, evening undergraduate educational programs are provided outside formal working hours and mostly at the weekend. Hence, evening or extension educational programs are important, which civil servants and others can improve their educational level from their daily formal and informal job. The problem is women have low participation. Table 4.2 represents women's enrolment in engineering and technology education in the evening undergraduate programs in government universities. In 2007, the percentage of women enrolment was 11.7% from the total of 4708 students. In 2008, it increased to 22.4%, but immediately it declined to 11.1% in 2009. After 2010 women's enrolment has increased slightly and reached 27.25% out of the total of 31073 students in 2014, which is the year that better participation has been seen. However, it failed down again to 20% during 2015 and 2016. The average women enrolment in engineering and technology in the evening undergraduate program for the last ten years is around 18%, which shows their under-representation in this area of study.

Table 4.3 Trends of women enrollment in engineering education in summer and distance undergraduate program

Year	Man	Women	Total	% Women from the total
2007	903	58	961	6.305%
2008	272	29	301	9.634%
2009	1524	98	1622	6.04%
2010	1745	288	2033	14.166%
2011	2847	359	3206	11.198%
2012	2867	674	3541	19.034%
2013	2867	674	3541	19.034%
2014	7388	2476	9864	25.10%
2015	10598	828	13605	6.085%
2016	11476	3157	14633	21.57%

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

Summer and distance undergraduate educational program are an essential method which is given at the time of summer. In this program, most teachers are involved in improving their educational level since teachers are free during summer for at least two months based on the law workers in Ethiopia. Here, the problem is that the quality of education will be under a question mark because a one-semester course has to be completed within two months. In Table 4.3, women enrolment in engineering and technology in summer and distance, undergraduate educational programs in government universities are presented.

As shown in Table 4.3, women's enrolment in this program was 58(6.3%) from a total of 961 students in 2007. Similarly, in 2008, only 29(9.634%) women were enrolled out of 301 students. Women's enrolment increased to 14.17% in 2010, but it failed again to 11% in 2011. In 2012 and 2013, it increased to 19% and reached 25.1% in 2014. This is the year where a better record has shown. However, women enrolment declined to 6% (828) in 2015 out of 13605 students, and again it increased to 21.5% in 2016. The average women enrolment in this program is 11.9% from 2007 to 2016. Generally, there has been an up and down trend in this program in the last ten years.

Table 4.4 Trends of women enrollment in engineering education in the regular postgraduate programmer (M.Sc. & Ph.D.).

Year	Man	Women	Total	% Women from the total
2007	590	22	613	3.5%
2008	596	39	635	6.14%
2009	1328	69	1397	4.93%
2010	1075	79	1154	6.84%
2011	2555	441	2996	14.7%
2012	2516	447	2963	15%
2013	2516	447	2963	15%
2014	2938	1945	4883	39.8%
2015	4327	674	5001	13.5%
2016	5635	988	6623	14.9%
Average women%	13.43%			

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

Table 4.4 represents trends of women enrolment in engineering and technology education in regular post-graduate programs of Master and Ph.D. degrees in government universities. In 2007 there were only 22 women enrolled, which is 3.5% out of the total 613 students. It slightly increased in 2008, which is 6.14% but declined to 4.93% from 1397 enrolled students in 2009. Again, it increased to 6.84% in 2010 and 14% in 2011. There was the same percentage of women enrolment during 2012 and 2013, which is 15%, and it goes up dramatically to 39.8% in 2014 that is considered as the best improvement has been seen. However, it immediately failed to 13.5% in 2015 and slightly went up to 14.9% in 2016. The average women's enrolment in engineering and technology education in masters and Ph.D. degree level is 13.4% during the last ten years.

To sum up, women enrolment in Masters and Ph.D. degree is very low proportion as we have seen in the table, and has an up and down trend. In fact, in Ethiopia, Master's and Ph.D. education programs are not expanded in domestic universities due to a shortage of supervisors. The government has taken action to solve this problem that students are sent to Asian and European countries to study for their post-graduate degrees. In some cases, the Ethiopian government also imports professors from other countries to provide these programs. However, even in this process also the number of women participating is understated. The average enrollment of women is 515, which is one-fourth (1/4) of man’s average enrollment of 2408. The maximum number of women enrolled occurred in 2014, accounting for 1945, while the minimum is only 29 women students. However, man enrolment is better than women, their maximum number accounts for 5635 students, and the minimum number is 590. This indicates their severe under-representation of women in engineering & technology education at all degree levels.

Table 4.5 Trends of women enrollment in engineering education in evening and summer postgraduate program (M.Sc. / Ph.D.)

Year	Man	Women	Total	% Women
2010	247	21	268	7.84%
2011	338	25	363	6.88%
2012	993	114	1107	10.298%
2013	993	124	1117	11.1%
2014	1106	338	1444	23.407%
2015	897	1199	2096	57.2%
2016	2575	388	2963	13.09%
Average women percentage 18.5%				

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

In Table 4.5, the number of women enrolled in engineering and technology is only 21 (7.84%) out of 268 students in 2010, even if decline to 6.88% in 2011. It has shown an increasing trend in 2012, 2013, and 2014, 10.3%, 11.1%, and 23.4%, respectively. In 2015 it reached a peak level and rose to 57.2%, a very high proportion and beyond 50%. However, this improvement unexpectedly declined to 13%. The average women enrolment in this program is 18.5 percent which is very low in other programs, as we have seen above.

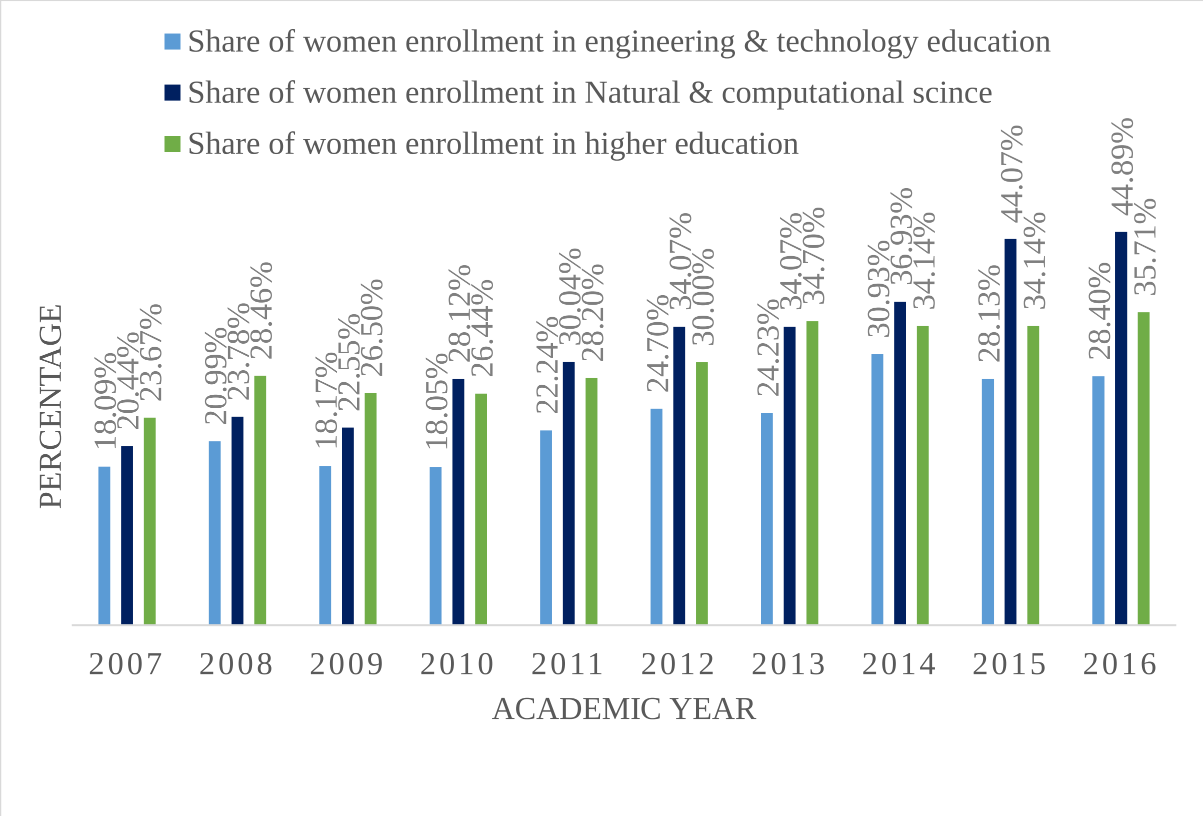

Figure 4.2 Women enrolment in the engineering, natural science, and higher education in Ethiopia

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

Women's participation in higher education was under-represented, although it improved currently and reached 35.7% from the total enrolment of higher education during 2016, as provided in Figure 4.2. The Ethiopian government designed and implemented an affirmative action policy, which aimed to promote gender equality in the country's universities. This affirmative action program enables females to enrol at universities with a 2.0 grade point average, which is less than males. This program also includes providing orientation for all first-year female students; female-only tutorials; a guidance and counselling service led by female professional counsellors; peer counselling and support from senior female students; academic support from capable senior students; and overall assertiveness training (Demise et al., 2002). There is one office, the so-called "gender office," in each university who is responsible for implementing and following up this affirmative action policy. However, there is an argument about this affirmative action provided for females at the university level. For example, Molla & Cuthbert (2014) argued that affirmative action policies slightly benefit females at the entry point.

Female Ethiopian students' participation in STEM was a low enrolment rate. In 2008, the Ethiopian Ministry of Education came up with a new policy whereby 70% of overall university enrolment is expected to be in a science field, with the remaining 30% in the social sciences and business economics. This policy has emerged based on Ethiopia's aim to produce more graduates in science, technology, engineering, and mathematics (STEM) to increase females in the field and secure sustainable development in the country. Hence, the share of women enrolment in engineering and technology increase from 8% during 2007 to 28% in 2016, as shown in Figure 4.2.

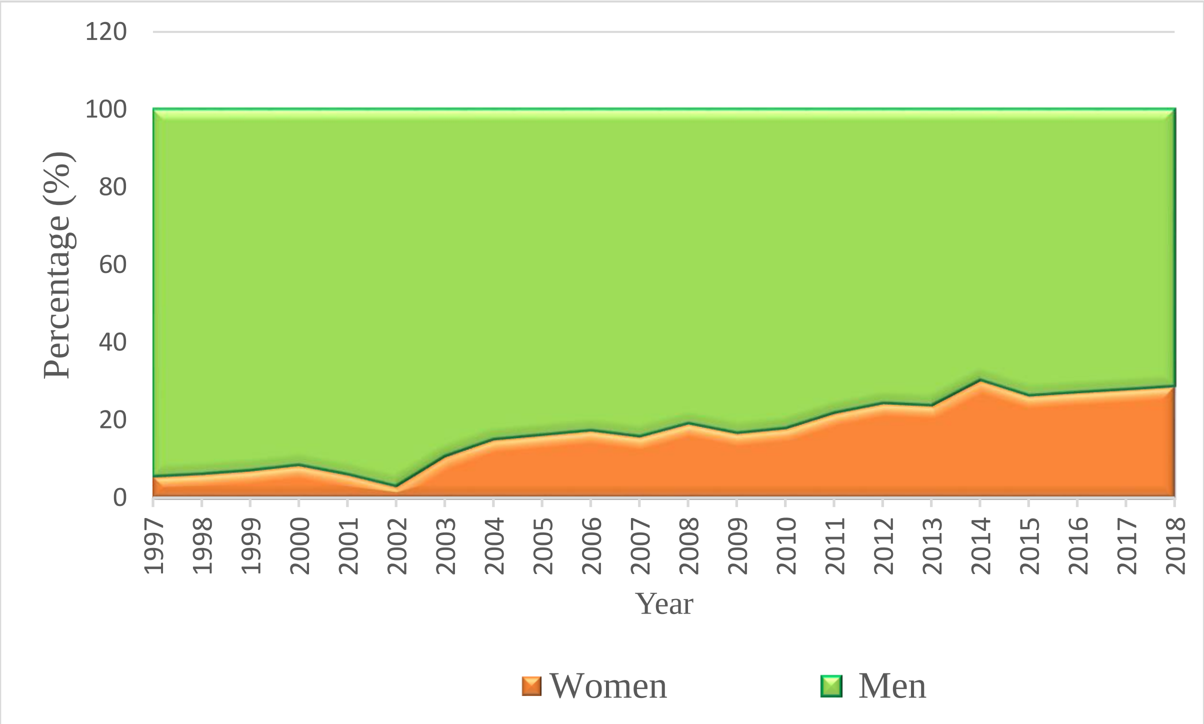

Figure 4.3 The status of women participation in engineering education in Ethiopia.

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

Figures 4.3 shows the number of women and men's human capital formation in engineering and technology education. The disparity existed in engineering and technology. There are social and economic issues beyond students' academic interest for the dismal proportion of women in engineering and technology educational enrolment. The social reason is that society's attitude is not encouraging women's participation in the science field since it needs physical work.

There is also, an economic issue in which parents cannot support their children to study engineering and technology that takes long training. Besides, women want to learn short-time training and get a job and establish a family. Hence, due to such conditions, the percentage share of women's enrolment in engineering and technology is below their male counterparts and other science subjects.

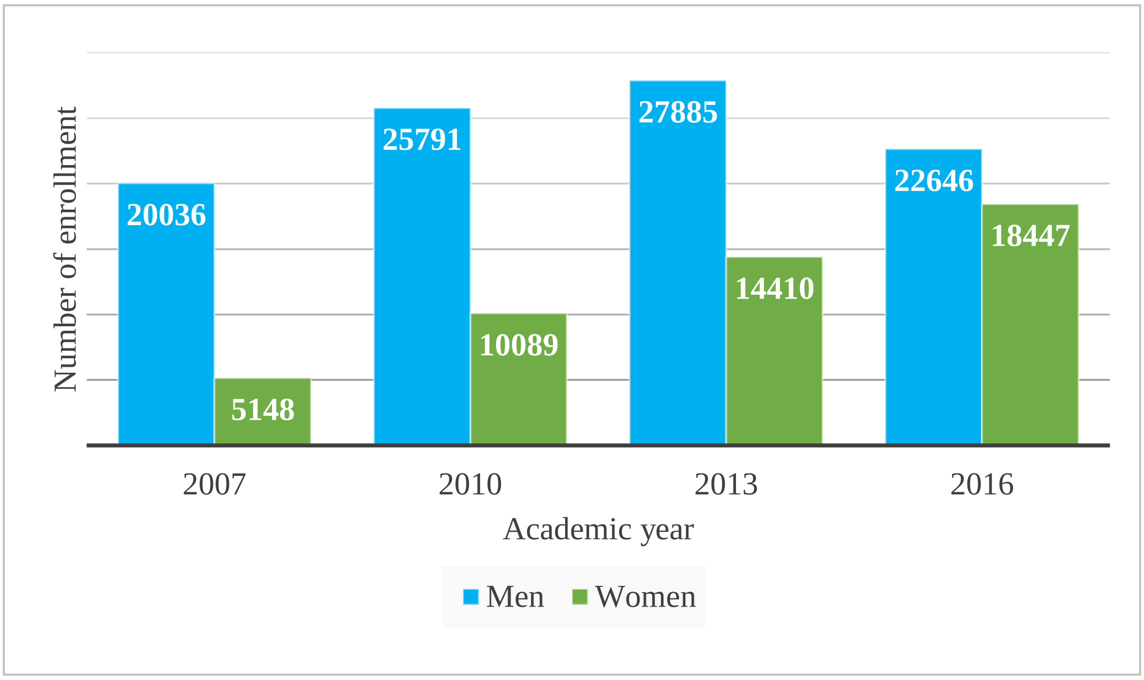

Figure 4.4 Students enrolment in STEM education excluding engineering in Ethiopia.

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

Figure 4.4 represents women students' enrolment in STEM education, excluding engineering and technology in Ethiopia. This figure also shows there is a gender gap; however, this gap is declined during 2016, that the number of men enrolment is more than women by 4199 male students.

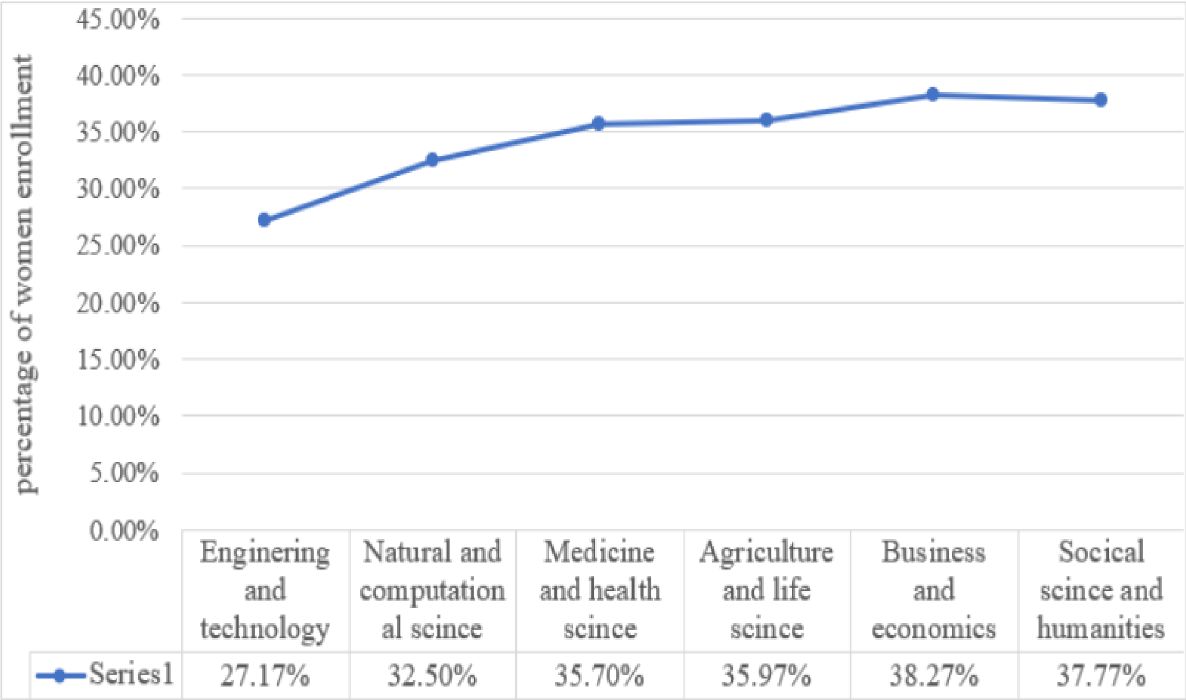

Figure 4.5 Percentage of women enrolment in an undergraduate degree in Ethiopian higher education institutions in 2016.

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

Academic departments in Ethiopia are categorized into six groups: Band 1 (engineering and technology), Band 2 (natural and computational science that includes biology, statistics, physics, etc.), Band 3 (medicine and health sciences), Band 4 (agriculture and life science), Band 5 (business and economics), and Band 6 (social science and humanities). Figure 4.5 also shows the percentage share of women enrolment within these faculties in all programs (i.e., regular, summer, evening or weekend and distance program). The percentage share of women from the total enrolment in engineering and technology education was 27.17% in 2016, lower than other departments. Similarly, Table 4.6 also shows enrolment in engineering and technology and the total enrolment in other science departments (biology, chemistry, mathematics, physics, statistics). Here also, the percentage of share of women in engineering and technology education is in low-level.

Table 4.6 Women enrolment in a regular undergraduate program in engineering and other science departments in Ethiopian.

Departments	Year	Men	Women	% of women from the total
Women enrollment in engineering	2007	10676	2394	18.087%
	2008	7561	2009	20.99%
	2009	25437	5647	18.1669%
	2010	43958	9679	18.045%
	2011	68276	19523	22.236%
	2012	91742	30145	24.7%
	2013	91192	29794	24.23%
	2014	118078	52881	30.93%
	2015	127837	50025	28.125%
	2016	125171	49657	28.4%
Women enrolment in natural and computational science (Biology, chemistry, mathematics, statistics, physics)	Year	Men	Total	% of women from the total
	2007	5148	25184	20.44%
	2008	5297	22268	23.78%
	2009	8153	36147	22.55%
	2010	10089	35880	28.12%
	2011	10964	36504	30.035%
	2012	14410	42295	34.07%
	2013	14410	42295	34.07%
	2014	14393	38979	36.93%
	2015	16488	37417	44.07%
	2016	18447	41093	44.89%

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

Figure 4.6 shows the number of graduated students in engineering and technology education in Ethiopia from 1999 to the present. Again, there is a huge imbalance between men and women, and the gap is increasing over time due to dropout. Since most female students are dismissed and drop out from universities after learning sometimes, low academic performance and related issues lead to a wide gender gap in STEM fields.

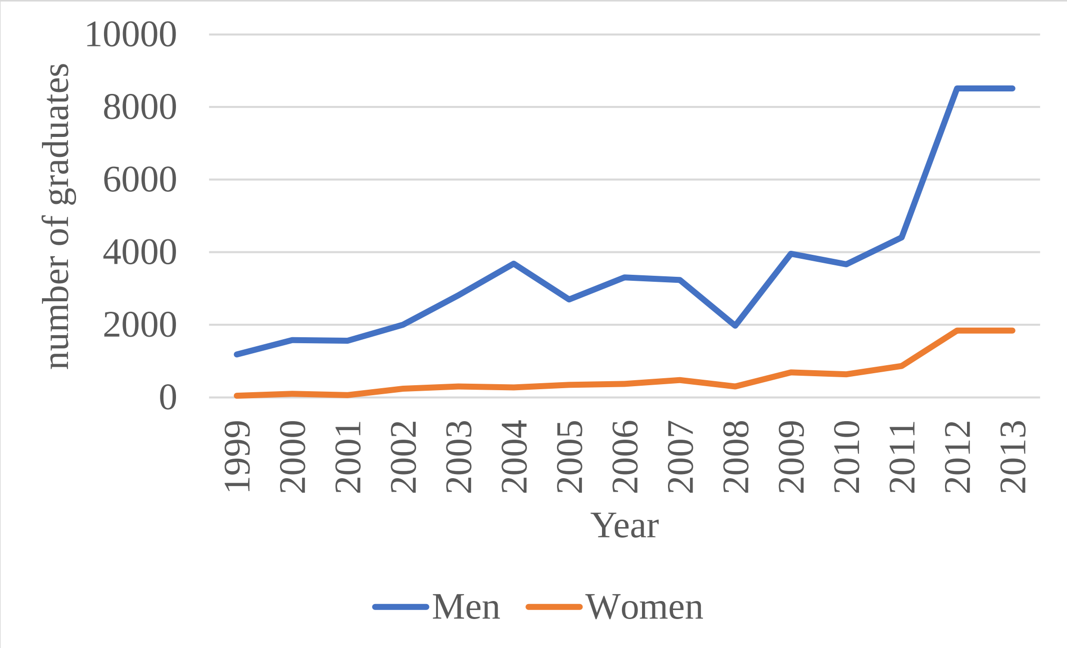

Figure 4.6 Students graduated in engineering education in Ethiopia.

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

African countries need to expand their infrastructure for economic growth. Consequently, engineering and technology are necessary to address the increased demands for water, transportation, food, housing, telecommunication, and sanitation in these countries. According to Deloitte's (2019) report, there will be 452 projects in Africa in 2019. 40.3% (182 projects) belong to East African countries, including Ethiopia, which also needs engineering and technology. Therefore, these countries have to increase women's human capital in engineering and technology and men's to complete such projects. Hence, the status of women's human capital formation in engineering, manufacturing, and construction regarding enrolment and graduation is given in Figures 4.7 and 4.8.

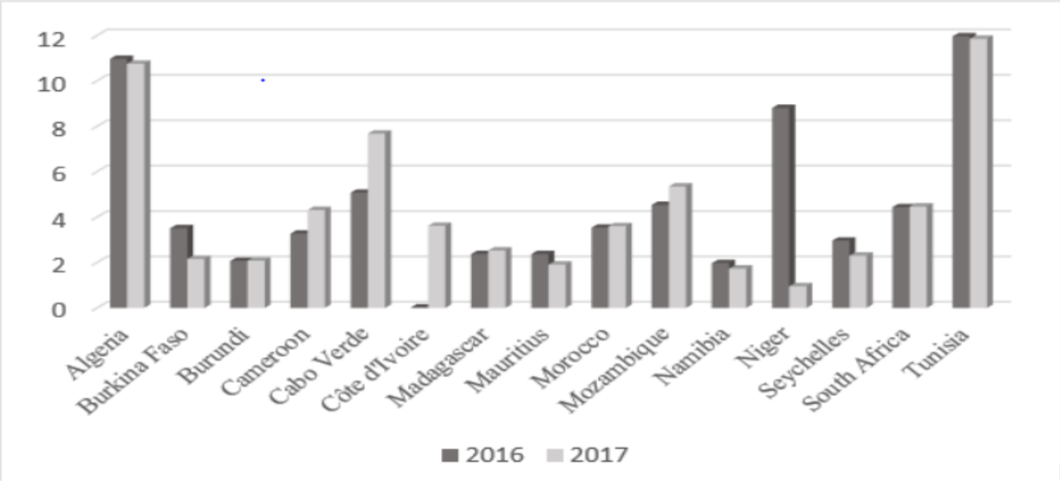

Figure 4.7 Status of percentage of women enrolment in engineering, manufacturing, and construction education in Africa.

Source: UNESCO. (2020). Education database. Retrieved from http://data.uis.unesco.org/

From figure 4.7, Tunisia (11.96%) and Algeria (10.97%) have a better percentage of women enrolment during 2016 and 2017, whereas it remains low in Namibia, Mauritius, Burundi, and Madagascar. The percentage of women graduates in Science, Technology, Engineering, and Mathematics is presented in Figure 4.8, which shows Mauritania (16.8% in 2016 and 29.4% in 2017), Morocco (17.53%), and Cameroon (16.078%) have better performance.

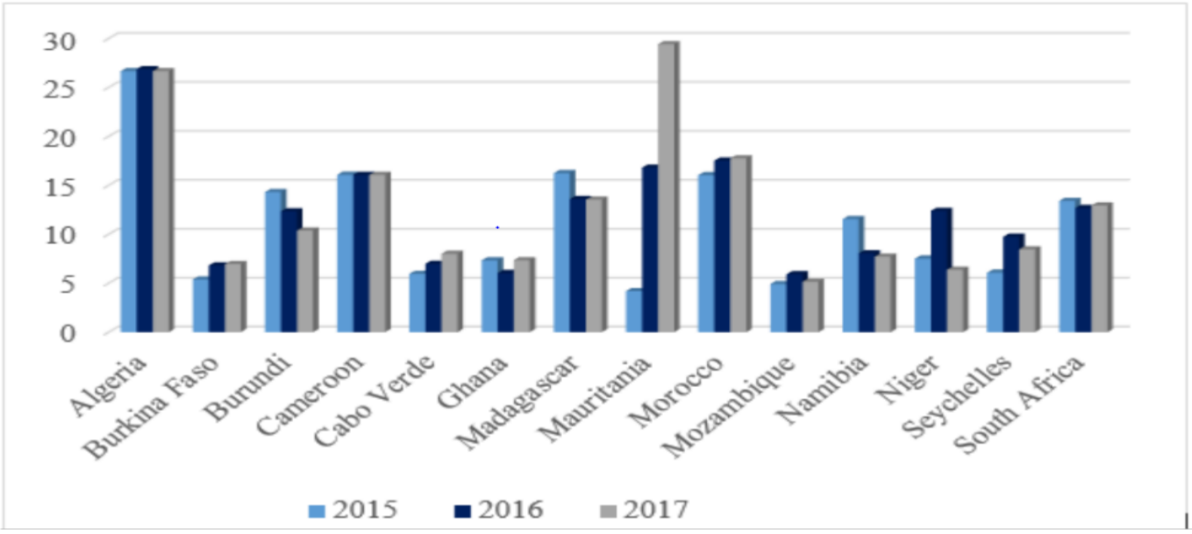

Figure 4.8 Percentage of women graduates in STEM education in Africa

Source: UNESCO. (2020). Education database. Retrieved from http://data.uis.unesco.org/

Women enrolment in engineering, manufacturing, and construction fields is below 14% in various countries, as shown in Figure 4.9. From this Figure, Romania, Tunisia, and Portugal have better performance during 2016 and 2017, whereas Burundi, Burkina Faso, the USA, and the UK show a low proportion. Cebr Analysis of Royal Academy also conducted a study using cross-sectional data from 90 countries that offer the gender gap in STEM education in most parts of the world, supporting the current study (Academy, 2016).

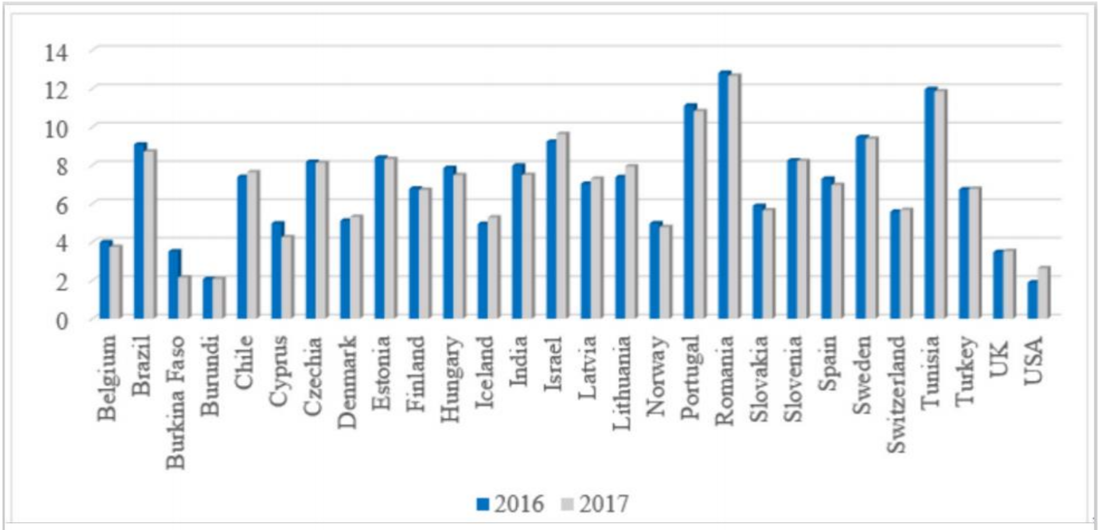

Figure 4.9 Status of women enrolment in engineering, manufacturing, and construction field across the globe.

Source: UNESCO. (2020). Education database. Retrieved from http://data.uis.unesco.org/

The status of women graduates in engineering, manufacturing, and construction in Europe during 2016 is shown in Figure 4.10, which shows Luxembourg, Malta, UK, Norway, and Switzerland have a small percentage of women graduates in these fields. Whereas Portugal, Romania, Poland, Sweden, Serbia, Greece, Germany, and Belarus have better performance.

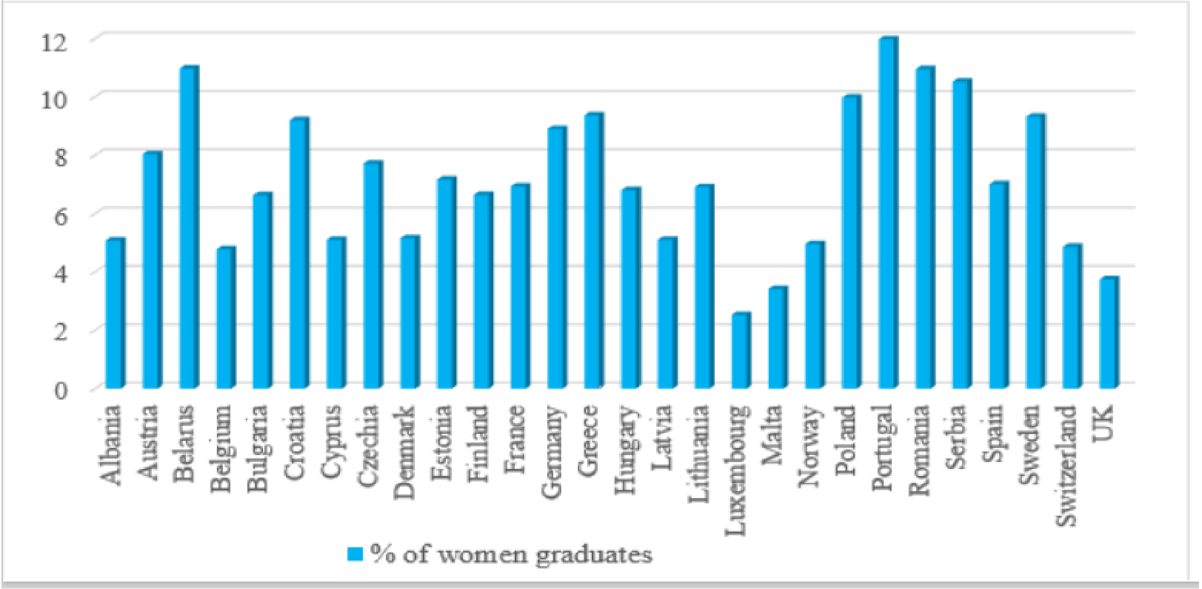

Figure 4.10 Status of women graduates in engineering, manufacturing, and construction in Europe during 2016.

Source: UNESCO. (2020). Education database. Retrieved from http://data.uis.unesco.org/

The distribution of women graduates in Africa, North and South America has illustrated in Figure 4.11, indicates that Eritrea from Africa, Mexico from North America, and Colombia from South America have better than other countries in 2016.

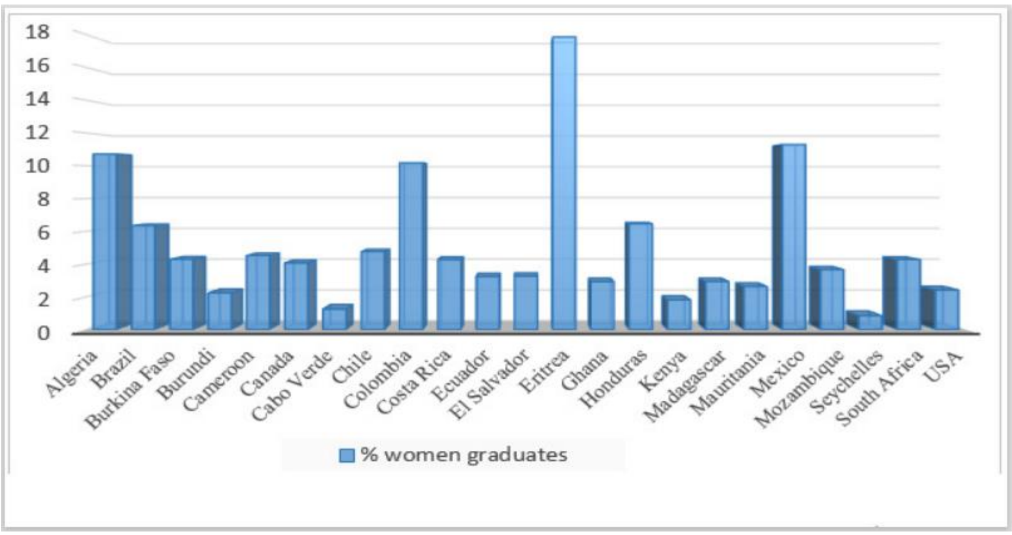

Figure 4.11 Status of women graduates in engineering, manufacturing and construction in Africa, North & South America during 2016.

Source: UNESCO. (2020). Education database. Retrieved from http://data.uis.unesco.org/

Similarly, Figure 4.12 shows the percentage of women graduates in science, technology, engineering, and mathematics areas of study in three consequent academic years worldwide. We can see that Oman and India (Singh and Peers, 2019; Academy, 2016; Gupta, 2012) have better performance. In general, these given Figures indicate the existence of low representation of women in STEM education worldwide.

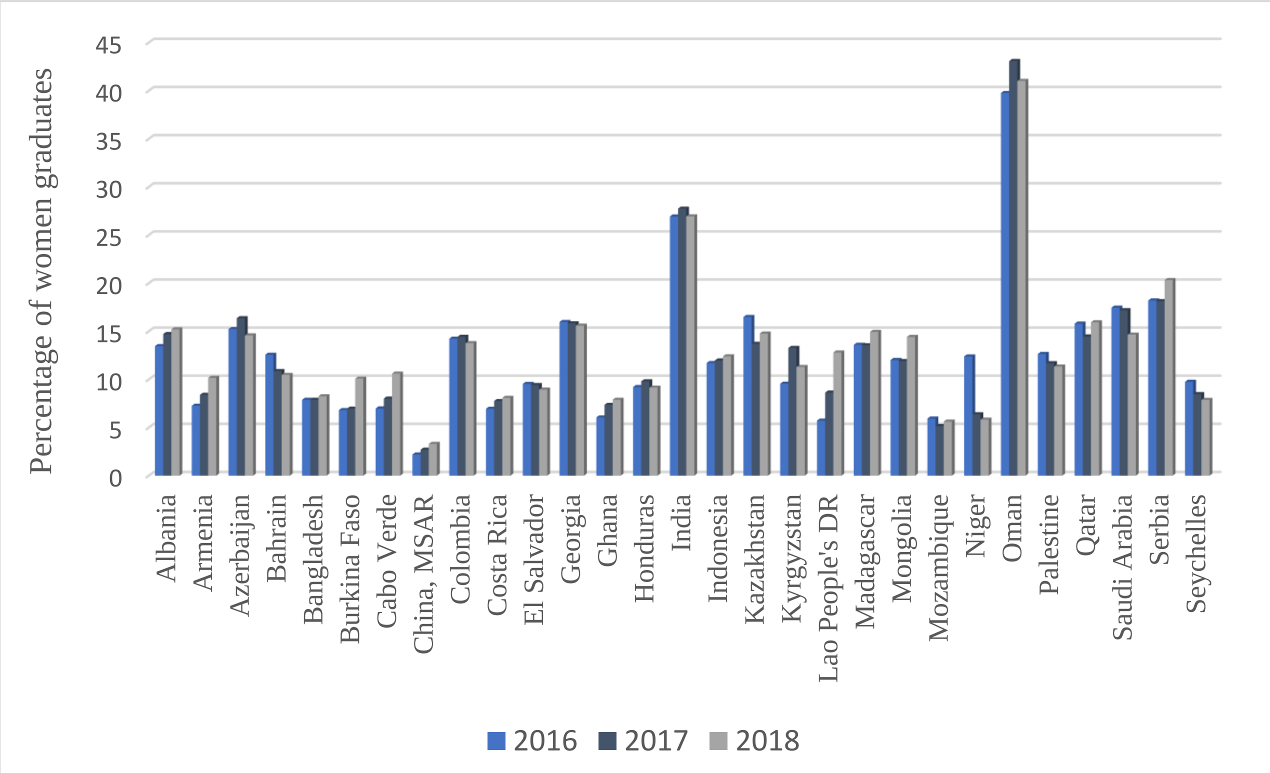

Figure 4.12 Percentage of women graduates in STEM education in various world countries

Source: UNESCO. (2020). Education database. Retrieved from http://data.uis.unesco.org/

4.2. Analysis of Women in Engineering Employment

The status of women's engineering faculty members in Ethiopia has been discussed in *Figure 4.13*. In engineering faculty, there is a significant difference in both genders. The average number of women from 2007 to 2016 is 7.6%. This is confirmed by Jote (2017), finding substantial variations observed between men and women, and women's employment status is consistently lower in Ethiopia.

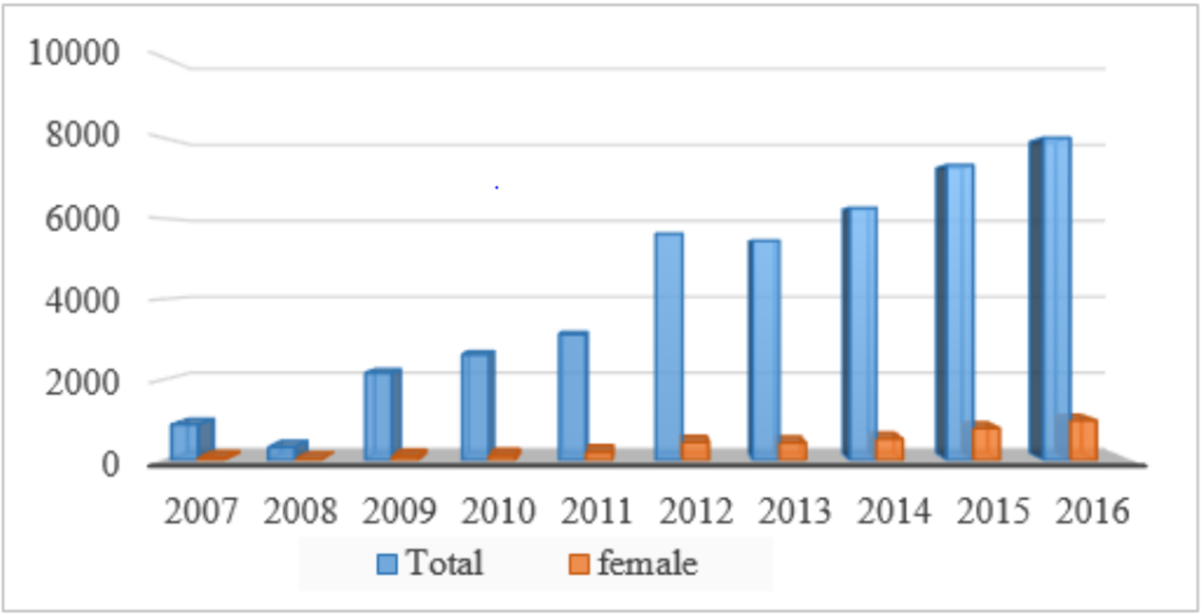

Figure 4.13 Status of women in engineering teaching professional employment.

Source: MOE Educational statistics annual abstract report (2016): http://www.moe.gov.et/statistics

Figure 4.14 shows there is low proportional status of women participation in the engineering labor market in various professions in Ethiopia. Such as: electro technology and architect; planning, surveying and designing; physical and engineering science technicians; mining manufacturing and construction supervisors; process control technicians; manufacturing of electrical equipment; production of machinery & equipment; manufacturing of motor vehicles, trailers & semi-trailers manufacturing of other transport equipment; repair and installation of machinery & equipment; and civil engineering.

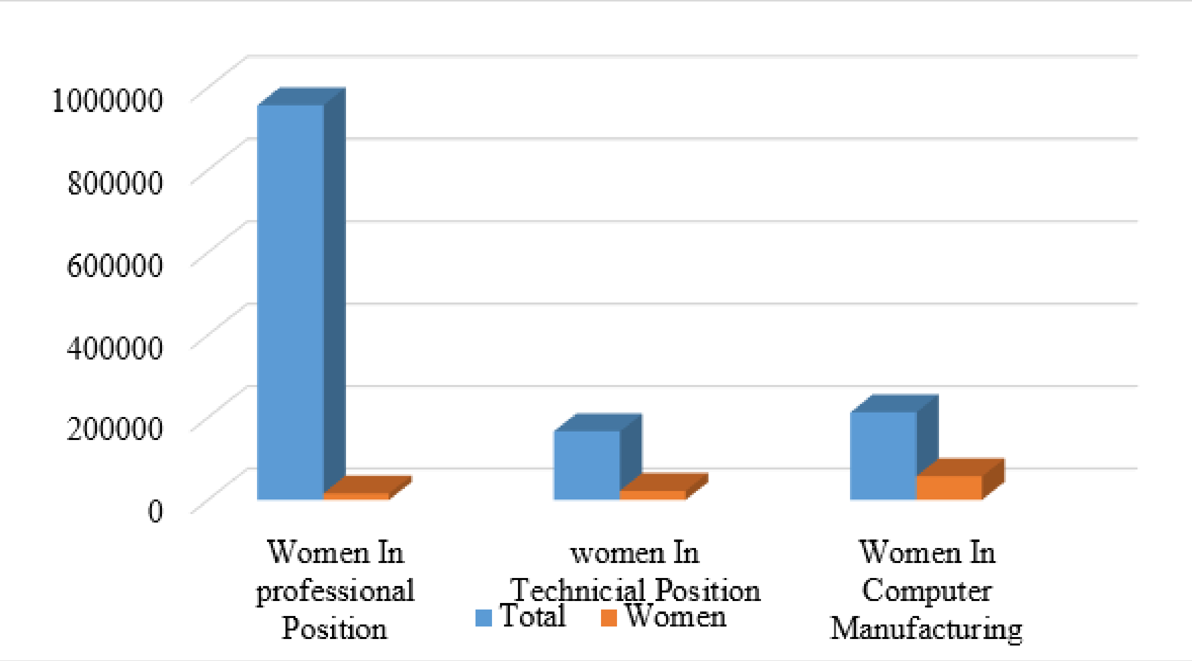

Figure 4.14. The status of women participation in the engineering employment in Ethiopia.
Source: Final report of national assessment (Beyene, 2015)

Figure 4.15 also shows the percentage share of women in STEM jobs globally, that most of the countries have more than 30% participation. However, Niger (9.8%), United Arab Emirates (15%), and Pakistan (18.9%) have the lowest share of women's participation in STEM occupations during 2020 (ILO, 2020).

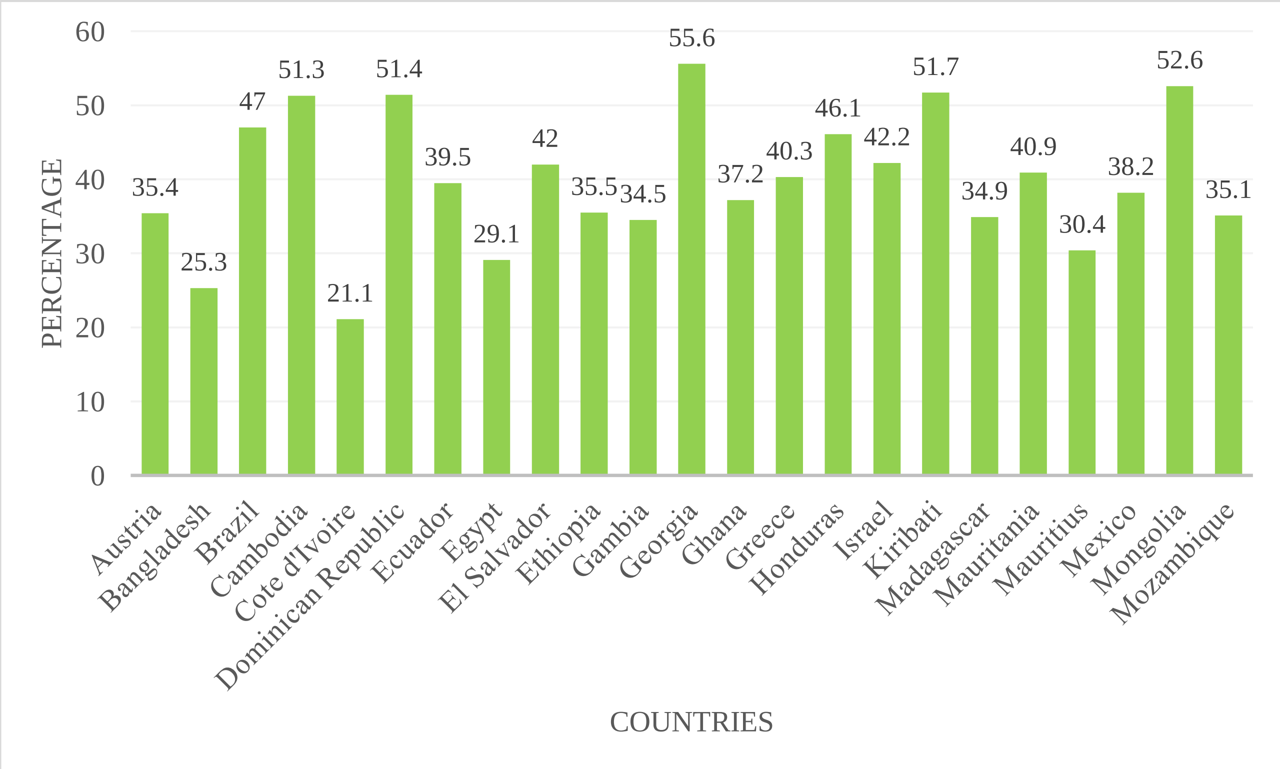

Figure 4.15. Percentage share of women in STEM jobs in 2020

Source: ILO (2020). How many women work in STEM? https://ilostat.ilo.org/how-many-women-work-in-stem/

In summary, the first goal of using secondary data to analyse the status of women in engineering education and employment was accomplished on the basis of enrolment in secondary school, higher education, engineering, and other science areas. Regular, evening, summer, and distant undergraduate degree programs, regular postgraduate (M.Sc. & Ph. D) programs, and evening and summer postgraduate (M.Sc. & Ph. D) programs in Ethiopia were used to collect enrolment statistics in engineering. The same information was gathered all across the world. As a result, the first objective's finding demonstrates the gender gap in engineering education and employment.

CHAPTER – FIVE

INFERENTIAL ANALYSIS

In this chapter, five objectives of the study have been discussed. These objectives (listed in page 52-53) are: examine the effect of economic growth on women human capital formation in engineering education, investigate factors affecting women's choice of pursuing engineering education, explore factors affecting academic performance of women in engineering education, analyses factors affecting women graduates' employability in engineering education, and identify challenges faced by women engenderers at the work place.

5.1.The Impact of Economic Growth on Human Capital Formation in Engineering Education among Women

The study employed an autoregressive distributed lag (ARDL) model focusing on analysing economic growth's impact on women's human capital formation in engineering and technology education. Data from 1997- 2018 available in the African Development Bank Group Socioeconomic database; Ethiopian Ministry of Education educational statistics annual abstract; and UNESCO database was used.

5.1.1. Results of the stationary test and maximum lag selection

The outcome of the Augmented Dickey-Fuller test rejected the null hypothesis that there is a unit root in the data and accepted the alternative hypothesis. The GDP and education value-added log are stationary at a level I (0), as given in Tables 5.1 and 5.2. The calculated t-value of women enrolment in engineering and technology education WHCE is higher than the 1%, 5%, and 10% critical value in all cases (1-3) given above.

Table 5.1 Augmented Dickey-Fuller unit root test of stationary of data at I (0)

Z(t) distribution test statistics				
Variable	No constant term	Including trend term	Including intercept or drift term	Order of integration
WHCE	1.238 (-2.660) * (-1.950) ** (-1.600) ***	-1.684(-4.380) * (-3.600) ** (-3.240)***	0.266 (-2.539) * (-1.729) ** (-1.328) ***	At level
GE	4.909 (-2.660) * (-1.950) ** (-1.600) ***	-0.716 (-4.380) * (-3.600) ** (-3.240) ***	2.585 (-2.539) * (-1.729) ** (-1.328) ***	At level
LGDP	8.421 (-1.950) ** (-1.600) ***	-3.673 (-3.600) ** (-3.240) ***	2.110 (-1.729) ** (-1.328) ***	At level
WHCS	4.714 (-2.660) * (-1.950) ** (-1.600) ***	-2.624 (-4.380) *(-3.600) ** (-3.240) ***	0.906 (-2.539) * (-1.729) ** (-1.328) ***	At level
LEVA	5.228 (-2.660) * (-1.950) ** (-1.600) ***	-5.464 (-4.380) *(-3.600) ** (-3.240) ***	-3.427 (-2.539) *(-1.729) ** (-1.328) ***	At level

Note: *, **, and *** refers to 1%, 5%, and 10% significant level of critical values respectively.

The log of women's human capital formation in engineering & technology education, government expenditure on education, and the log of women's human capital formation in secondary school are stationary after the first order of integration I (1) as given in Table 5.2.

Table 5.2 Augmented Dickey-Fuller unit root test of stationary of data at I (1).

Z(t)t distribution test statistics				
Variable	No constant term	Including trend term	Including intercept or drift term	Order of integration
WHCE	-4.698 (-2.660) * (-1.950) ** (-1.600) ***	-6.002(-4.380) * (-3.600) ** (-3.240) ***	-5.461(-2.552) * (-1.734) ** (-1.330) ***	1st difference
GE	-2.207 (-1.950) ** (-1.600) ***	-5.104 (-4.380) * (-3.600) **	-3.591(-2.552) * (-1.734) ** (-1.330) ***	1st difference
LGDP	0.708(-2.660) * (-1.950) ** (-1.600) ***	-4.497(-4.380) * (-3.600) ** (-3.240) ***	-1.021(-2.552) * (-1.734) ** (-1.330) ***	1st difference
WHCS	-2.156 (-1.950)	-5.029(-4.380) *	-4.933(-2.552) *	1st difference

	** (-1.600) ***	(-3.600) ** (-3.240) ***	(-1.734) ** (-1.330) ***	
LEVA	-0.415(-2.660) * (-1.950) ** (-1.600) ***	-2.263(-4.380) * (-3.600) ** (-3.240) ***	-5.763(-1.291) * (-2.552) ** (-1.734) ***	1st difference

Note: *, **, and *** refers to 1%, 5%, and 10% significant level of critical values respectively

The technique of optimum lag selection of Akaike' information criterion gives a maximum lag of (1 1 1 1 0) which refers, the dependent variable women human capital formation in engineering and technology education LWHCE regressed at the first lag of its value. Whereas the log of government expenditure on education LGE, the log of LGDP, the log of LWHCS, and the log of education value added have regressed at current values and first lag value as given in Table 5.3. Optimum lag of (1 1 1 1 0) is obtained after computed regression of ARDL with maximum lags (2) followed by dependent and independent variables with the syntax of matrix list e(lags). The value of the Akaike information criterion (3.890213) is obtained by estate post estimation of ARDL with maxlags (2).

Table 5.3 Results of Akaike's Information Criterion maximum lag selection.

Variables	Number of lags
LW HCE	1
LGE	1
LGDP	1
WHCS	1
LEVA	0
AIC (Akaike's information criterion) result	3.890213

The unbiasedness of the estimated coefficients of the variable has been checked through various diagnostic tests of the model. The existence of serial correlation has been studied through the Breusch-Godfrey LM test. The p-value (0.5603) result can accept the null hypothesis that there is no serial correlation in residuals in the order of lag two, which is desirable as presented in Table 5.4. According to the result of Durbin's alternative test[6],

[6] Durbin's alternative test King (1981) serial correlation can be performed by estat durbinalt which is more desirable than Durbin-Watson d statistics. In this test, all regressors do not necessarily be exogenous, unlike Durbin Watson d statistics test of 1st order serial correlation (Durbin & Watson, 1950).

we cannot reject the null hypothesis; H0: no serial correlation since the p-value is 0.4573, which is more than a 5% significant level in Table 5.4. This shows serial correlation does not exist in the error term. Similarly, the result of the white test also indicates that constant variance of errors term since its p-value is 0.3971, as given in Table 5.4.

Table 5.4 Results of diagnostic test after ARDL model estimation.

Diagnostic tests	Lags (p)	chi2	DF	P rob > chi2
Breusch-Godfrey LM test	2	1.159	2	0.5603
Durbin's alternative test	1	0.553	1	0.4573
White's test of H0: homoscedasticity		21.00		0.3971

5.1.2. Cointegration test

After proper lag selection, the cointegration test of the variable has been computed based on a bound test, as shown in Table 5.5. After the determination of optimum lags of the variable, a bound test of cointegration has been calculated. In this method, the null hypothesis assumes that there is no level relationship among the variable. The Bound test is performed by 'estatb' test after conducting ARDL regression with error correction term(etc.). The decision criteria are execute based on the results of Wald statistics (F) and t-statistics. The critical value of F statistics at 1% and 5% significant level is lower than the upper bound I (1) calculated value of regressors, leading to rejecting the null hypothesis. Therefore, the bound test can reject the null hypothesis that there is no level relationship. As a result, there are long-run and short-run relationships among economic growth, women's human capital formation in engineering and technology education, government expenditure on education, women's human capital formation in secondary school, and education value-added. Therefore, the ARDL model with error correction terms has been conducted.

Table 5.5 Results of Bounds test of level relationship in ARDL model.

Computed value of F − statistics and t − statistics			F = 6.953 t = −2.359
A critical value of F−statistics, Case 2		A critical value of t−statistics, Case 2	
Lower bound (I (0))	Upper bound (I (1))	Lower bound (I (0))	Upper bound (I (1))
2.20	3.09	−2.57	−3.66

2.56*	3.49*	−2.86*	−3.99*
2.88**	3.87**	−3.13**	−4.26**
3.29***	4.37***	−3.43***	−4.60***

Note: *, **, and *** refers to 5%, 2.5% & 1% significant level and the remaining is at 10% significant level of regressor variables k4.

The recursive residuals from the CUSUM Square (cumulative sum of squares) tests of model stability have been computed. The result illustrated in Figure 5.1 shows the residuals are normally distributed, and the model is stable.

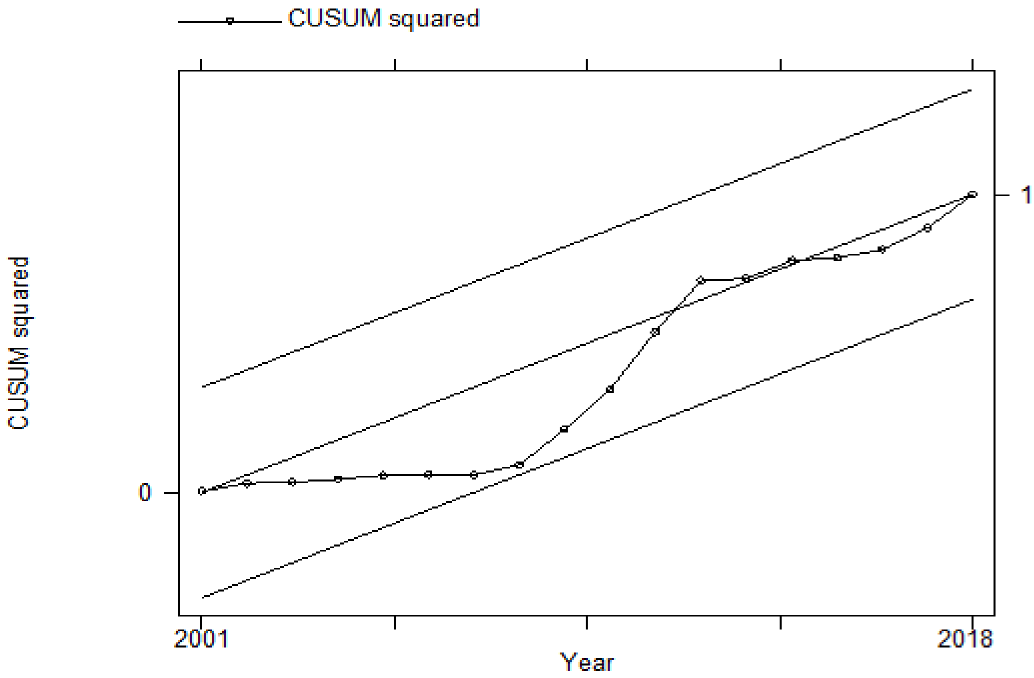

Figure 5.1 Stability test.

The ARDL regression estimation result of Table 5.6 shows that the gross domestic product has a positive and significant (at 1%) impact on women's human capital formation in engineering and technology education. It is found that when GDP increases by 1%, this can yield a 4.99% increase in women's human capital formation in engineering and technology education in the long run[7] . The result confirms the hypothesis that better economic growth will increase women's engineering and technology education enrolment. The result indicates that increasing economic growth will lead to more labor demand in

[7] As usual, the result can be interpreted as the percentage change (Bruin, 2006)

the science and technology sector, creating more opportunities for women enrolment in engineering and technology fields (women human capital formation in engineering and technology). The result supports the previous studies by Chang et al. (2018) found that the national economic expansion granger caused increased tertiary enrolment in Russia and India, even though the current study concerned only with engineering and technology education. But the result contrasts with the study by Gumus & Kayhan (2012), who stated no causal relationship was found between changes in GDP per capita and the school enrolment rate in the tertiary level in Turkey. The impact of economic growth has negative and insignificant impact on women enrolment in engineering education in the short run. This because, since the time is short, most probably positive impact will not expect.

The amount of government expenditure on education also has a positive and significant impact on women's human capital formation at the 10% level in the long run. A 1 percent increase in government expenditure on education leads to a 0.62% increase in women's human capital formation in engineering and technology education. The findings show that if the government invests more in education, it would build a conducive learning and teaching atmosphere, provide learning resources (such as laboratory equipment, workshops, internships, and so on), and provide incentives for girls to enrol in science subjects. The previous studies by Shafuda & De (2020) found a significant long-run positive relationship between government spending on education and Namibia's gross tertiary enrolment rate. Megawati (2020) also found that government education spending positively and significantly affects school enrolment. It also shows that government education spending is associated with a greater probability of school enrolment for needy children and girls in Indonesia.

Whereas education value-added (return on education) has negative and significant influence (at 5% in the short run and 10% level in the long run)[8], that a 1% increase in education value-added resulted in a 2.7% and 1.46% decline in women human capital

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[8] Since the probability of the coefficients which is $p \leq 0.05$ possible is still significant (Wasserstein et al., 2019)

formation in engineering and technology education in the long run and short-run respectively.

This negative impact can be justified in to two ways; (A) according to Harvey & Green (1993), education value-added (return on education) measures students' ability, skill, and knowledge. Hence, if the quality measure of the student's education is very high (it might be in terms of entrance exam for higher education entry), women's enrolment in engineering and technology fields will decline. The reverse is true, which might affect education quality. (B) The returns to education (impact of education on earnings) can be defined in at least three ways: (1) the private return, (2) the social return, and (3) the labor productivity return. The first is made up of the individual's costs and benefits, and it is net of any state transfers and taxes paid. The second definition, which includes transfers and taxes, any externalities or spill-over impacts. The third definition refers to the growth in labor productivity on a gross basis (Blundell et al., 2001). Based on this definition, return on education is the summation of these three components. Therefore, when the private earnings on education, the social return on education, and labor productivity from engineering education decline, enrolment in this field will also decline.

The result also shows the error correction term from the ARDL short-run ECM model adjusts a disequilibrium created between the long run and short run in one period, which can be corrected in the next period. Thus, the result shows that this structural break can be rectified by a 54% speed of adjustment, as given in Table 5.6.

Table 5.6 Results of ARDL model with error correction term.

ARDL (1,1,1,1,0) regression Sample: 1998 – 2018 Loglikelihood = 1.713444				Number of obs = 21 R− squared = 0.7692 Adj R− squared = 0.6154 Root MSE = 0.2950		
	Coef.	St. Err.	T	P > |t|	[95%Conf. Interval]	
Long run model dependent variable (LWHCE)						
LGE	0.6230513	0.3125788	1.99	0.069	−0.0579994	1.304102
LGDP	4.993848	1.101859	4.53	0.001	2.593104	7.394592
LWHCS	0.1413781	0.6444567	0.22	0.830	−1.262772	1.545529
LEVA	−2.689651	1.267371	−2.12	0.055	−5.451015	0.0717142
Cons	−87.04057	16.73016	−5.20	0.000	−123.4925	−50.58868

Short run model dependent variable (ΔLWHCE)						
ΔLGE	−0.077472	0.1261839	−0.61	0.551	−0.3524031	0.197459
ΔLGDP	−2.15852	3.383055	−0.64	0.535	−9.529563	5.212523
ΔLWHCS	0.4495846	0.3035861	1.48	0.164	−0.2118728	1.111042
ΔLEVA	−1.460374	0.6190868	−2.36	0.036	−2.809248	−0.1114996
ECM_{t-1}	−0.5429605	0.2301849	−2.36	0.036	−1.04449	−0.0414308

Source: Authors own computation

5.2 Logit Regression Results of Factors Affecting Women Student's Choice of Pursuing Engineering

The engineering and technology profession makes essential contributions to the economy from the point of view of income generation and poverty reduction. However, the number of women in this profession is bleak. In this background, the paper under discussion investigates factors affecting women's engineering and technology education choice. This study used logistic regression to identify the factors that influence women's decision to pursue engineering and technology education, which is the primary explanation for women's underrepresentation in STEM fields. The dependent variable is women's choice of engineering and technology education, determined by 1= student studying engineering and technology fields and 0= students studying other science subjects, as discussed in the second section of the article. After checking Spearman's rank correlation test, six independent variables were included in the model, and various diagnostic tests were conducted.

With all of these diagnostic tests, the expected salary is an important variable with a significant and positive impact at a 1% level. The result indicates the probability of women's choice of learning engineering and technology education increases by 28.78 percent as women students expect a higher salary than students who don't have higher salary expectations, as given in Table 5.7.

The existence of engineering and technology professionals positively and significantly affect women students' choice of engineering and technology education at a 1% level. Women students who have engineering and technology professionals in the family increase their probability of studying engineering and technology by 9.3% than women students who don't have such persons in their family members.

The accessibility of role models positively and significantly affects women students' choice to learn engineering and technology education at a 1% level. The result shows the probability of women's selection of learning engineering and technology education increase by 9.16% if they have role models than those who don't have, keeping other things constant.

Grade 12 final exam (high school education performance) positively and significantly impacts the probability of women students' choice of learning engineering and technology at 1% level. The high school education performance increased by 1 unit, the probability of women students' choice of learning engineering and technology increased by 0.18 percent. The family's annual income is also an essential variable with a positive influence at a 10% level, even though it has a negligible impact on the probability of women's choice of learning engineering and technology education as given in Table 5.7.

The result indicates that students' high salary expectation is the most significant variable that positively impacts women students' choice of engineering and technology education. Most students choose their area of study, which will provide a better salary after graduation. Existing studies did not study this variable in the literature as factors that affect women students' choice of learning engineering and technology. Hence, this factor's finding, which positively influences women students' choice of learning engineering and technology, will add value to the existing literature.

Additionally, the result confirms the positive relationship between engineering and technology professionals' existence in the family and women students' choice of learning engineering and technology education. It indicates most students adapt to the experience of their families. The result is in line with the finding of (Talley and Ortiz, 2017). According to their conclusion, students described early involvement in STEM activities and family socializing training as the factors that most affected their interest in STEM and encouraged them to continue their studies and seek careers as potential STEM professionals.

The result also confirms that the accessibility of a role model is another significant variable that can improve women students' engineering and technology education choices.

The role model can determine student field selection, who can be a teacher or other professionals. The result confirms that Webb et al. (2019) finding that teachers' practice and dialogs promote students learning of mathematics as role models. This can be a base for selecting engineering and technology education since it is mainly related to mathematical computation. Other studies were also confirmed the positive association between students’ choice of field stream and role models (Marginson et al., 2013; Vidal et al., 2020; Imasogie et al., 2018). Hence, the accessibility of role models affected women students’ choice of learning engineering and technology education positively and significantly.

High school education performance measured by grade 12 final semester exam provided as countrywide is another significant variable affecting women students’ choice of engineering and technology education. The result confirms the previous finding by Wang (2013), who found that choosing a STEM major is directly influenced by 12th-grade math achievement, exposure to math and science courses, and math self-efficacy (Wang, 2013). Ünlü and Dökme (2020) also found students’ who have higher end-of-semester grades had a higher interest in STEM careers than those with lower achievement (Ünlü and Dökme, 2020). So, the entrance exam results in grade 12 are the main criteria for keeping students’ choice of departments regarding a country’s higher education policy.

The result also indicates that the family’s annual income has a positive but small impact on women students' choice of engineering and technology education. This might be the yearly income of Ethiopian people is found at a low level. The collected data from the respondents had also confirmed that the average annual income of the family is only 62 thousand Ethiopian Birr (US$ 1,253) in the current exchange rate. The result confirms Ünlü and Dökme (2020) finding that their family income level did not influence students’ interest in STEM education. Hence, the family’s yearly revenue has a negligible impact on women students’ choice of engineering and technology education. However, Großkreutz et al. (2017) studied the influence on career choice to increase female students’ participation in STEM. They noticed that the importance of family income is a crucial factor in advancing women in engineering.

Furthermore, this study indicates that peer pressure has a positive but insignificant impact even though Spearman’s rank correlation coefficient shows a relation between women students’ choice of learning engineering and technology education and peer pressure. However, Zamora-Hernández et al. (2020) found 46% of participants answered that peer pressure is the most crucial factor affecting women’s decision to study engineering. Similarly, Spearman’s rank correlation coefficient of family suggestion to study engineering and technology, and duration of the program (Curriculum), with women’s choice of learning engineering and technology education being insignificant. Hence, these variables are dropped from the regression analysis. However, a study by Rankin et al. (2020) found a positive relation. Zamora-Hernández et al. (2020) found that 93% of women participants positively responded from their families on learning engineering education. Palincsar et al. (2018) found that the educational curriculum is an essential determinant of students’ interest in learning. Garcia Villa and Gonzalez (2014) also found that the challenges faced by female students in engineering colleges due to the academic curriculum impact the choice of learning engineering and technology.

Table 5.7 Logistic regression results of significant variables.

Variables	Coefficient of AME	Robust St. Err.	Z	Sig.level	[95% Conf. Interval]	
					Lower	Upper
Expected salary	0.2878595	0.0174039	16.54	0.000	0.2537484	0.3219706
Family professionals	0.0936166	0.0269222	3.48	0.001	0.04085	0.1463831
Accessibility of role model	0.0916579	0.0268008	3.42	0.001	0.0391293	0.1441866
Peer pressure	0.0237836	0.0536182	0.44	0.657	-0.0813062	0.1288734
High school education background	0.0017668	0.0004555	3.88	0.000	0.000874	0.0026597
Income of the family	2.42e-07	1.32e-07	1.84	0.066	-1.64e-08	5.01e-07

The value of Pseudo R^2 (57%) and Hosmer-Lemeshow test with a p-value of (0.8667) given in Table 5.8 shows the model fit, and accepting the null hypothesis stated that the model is well specified. Furthermore, the model’s overall significance was tested by the Wald chi^2, which is highly significant with a p-value of zero. Hence, the estimated coefficients are free from biasedness.

Table 5.8 Hosmer-Lemeshow goodness-of-fit test of the model.

Number of observations	384
Number of groups	10
Hosmer-Lemeshow chi2(8)	3.89
Significance level	Prob > chi2 = 0.8667

To sum up the result from Logit analysis, students expected salary, high school education background of students, availability of engineering and technology professionals in the family, and accessibility of role models are essential factors affecting women's choice of learning engineering and technology education. This is based on the importance of t-statistics in the regression result shown in Table 5.7, rating the frequency of the variable's impacts. In comparison, the annual family income of women students has positive but minor effects. The post estimation results from Logit regression show that the model is fitted and that the coefficients are unbiased.

5.3 OLS Regression Results on Factors Affecting Academic Performance of Women in Engineering Education

The developing economy needs academically qualified STEM professionals, including women, to contribute crucial sustainable development roles and achieve the 2030 Agenda of SDGs. These can be considered to promote women's empowerment, mainstream gender equality, and achieve peaceful societies with full human potential (UN, 2020; Di Fabio, 2017; Robert et al., 2005; Benavent et al., 2020). In this background, the paper under discussion analyses women's enrolment and graduation in STEM education.

OLS linear regression was used to identify the factors that affect women's academic performance, which is the primary reason for under-representing women in STEM education. As explained in the second section of the paper, the dependent variable is women's academic performance, measured by the cumulative grade. After checking Spearman's rank correlation test, nine independent variables were included in the model, and various diagnostic tests were conducted. The value of R^2 64.9% shows the model fit.

Scatter diagrams were made in the residual of variable and found that the error has a constant distribution, which is mean zero, homoscedasticity, and independent of each other. Figure 5.2 shows the residual's variation stays much the same across the data, apart from the one outlier.

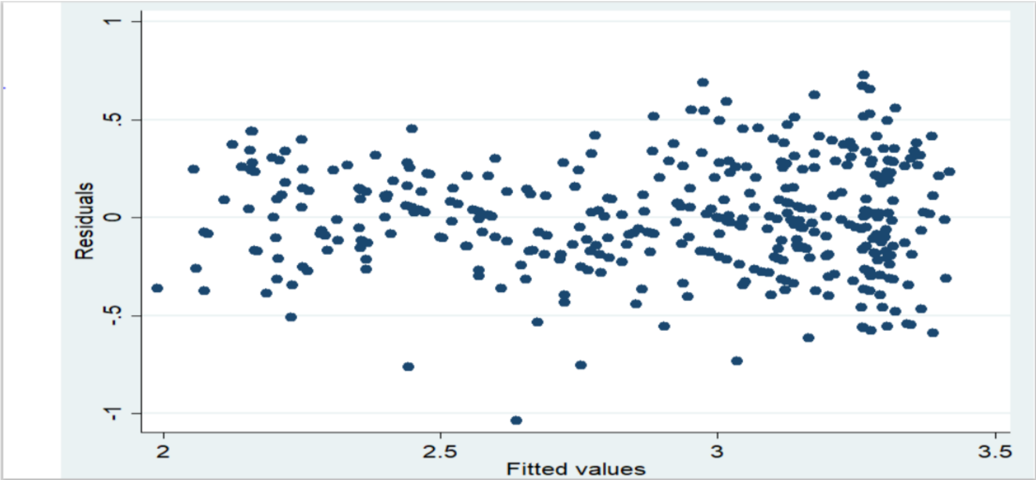

Figure 5.2 Residuals constant variance test.

A histogram given in Figure 5.3 was also made in the residual of variable and found that the error has a normal distribution. Hence, the residual variance can be treated as constant, and the mean of residuals is approximately zero.

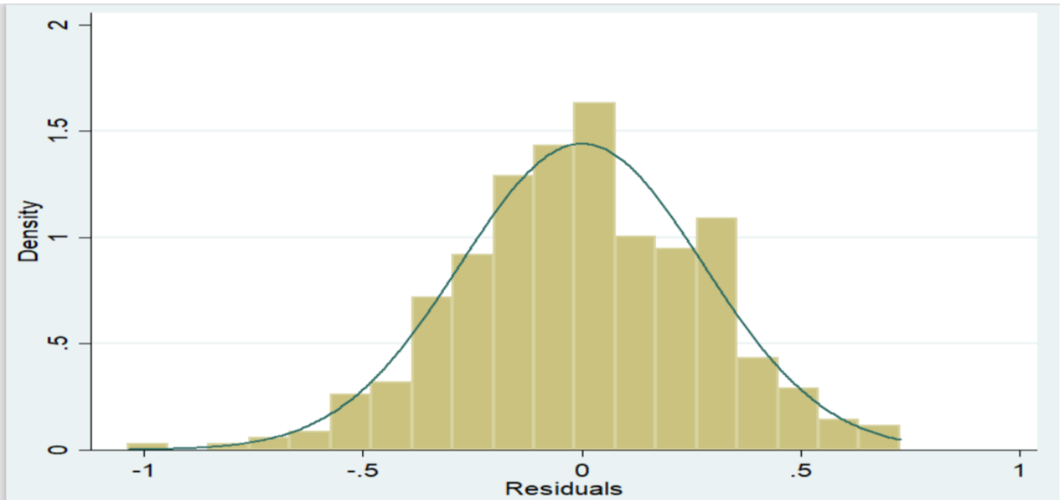

Figure 5.3 Normality test of residuals.

Corresponding to all of these diagnostic tests of regression coefficients, students having prior information about the institution is an important variable with a significant and positive impact at the 1% level. A unit increase in students gathering preliminary information about the university leads to 0.375 unit increases in their academic performance than others on average, as given in Table 5.9.

The interventions of universities in supporting women positively and significantly affects women students' academic performance in engineering and technology education at 1% level. A one-unit increase in university support yields 0.187-unit improvement in women's academic performance.

Peer learning is also an essential variable with a positive and significant influence at the 1% level. A unit increase in this variable leads to a 0.132 unit that increases averagely on women students' academic performance in engineering and technology education.

Similarly, accessibility of university infrastructure has a positive and significant impact at 1% level that on average, 1 unit increase in the supply of these infrastructure related to 0.168- and 0.39-unit improvement, respectively when the supply is medium and a good standard on academic performance of women students in engineering and technology education.

The existence of engineering and technology professionals in the family or family profession has a negative and significant impact at 10%. On average, a unit increase in the existence of engineering and technology family professionals leads to a 0.063-unit decline in women students' academic performance. Sexual harassment also has a significant and negative impact at a 1% level that, on average, a unit increase in sexual harassment leads to a 0.136-unit decline in women students' academic performance.

The result indicates that students having prior information about the institution is the most significant variable that positively impacts academic performance. When the students have previous general information about the institution before joining, they will have psychological readiness, which improves academic performance. The prior knowledge can be about courses, curriculum, administration, examination system, etc., performing in the universities. Thus, a variable was not studied by existing studies in the literature as factors that affect students' academic performance. Hence, this factor's finding, which positively influences educational performance, will add value to the existing literature.

Additionally, the result confirms the hypothesis of the positive relationship between the accessibility of university infrastructure (i.e., library, laboratory, dormitory, internet access, water sanitation, food supply, security, etc.). Furthermore, as supported by the previous studies, women students' academic performance in engineering and technology education found that the university environment contributes to students' academic performance (Mamo et al., 2017; Mersha et al., 2013).

The result also confirms that interventions followed by institutions for supporting women students like the (academic, financial, and psychological treatment) given to girls by the university community are another significant variable that can improve women's academic performance. The previous study also finds and confirms the effectiveness of interventions applied in STEM education associated with academic successes (Van den Hurk et al., 2019). Robsan Margo (2014) also argued that students' capability to complete their studies is related to the sustainable supports of universities.

Students' learning habits are a significant variable that affects women students' academic performance in engineering and technology. It is consistent with the finding of Chachashvili-Bolotin et al. (2016) state that the STEM learning experience positively associates with students' interest in pursuing and achieving STEM fields in tertiary education.

A finding by Hosaka (2014) also confirmed a link between students' learning experience and academic performance. He found that women were not interested in learning in groups with their friends (which is essential for experience and knowledge sharing), leading to low academic performance.

The hypothesis of the negative impact of sexual harassment on women's academic performance has been confirmed in this study. Several existing studies confirm these results. Molla and Cuthbert (2014) found women's experience of sexual violence and bias affects women students' psychological and academic performance. The World Economic Forum and UN also identified negative peer pressure and harassment as reasons women's academic performance remains low-level (UN, 2020; WEF, 2017).

Furthermore, this study indicates that engineering and technology professionals in the family have a negative and significant impact on women’s academic performance in engineering and technology education. Which may happen: if the family members who graduated in this profession may not have a job due to a shortage of employment opportunities, STEM professionals in the family may provide exaggerated pessimistic information about STEM education that will create tension in the students mined, the student may observe lack of freedom from their STEM professional families due to the challenging nature of STEM courses that need more effort for success, if students observe discouraging experience of their family who holds STEM profession by government or others bodies on the bases of political perception, race, religion, gender, etc., and if professionals in STEM have an unsuccessful life. As far as our knowledge, this variable did not study by existing research. The previous studies in the literature mostly take the family’s academic background, which affects academic successes but not considering engineering and technology professionals in the family specifically.

The previous studies (Muhammedhussen, 2016; Mersha et al., 2013; Yigermal, 2017; Gilar-Corbi et al., 2020) found that high school educational background impacts students’ future academic performance. However, Spearman’s rank correlation test shows that high school education performance is insignificant. It may happen due to maladministration of grade 12 examinations that are highly exposed to cheating, leading to high score recording without their skill and knowledge. Additionally, there may be limited access to employment opportunities and a highly corrupted government system during recruitment, leading students to be hopeless and careless in their academic performance.

Having such results, the finding from OLS regression analysis shows that students, having prior information about the university before joining, and better accessibility of university infrastructure are essential factors that affect women's academic performance. Moreover, interventions followed by institutions for supporting women students, peer learning habits of students, sexual harassment, and the existence of engineering and technology professionals in the family also affect women's academic performance. This is based on the value of t-statistics in the regression result given in Table 5.9.

Table 5.9 Significant variables in the OLS model regression.

Variables	Coefficient	Robust St. Err.	T	Sig. level	[95% Conf. Interval]	
					Lower	Upper
University support	0.1878082	0.0365764	5.13	0.000	0.1158813	0.259735
Sexual harassment	−0.1365386	0.0386175	−3.54	0.000	−0.2124793	−0.060598
Peer learning	0.1318955	0.0361807	3.65	0.000	0.0607467	0.2030442
University infrastructure						
Medium	0.1685265	0.0490086	3.44	0.001	0.0721519	0.2649012
Good	0.3924886	0.0547922	7.16	0.000	0.2847406	0.5002367
Prior information	0.3752453	0.0406874	9.22	0.000	0.2952342	0.4552564
Family profession	−0.0630425	0.0342077	−1.84	0.066	−0.1303114	0.0042263
Cons	2.233827	0.0608458	36.71	0.000	2.114175	2.35348

coef. = coefficients, Robust SE = robust standard error, p-value = significance level.

The Shapiro-Wilk normality test of residuals in Table 5.10 is also one of the tests which confirm residuals are normally distributed with a p-value of 0.61283.

Table 5.10 Normality test of residuals of OLS regression.

Shapiro-Wilk test for normal data					
Variable	Obs	W	V	z	Prob>z
Residuals (r)	376	0.99660	0.886	-0.287	0.61283

The link test is given in Table 5.11 also supports the Shapiro-Wilk test since a p-value of residual square 0.226 leads to accepting the null hypothesis stated that the model is well specified.

Table 5.11 Link test of OLS model.

Source	SS	df	MS	
				Number of obs = 376
				F (2; 373) = 346.88
Model	54.7096828	2	27.3548414	Prob > F = 0.0000
Residual	29.4145254	373	0.078859317	R-squared = 0.6503
				Adj R-squared = 0.6485
Total	84.1242082	375	0.224331222	Root MSE = 0.28082

CGPA	Coef.	Std. Err.	t	P > |t|	[95% Conf. Interval]	
_hat	0.2007448	0.6599016	0.30	0.761	-1.096849	1.498338
_hatsq	0.1437674	0.1185039	1.21	0.226	-0.089252	0.3767868
Cons	1.087929	0.9036104	1.20	0.229	-0.6888803	2.864738

The Variance Inflation Factor test also conducts a multicollinearity problem among independent variables. A Mean VIF of 1.72 given in Table 5.12 shows no such problem among the explanatory variables. The Robust test has also checked the assumption of constant variance in the model to avoid heteroscedasticity if any.

Table 5.12 Multicollinearity test of independent factors.

Variable	VIF	1/VIF	Variable	VIF	1/VIF
Usport	1.48	0.67567	PI	1.76	0.566879
SH	1.50	0.666524	FEDUC	1.18	0.848089
PL	1.30	0.770832	FP	1.32	0.756595
RP	1.06	0.943881	RM	1.21	0.829177
AUIF					
1	2.1	0.355609			
2	3.4	0.28263	Mean VIF 1.72		

5.4. Probit Regression Result on Factors Affecting Employment of Women Graduates in Engineering

The study has made a modest attempt to discuss women graduates' employability in engineering and technology education in Ethiopia. Hence, this study analyses factors affecting the employability of women graduates in engineering and technology jobs with collected data from 384 respondents.

Probit binary regression was used to identify the factors that affect the employability of women graduates in engineering and technology education. As explained in the second section of the paper, the dependent variable is the unemployment of women graduates in engineering and technology education. After checking Spearman’s rank correlation test, seven independent variables were included in the model, and various diagnostic tests were conducted. The value of Pseudo R^2 = 93.71% shows the model fit. The existence of the multicollinearity problem has been tested using a pairwise correlation test. The regressor variables are free from serious multicollinearity problems, Hosmer-Lemeshow test in Table 5.13, with the maximum p-value of (p=0.9968) showing that the model is fitted. Robust regression, if any, is used to avoid the heteroscedasticity problem.

Wald chi[2], which is highly important with a p-value of zero, evaluated the overall significance of the model.

Table 5.13 Hosmer-Lemeshow goodness-of-fit test result for Probit model.

Number of observations	384
Number of groups	8
Hosmer-Lemeshow chi2(6)	0.57
Significance level	Prob > chi2 = 0.9968

The result in Figure 5.4 also shows 97.66% of outcomes are classified correctly[9], which is the receiver operating characteristic curve (ROC)[10] that indicates the model is good since the area under the ROC curve is 0.9987, which is high enough

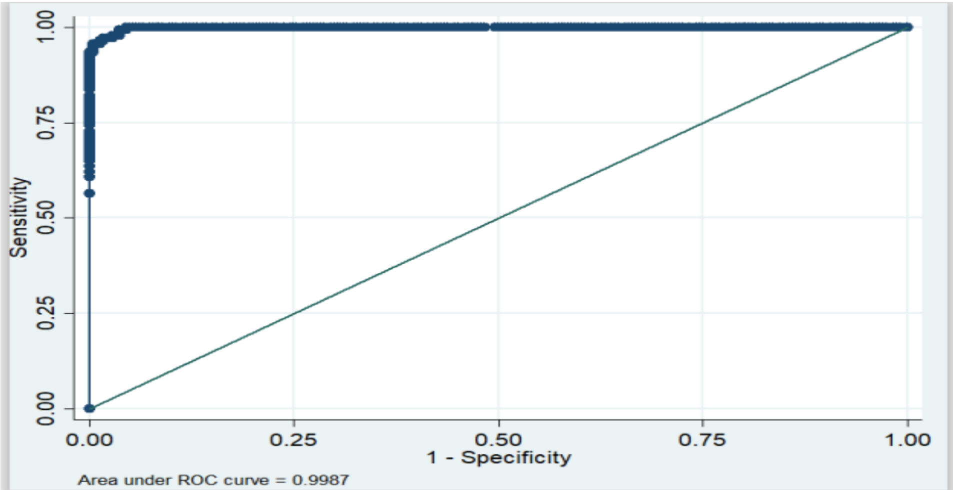

Figure 5.4. Sensitivity vs specificity test true classification of outcomes.

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[9] Define a as the cutoff specified as 0.5. Let pi be the predicted probability of a positive outcome and yi be the actual outcome, which we will treat as 0 or 1. A prediction is classified as positive if pi ≥ c and otherwise is classified as negative. The classification is correct if it is positive and yi = 1 or if it is negative and yi = 0. Sensitivity is the fraction of yi = 1 observations that are correctly classified. Specificity is the percentage of yi = 0 observations that are correctly classified.

[10] ROC curve, is a graphical plot of the sensitivity, or true positives, versus (1 - specificity), or false positives, for a binary classifier system as its discrimination threshold is varied. The higher is the area under the ROC curve, the better is the model.

Corresponding to all of these diagnostic tests of regression coefficients, the marginal effect[11] of the variable in Probit estimation has been presented in Table 5.14. From this table, marital status has a positive and significant impact on the unemployment of women graduates in engineering and technology. Married women graduates are 7.98 % more likely to remain unemployed than unmarried women graduate in engineering and technology, keeping other factors constant. The result is in line with the finding of Roy and Mukherjee (2013), who stated that unmarried women graduate has a higher probability of getting a job than married graduates. This increasing employment opportunity of women graduates leads to an increase in the benefits of women's economic independence (Mamun et al., 2008).

Academic performance measured by cumulative GPA is another significant variable, and it harms the unemployment of women in engineering and technology graduates. A unit increase in the average cumulative marks of graduates resulted in 9.68% less likely to remain unemployed, keeping ceteris paribus. The result confirms the previous study by Xu (2017) found that the cumulative GPA of graduates negatively impacted unemployment and concluded that students who were confident in self-asset readiness and competitiveness in academic achievement were more likely to seek jobs. They should pursue academic knowledge and prepare for work simultaneously. Moreover, individual competency is a crucial measure of obtaining employment and future career development. Previous studies (Imose and Barber, 2015; Drydakis, 2016) also found a positive association between graduate employability and academic performance.

As the estimation shows, when graduates' communication skills improve by 1%, it leads to declines in their probability of remaining unemployed by 13.98% than those who are not decent communicators. The result confirms the hypothesis of the positive relationship between women graduates with good communication skills and employability. This is supported by the previous studies (Osmani et al., 2015), who stated that communication skill is the significant criterion of graduate employability, which

[11] Interpretations has performed based on the marginal effect of Probit estimation, as it is used by several studies such as (Abebe 2011; BAAH 2013). The result from the Probit and Logit model considered as similar except little different (Maddala and Lahiri 1992).

becomes an issue since there are broad mismatches between the acquired graduate skills from university and the required skills by employers. This result is also consistent with a study by Salleh et al. (2010), who argued that communication skills are soft skills that employers need to hire graduates in particular occupations. The result also confirms (Teijeiro et al., 2013) that participating in various activities such as student councils, scouts' clubs, sports, music, and arts clubs, besides academic studying, will improve graduates' communication skills. This contributes to increasing the probability of their employability.

The absolute value of the z-score of the variable communication skill presented in Table 5.14 and Table 5.15 is more than others. It has a higher impact on women graduates' employability than others. According to the rule of thumb, this is true, which tells the value of z- score more than 2.0 shows the significance of variables. Therefore, employability could be enhanced through work-integrated learning and collaborative practice, essential for women to intensify confidence, improve social interaction, and thoughtful principal for employment after graduation (Wilson and Wilson, 2019).

The result also indicates that willingness to migrate is another significant factor, which reduces the unemployment of women graduates in engineering and technology education. It suggests that a 1% increase in women who can travel to search for jobs can decrease their probability of unemployment by 5.55% than those who couldn't move from place to place to search for a job by assuming other things remain constant. Graduates may not be freely moving from place to place to search for a job due to political instability, shortage of money to cover moving costs, preference of residence, and weak inter-industry labor mobility, leading to unemployed graduates. Existing studies in the literature did not study this variable as a factor that affects women graduates' employability. Hence, this factor's finding, which negatively influences unemployment, will add value to the existing literature.

Another result of this study indicates that job preference positively and significantly impacts women graduates' unemployment in engineering and technology education. Women who prefer a job by any means increase their probability of being unemployed by 17.34% than those who do not select a job, keeping other factors constant. This is consistent with Schuster et al. (2020), who found that graduates' job preferences and expectations may be heterogeneous with available employment, leading to increased unemployment of graduates.

This study also confirms the negative association between women graduates in engineering and technology education with non-technical skills and unemployment. Thus, women graduate with better non-technical skills are 4.57% less likely to remain unemployed than those who don't have such talent keeping other variables unchanged. Apart from engineering, technology, and technical skills, graduates need to have many non-technical skills such as negotiating, aware of the fiscal system, self-management, teamwork, business and customer awareness, problem-solving, etc. Due to a lack of them, a woman may not get a job. The result of the study is also supported by (Humburg et al., 2013; Jackson, 2016; Pan et al., 2018) showed that working in a team, being given duty, and joint learning in work placement has provided tremendous value for generating skill development and actual knowledge, which is vital to get employment after graduation. So that graduates must be taking the initiative and improving their entrepreneurial skills.

Table 5.14 Probit regression results of average marginal effects of significant variables.

Variables	Delta-method					
	Coefficient	Robust SE.	z	p	(95 % Conf. interval)	
Marital status	0.0798111	0.0173748	4.59	0.000	0.045757	0.1138651
GPA	-0.0967624	0.017043	-5.68	0.000	-0.1301661	0.0633587
Communication skill	-0.1398106	0.015546	-8.99	0.000	-0.1702803	-0.1093409
Willingness to migrate	-0.0554699	0.0142542	-3.89	0.000	-0.0834075	-0.0275322
Job preference	0.1734469	0.0263274	6.59	0.000	0.1218462	0.2250476
Non-technical skill	-0.0457021	0.0151482	-3.02	0.003	-0.0753919	-0.0160122
Year dummy 2017	-0.0298002	0.0142708	-2.09	0.037	-0.0577704	-0.0018299
Model VCE: Robust		Number of obs = 384				

Additionally, the estimated coefficient of the included year dummy variable, the intercept in 2016 and 2017, is differed by -2.98 percent. The interaction effect based on equations 21 and 22 have also been given in Table 5.15. This shows the estimated coefficient of the interaction between explanatory variables, and the year dummy is the difference between the effect of independent var in the period 2017 and 2016. Hence, marriage's impact on the probability of employability of women graduates in engineering and technology differs between 2016 and 2017 by -3.05 percentage points. Similarly, the impact of decent communication skills and willingness to migrate for searching jobs on the predicted probability of unemployed women graduates differs between 2016 and 2017 by -6.2 and 9.7 percentage points. The effect of job preference and non-technical skills also vary between these two periods by -1.4 and 5.2 percent, respectively.

Table 5.15 Results of interaction effect.

at: YD = 0 2 at: YD =1		Dy/dx	Std. err	z	$P > \|z\|$	(95 % Conf. interval)	
MR	at 1	0.0947772	0.029748	3.19	0.001	0.0366157	0.1529388
	at 2	0.0642114	0.0214668	2.99	0.003	0.0221372	0.1062856
GPA	at1	-0.0500624	0.0345745	-1.45	0.148	-0.1178272	0.0177024
	at 2	-0.1061452	0.0776175	-1.37	0.171	-0.2582727	0.0459824
CS	at 1	-0.1828978	0.0278222	6.57	0.000	-0.2374284	-0.1283672
	at 2	-0.2445419	0.0289438	-8.45	0.000	-0.3012708	-0.1878131
WM	at 1	-0.1130036	0.0194068	-5.82	0.000	-0.1510402	-0.074967
	at 2	-0.0163193	0.0073633	-2.22	0.027	-0.030751	-0.0018876
JP	at 1	0.4617063	0.0512428	9.01	0.000	0.3612723	0.5621403
	at 2	0.448005	0.0208866	21.45	0.000	0.407068	0.488942
NTS	at 1	-0.068717	0.0271723	-2.53	0.011	-0.1219737	-0.0154603
	at 2	-0.016342	0.0056993	-2.87	0.004	-0.0275123	-0.0051717

In general, the Probit model results reveal that the unemployment of engineering and technology graduated women is negatively influenced by communication skills, academic performance (cumulative GPA), willingness to migrate from one place to another for searching jobs, and non-technical skills. While job preference and marriage positively influence women's unemployment, it implies that women who graduate with the habit of job preference and married will increase their probability of remaining unemployed, keeping other things constant. These results are confirmed by model fitting diagnostic tests such as the Hosmer-Lemeshow test.

5.5. Challenges Faced by Women in Engineering Working Place

The sixth objective is on challenges or barriers faced by women engineers at the work place (page). Thirteen challenges have been identified through review of literature.

Table 5.16 Challenges faced by women engineers at the work place.

S. N	Challenges	Frequency	Percentage
1	Sometimes I have problem of conflict with costumers, staff members and leaders	19	7.79
2	There was problem of communication with costumers, students and staff members at the beginning of joining my organization	8	3.28
3	There is discrimination, undermining and discouraging on the bases of gender, race and religion	18	7.38
4	Problem of accessibility of infrastructure like water sanitation, electricity and materials and problem of adaptation of whether condition.	6	2.46
5	Work load and conflict with leaders	10	4.10
6	Conflict with leaders and discrimination	2	0.82
7	Financial problems due to minimum salary and absence of clear system of work	3	1.23
8	Financial problem and conflict with costumers	2	0.82
9	Problem of housing residence	4	1.64
10	Lack of good governance of managers and shortage of materials	6	2.46
11	Scarcity of capital, working place, and market accessibility to run own business	6	2.46
12	There is selfishness among staff members	2	0.82
13	I didn’t suffer any challenges in my work place still now	158	64.75

The results from Table 5.16 shows that out of 244 total respondents, 35.25 % have mentioned significant problems and challenges, which women in engineering and technology professionals are suffering. Such obstacles are:

- The problem of conflict with customers, staff members, and leaders,
- The problem of communication with customers and students, discrimination, undermining and discouraging based on gender, race, and religion,
- The problem of accessibility of infrastructures like water sanitation and electricity,

- The problem of workload and conflict with leaders, lack of good governance of managers,
- Shortage of materials, scarcity of capital, working place, and market accessibility to run their own business and others,
- The minimum and unequal wage, progression, security, unconscious biases, stereotype, societal, cultural, and institutional issues

Fortunately, the result of this current study indicates that most women professionals in engineering and technology have better working environments in Ethiopia. However, the previous studies done by Gill et al. (2008) founds the attitudes and experiences of engineering workplaces continue to be uncertain environments for professional women. Botella et al. (2019) also studied gender diversity in STEM education. He found that 42% of skilled women workers thought there was a lack of female role models. 39% experienced gender biasing in the workplace, 36% pointed out that they had unequal growth opportunities than men, and 35% indicated a gender pay gap for the same skills.

In summary of chapter five, the second to six objectives (i.e. examine the effect of economic growth on women human capital formation in engineering education in Ethiopia, investigate factors affecting women's choice of pursuing engineering education, explore factors affecting academic performance of women in engineering education, analyses factors affecting women graduates' employability in engineering, identify challenges faced by working women engenderers) are analysed through four models using primary and secondary data.

CHAPTER -SIX

CONCLUSION AND RECOMMENDATION

6.1.Background

Like many countries, women are underrepresented in higher education in general and in engineering education particular in Ethiopia. Regarding of achieving sustainable goals, engineers have to come to the entire stage of development framework. Out of 17 goals almost ten needs direct involvement of engineers for its achievement (Singh, 2019). So, government across the globe and in Ethiopia are taking effort to increase participation of women engineers. In this background the study has investigate the status of women in engineering education and employment on the basis of secondary and primary data analysed through appropriate econometric tools.

Secondary data was gathered from various sources, such as annual reports from the Ethiopian Ministry of Education, UNESCO, the African Development Bank Group, the World Bank, and ILOSTAT. Journals papers, books, periodicals, proceedings, on women's participation in STEM education, have been considered. Primary data have also been collected from 843 women university students and graduates using structured questionnaires and extensive interview.

The Augmented Dickey-Fuller Unit Root test has been conducted. The study also used the bound test to investigate whether there is co-integration in the short and long run. After conducting a bound test, the ARDL model with error correction term has been estimated. Logit and Probit binary regression models and OLS (ordinary least square multiple linear regression estimation) have also been used in this study. Spearman's Rank Correlation test of selected variables has also been computed. In addition, various post estimation tests, such as multicollinearity, heteroscedasticity, Hosmer-Lemeshow tests, etc., were computed to check the unbiasedness of estimated coefficients and model fitting.

6.2.Conclusion

With this background, there are six objectives of the study. the first objective of this study is analysing women's participation in STEM education and employment. The statistical analysis of secondary data shows low-level women enrollment in engineering and technology fields, accounting for 24% from 2007 to 2016 in the case of Ethiopia. The statistical analysis of secondary data also shows women under-represented in STEM employment in Ethiopia and the world, even though some countries have better trends (see figures and tables in chapter 4). As these countries are at different level of economic development, the socio-economic reasons of these countries may be different and that is why there is urgent need of country wise investigation.

The second objective is to examine the effect of economic growth on women's human capital formation in engineering and technology education in Ethiopia during 1997-2018. The result shows that economic growth and government expenditure on education have a significant and positive impact on women's human capital formation in engineering and technology education in the long run. However, education value-added affects negatively and significantly in the long run and the short run. The presentation of the co-integration model has been checked through Durbin's alternative test, Breusch-Godfrey test, and serial correlation LM test. These tests approve of the nonexistence of serial correlation. Similarly, the cumulative sum of the square test (CUSUM Square) reveals the stability of the model. As the finding shows that the government expenditure has positive impact on women's participation. It is suggested that the government should made some exclusive expenditure to enhance women participation as it has been done in India. A technological university at Delhi is exclusive for women. There is reservation of seats for women in all IITs. Various states of India have also reserved seats in engineering colleges. As already discussed, that the growth rate of Ethiopian economy was very low before 2000. However, during last two decades, it has remained very high. This also leads to increase women enrolment in engineering.

In the third objective, we have discussed the factors affecting women's choice of pursuing engineering and technology education. The outcome of this objective shows expected salary is the most influencing factor. Other factors, high school education performance (results of grade 12 exam), the presence of an engineer and technologist in the family, access to role models, and the family's annual income, positively affect women's choice of learning engineering and technology education. The professional bodies working in this area (a long list is given in the first chapter- Introduction, p 15-16), may take care of the factor, 'absence of role models.' Fellowship may be given to brilliant girl students from poor households. Special coaching may be arranged for girls for improving their performance at higher school level.

The fourth objective is investigating the factors affecting women’s academic achievements in engineering and technology education in Ethiopia. In this objective, we found that the academic performance of women students in engineering and technology education is positively influenced by students’ capabilities to gather information about the institution before joining the university. Interventions that support women students, peer learning habits of students, and the accessibility of university infrastructure also positively affect women’s academic performance. In contrast, sexual harassment and the existence of engineering and technology professionals in the family negatively influence women's academic performance. Shapiro-Wilk test for normal data, link test, normality test of residuals, and the robust test, etc., confirmed unbiasedness of estimated coefficients.

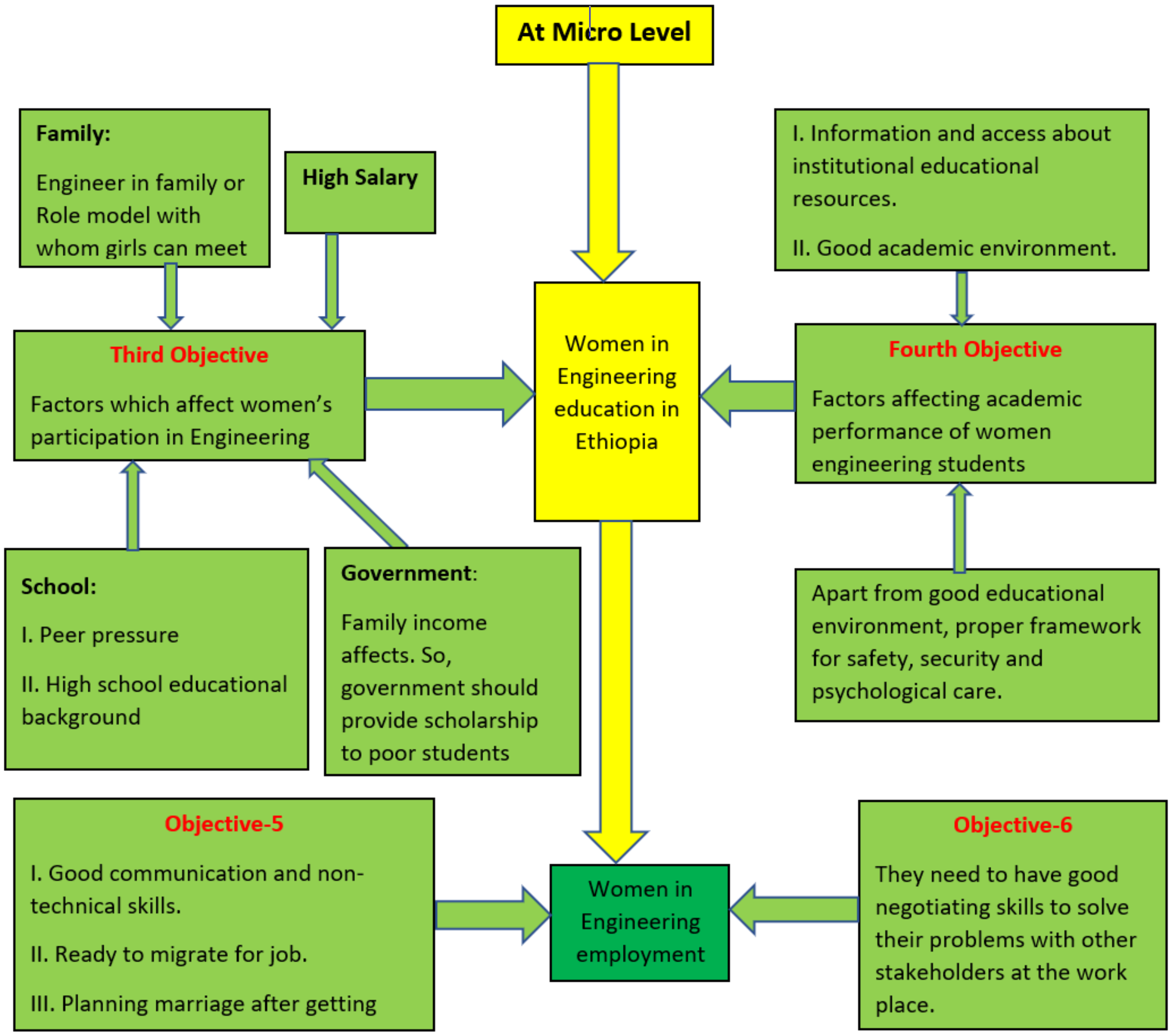
The fifth objective is exploring the factors affecting the employability of women graduates in engineering and technology education in Ethiopia. Here, we found that the unemployment of women graduates in engineering and technology is negatively influenced by communication skills, academic performance (cumulative GPA), willingness to migrate from one place to another for searching jobs, and non-technical skills. While job preference and marriage impact women's unemployment positively. These results are confirmed by model fitting diagnostic tests such as the Hosmer-Lemeshow test.

The last objective six is analysing the challenges faced by working women engineers and technologists even after getting employment. Regarding this objective, out of 244 total respondents, 35.25% have mentioned major problems and challenges that woman in engineering and technology professionals are suffering. Among these: the problem of conflict with costumers, staff members, and leaders; discrimination, undermining, and discouraging on the basis of gender, race, and religion; problem of accessibility of infrastructures like water sanitation, electricity, and materials and the problem of adaptation of whether condition; Financial problem due to minimum salary, work load; the problem of housing residence, lack of good governance, etc.

Figure- 6.1 Graphical Representations of the Finding

At Macro Level

I. Women participation in engineering education and employment is low in both type of countries, developed and developing (First Objective).
II. As countries growth rate increases, there is more women human capital formation in engineering (Second Objective).
III. Out of seventeen SDGs, ten goals need intensive participation of engineers for their achievement (Singh, 2019) as technological intensity of even non-technological sectors have increased manifold.
IV. To provide personalized technical based services in the market, diversity is required among engineers.
V. Thus, there is urgent need to enhance women human capital formation in engineering.
VI. As there may be difference in socio-economic factors affecting women's participation in engineering, there is urgent need of conducting country wise studies.
VII. Women in engineering education and employment in Ethiopia has been undertaken.



6.3. Suggestions and Recommendations

For Regulatory Bodies and Stakeholders

The study's finding regarding the impact of economic growth on women's human capital formation implies that improving economic growth and government expenditure on education is necessary for increasing women's human capital formation in engineering and technology education. This helps expand economic development in the long run. Hence, the government should work to enhance economic growth indicators and public expenditure on education. The finding also implies that government should improve women's enrollment in engineering and technology education by providing better wages for women graduates in this profession.

In addition, the finding implies that government should enhance women's academic performance, reduce gender gaps in STEM education, and promote sustainable development. The government must enhance education quality by paying more attention to the examination system, recruiting professionals according to their ability rather than through corruption, race, gender, religion, etc. that leads to discouraging students' academic achievement.

This study provides an attempt for the government to provide more concern for apparent ship, practical works, workshops, and class teaching. These can help students improve their communication and technical and non-technical skills, which is the basis for employment.

Moreover, the government should approve citizens' peace and security and expand infrastructures such as power, roads, and health. Accordingly, graduates will have the freedom to go everywhere in the country to search for jobs. The government must work on a channel between universities and firms through teaching with a work placement curriculum. These all can reduce human capital resource wastage and unemployment problems among graduates.

Besides the low proportion of participation of women in engineering and technology professions, they have many challenges in the working place of these professions, as discussed in the result section of this study. This study finding implies low participation of women in engineering & technology education and employment needs great emphasis by the prospective government bodies to improve the role of women in the route of economic development. Such as the government must work on: creating awareness about gender equality for the concerned body, establishing good governance of managers, must have rules and regulations to reduce discrimination and violation, must enhance basic infrastructure like electricity, water, road, etc., by using endogenous knowledge and materials, must have financial credit availability, and must have strong security of citizens. Reservations should be made by regulatory agencies to encourage women to pursue engineering degrees. For example, practically all engineering institutes in India set aside at least 5% of seats for women in order to increase women's participation in engineering study and employment.

The concerned stakeholders should maintain education quality and produce eligible women students (i.e., improve access to learning materials, support girls, accessibility of role models, etc.) who can pass the standard qualification required to join engineering and technology education. The finding also implies stakeholders should enhance women's enrollment in engineering and technology education. Such as employers must provide better wages for women graduates in this profession.

In addition, the finding implies that stakeholders should enhance women's academic performance, reduce gender gaps in STEM education, and promote sustainable development. Engineering colleges must pay attention to students' psychological, economic, and academic support, arrange infrastructure and learning facilities, and protect students from sexual harassment through strong commitment and regulations. Employers must provide better wages for women graduates in this profession.

For Parents and Students

There must be family's encouragement for their girls to join engineering and technology. As a mode of encouragement, families should arrange and facilitate meeting between young girls with the role models from the area of engineering and technology. Girls need to work hard not only to perform better in the entrance exams but to enhance their academic performance while pursuing engineering education. Students must have a peer learning experience and have information about the universities (system, rules, regulations, etc.).

Engineering and technology graduates must improve their communication and non-technical skills beyond recording better grade points to decrease their probability of being unemployed after graduation. Graduates must be ready to go anywhere to search for jobs rather than comparing and preferring jobs under the presence of job scarcity. The finding related to marital status implies that graduated women should not engage in marriage before having her job to reduce economic dependency. These all can reduce human capital resource wastage and unemployment problems among graduates. This study finding also implies women laborers must try to solve conflict with others through negotiation.

6.4. Limitation of the Study

The current study has following two main limitations:

I. First and foremost, limitation of the study is considering only female students for primary data collection.

II. Second limitation may be considering women engineers to study the employment aspect who have graduated during last three years. The study has been conducted based on cross-sectional primary data.

6.5.Suggestions for Future Research

The area is very relevant and less researched. So, many related works may be done in future. A similar work may be done by including male students in the sample. Secondly, a backward linkage also may be investigated with study of girls in secondary and higher secondary education as why women's enrolment in secondary school has shown an insignificant impact on women's human capital formation in engineering and technology education at the university level. Next suggestion is about a full-fledged study of employment among women engineers considering women engineers of different age groups. The study may conduct at national or even at international level.

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Appendix

1. The mathematical form of bounds test for each variable

$$\Delta LGDP_t = \alpha_0 + \sum_{i=1}^{m} \alpha_1 \Delta LGDP_{t-i} + \sum_{i=0}^{n} \beta_1 \Delta LWHCE_{t-i} + \sum_{i=0}^{p} \beta_2 \Delta LGE_{t-i} + \sum_{i=0}^{q} \beta_3 \Delta LWHCS_{t-i} + \sum_{i=0}^{r} \beta_4 \Delta LEVA_{t-i} + \delta_1 LW\ HCE_{t-1} + \delta_2 LGDP_{t-1} + \delta_3 LGE_{t-1} + \delta_4 LW\ HCS_{t-1} + \delta_5 LEVA_{t-1} + \varepsilon_{2t}$$

$$\Delta LGE_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta LGE_{t-i} + \sum_{i=0}^{r} \beta_1 \Delta LW\ HCE_{t-i} + \sum_{i=0}^{q} \beta_2 \Delta LGDP_{t-i} + \sum_{i=0}^{m} \beta_3 \Delta LW\ HCS_{t-i} + \sum_{i=0}^{n} \beta_4 \Delta LEVA_{t-i} + \delta_1 LWHCE_{t-1} + \delta_2 LGE_{t-1} + \delta_3 LGDP_{t-1} + \delta_4 LW\ HCS_{t-1} + \delta_5 LEVA_{t-1} + \varepsilon_{3t}$$

$$\Delta LWHCS_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta LWHCS_{t-i} + \sum_{i=0}^{r} \beta_1 \Delta LWHCE_{t-i} + \sum_{i=0}^{q} \beta_2 \Delta LGDP_{t-i} + \sum_{i=0}^{m} \beta_3 \Delta LGE_{t-i} + \sum_{i=0}^{n} \beta_4 \Delta LEVA_{t-i} + \delta_1 LW\ HCE_{t-1} + \delta_2 LGE_{t-1} + \delta_3 LGDP_{t-1} + \delta_4 LW\ HCS_{t-1} + \delta_5 LEVA_{t-1} + \varepsilon_{4t}$$

$$\Delta LEVA_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta LEVA_{t-i} + \sum_{i=0}^{r} \beta_1 \Delta LWHCE_{t-i} + \sum_{i=0}^{p} \beta_2 \Delta LGDP_{t-i} + \sum_{i=0}^{m} \beta_3 \Delta LWHCS_{t-i} + \sum_{i=0}^{m} \beta_4 \Delta LGE_{t-i} + \delta_1 LWHCE_{t-1} + \delta_2 LGE_{t-1} + \delta_3 LGDP_{t-1} + \delta_4 LWHCS_{t-1} + \delta_5 LEVA_{t-1} + \varepsilon_{5t}$$

2. Questionnaires

2.1 Questionnaire for (Natural Science Students First Year to Final)

Dear Respondents!!

I am PhD student at Delhi technological University – Delhi carrying out my research on 'ANALYSIS OF WOMEN HUMAN CAPITAL IN ENGINEERING & TECHNOLOGY EDUCATION, AND EMPLOYMENT PARTICIPATION IN ETHIOPIA: A STUDY OF AMHARA REGION' and I am looking your cooperation and would really appreciate your help for completing my questionnaire. Please fill carefully and honestly the following questions accordingly. Thank you for your kind cooperation. Your information is secured.

Mrs. Addissie Melak

1.Identification Code (መለያ ቁጥር): ___________________

2.Student's faculty (ፋኩሊቲ): – Engineering (ኢንጅነሪንግ) ☐ N. Science (ተፈጥሮ ሳይንስ) ☐

3.Branch/Area (ትምህርት ክፍል): ________________________

4.Number of people in the family (የቤተሰብ ብዛት): _________________

5.Is there any highest degree holder in your family member? (በቤተሰብ ዉስጥ በማንኛዉም ዲግሪ የተመረቀ ሰዉ አለ)?

Yes (አለ) ☐ No (የለም) ☐

6.Do you have Engineering and Technology graduate in your family? (በኢንጅነሪንግ እና በቴክኖሎጂ የተመረቀ ቤተሰብ አለ)?

Yes (አለ) ☐ No (የለም) ☐

7.Annual Income of your Family (ዓመታዊ የቤተሰብ ገቢ) (in near '00,000) _______________

8.Area of original residence (የትዉልድ አካባቢ): Urban (ከተማ) ☐ Rural (ገጠር) ☐

9.Do you have a role model (እንደ ሞዴል የምታይዉ ሰዉ አለሽ)? Yes (አዎ) ☐ No (የለም) ☐

10.Do the duration of programme bothers you (ት/ቱን ለመማር የሚጨርሰዉ ዓመት መብዛት አሳስቦሽ ያዉቃል)? Yes (አዎ) ☐ No (የለም) ☐

11.Whether your family suggested you to join the courses which are pursuing (የምትማሪዉን ት/ት የመረጥሽዉ በቤተሰብ ምክር እና ግፊት ነዉ)? Yes (አዎ) ☐ No (አይደለም) ☐

12.Whether your friends made pressure on you to join the course you are studying (የምትማሪዉን ት/ት የመረጥሽዉ በጓደኞችሽ ግፊት ነዉ)? Yes (አዎ) ☐ No (አይደለም) ☐

13.What was the aggregate mark of your grade 12 examination (የ12ኛ ክፍል ብሔራዊ ፈተና ዉጤት ምን ያህል ነበር)? _______________

14. Do you think that the salary you are expecting after graduation pushes you to join the course you are pursuing? የምትማሪው ትምህርት የመረጥሽው በዚህ ትምህርት ክፍል ብማር የተሻለ ደሞዝ ይከፈለኛል ብለሽ አስበሽ ነው? Yes (አዎ) ☐ No (አይደለም) ☐

2.2.Questionnaire for (Engineering and Technology Students in 1st Year to 5th Year)

Dear Respondents!!

I am PhD student at Delhi technological University – Delhi carrying out my research on 'Women Engineers: Participation in Education and Employment in Ethiopia' and I am looking your cooperation and would really appreciate your help for completing my questionnaire. Please fill carefully and honestly the following questions accordingly. Thank you for your kind cooperation. Your information is secured.

Mrs. Addissie Melak

1.Identification Code (መለያ ቁጥር): ___________________

2.Student's faculty (ፋኩሊቲ): – Engineering and Technology (ኢንጅነሪንግ እና ቴክኖሎጂ) ☐

3.Branch/Area (ትምህርት ክፍል): ________________________

4.Number of people in the family (የቤተሰብ ብዛት): _________________

5.Is there any highest degree holder in your family member? (በቤተሰብ ዉስጥ በማንኛዉም ዲግሪ የተመረቀ ሰዉ አለ)? Yes (አለ) ☐ No (የለም) ☐

6.Do you have an Engineering and technology graduate in your family? (በኢንጅነሪንግ እና በቴክኖሎጂ የተመረቀ ቤተሰብ አለ)? Yes (አለ) ☐ No (የለም) ☐

7.Annual Income of the Family (ዓመታዊ የቤተሰብ ገቢ) (in near '00,000) ________________

8.Area of original residence (የትዉልድ አካባቢ): Urban (ከተማ) ☐ Rural (ገጠር) ☐

9.Do you have a role model (እንደ ሞዴል የምታይዉ ሰዉ አለሽ)? Yes (አዎ) ☐ No (የለም) ☐

10.Do the duration of the programme bothers you (ት/ቱን ለመማር የሚጨርሰዉ ዓመት መብዛት አሳስቦሽ ያዉቃል)? Yes (አዎ) ☐ No (የለም) ☐

11.Whether your family suggested you join the courses which are pursuing (የምትማሪዉን ት/ት የመረጥሽዉ በቤተሰብ ምክር እና ግፊት ነዉ)? Yes (አዎ) ☐ No (አይደለም) ☐

12.Whether your friends made pressure on you to join the course you are studying (የምትማሪዉ የመረጥሽዉ በጓደኞችሽ ግፊት ነዉ)? Yes (አዎ) ☐ No (አይደለም) ☐

13. What was the aggregate mark of your grade 12 examination (የ12ኛ ክፍል ብሔራዊ ፈተና ዉጤት ምን ያክል ነበር)? ______________

14. What is your cumulative GPA (አሁን ያለሽ አማካይ ጂፒኤ ስንት ነው)? ________________

15. Do you think that the salary you are expecting after graduation pushes you to join the course you are pursuing? የምትማሪውን ትምህርት የመረጥሽው በዚህ ትምህርት ክፍል ብማር የተሻለ ደሞዝ ይከፈለኛል ብለሽ አስበሽ ነው? Yes (አዎ) ☐ No (አይደለም) ☐

16. Are you comfortable with teaching methodology of your teachers (የመምህራኖች የማስተማር ዘዴ ይስማማሻል)? Yes (አዎ) ☐ Partly (በከፊል) ☐

17. Do you have an experience of peer learning (learning groups) beyond normal class (ከመደበኛው ክፍለ ጊዜ በተጨማሪ ከጓደኞችሽ ጋር የመማማር ልምድ አለሽ)? Yes (አዎ) ☐ No (የለም) ☐

18.How do you rate the university infrastructure i.e laboratory, library, hostel etc. (የምትማሪበትን ዩኒቨርሲቲ የመሰረተ ልማት አቅርቦት ለምሳሌ:-ቤተ ሙከራ፣ ቤተ መጻህፍት፣ የምኝታ ክፍልና የመሳሰሉት እንዴት ታይዋለሽ)? Good (በጣም ጥሩ) ☐ Medium (መካከለኛ) ☐ Low (ዝቅተኛ) ☐

19.Have you faced sexual harassment (በዩኒቨርሲቲዉ ዉስጥ ጾታዊ ጥቃት ደርሶብሽ ያዉቃል)?

Yes (አዎ) ☐ No (የለም) ☐

20.Have you got any affirmative action from the concerned body of the university like financial, academic, guidance & counselling support to improve your academic performance (በዩኒቨርሲቲዉ ማህበረሰብ ት/ትሽን ለማሻሻል የሚያግዝ የተደረገልሽ ድጋፍ አለ? ለምሳሌ:- የገንዘብ፣ ትምህርታዊ፣የምክር እና የመሳሰሉት አገልግሎት) Yes (አዎ) ☐ No (የለም) ☐

21. Did you informed about the university before you join (ስለምትማሪበት ዩኒቨርሲቲ ከመግባትሽ በፊት ቅድመ መረጃ ነበረሽ)? Yes (አዎ) ☐ No (አልነበረኝም) ☐

2.3.**Questionnaire (For Graduated Students from Engineering and Technology, Including Employed in Those Graduates**)

Dear Respondents!!

I am PhD student at Delhi technological University – Delhi carrying out my research on 'Women Engineers: Participation in Education and Employment in Ethiopia' and I am looking your cooperation and would really appreciate your help for completing my questionnaire. Please fill carefully and honestly by marking ✓ sign for the following questions accordingly. Thank you for your kind cooperation. Your information is secured.

Mrs. Addissie Melak

1.Introduction (የግላዊ ሁኔታ መግቢያ)

1.1Identification Code (መለያ ቁጥር): _______________

1.2. Student's faculty (ፋኩሊቲ): – Engineering (ኢንጅነሪንግ)

1.3. Branch/Area (ትምህርት ክፍል): ______________________

1.4. Number of people in the family (በቤተሰብዎ ዉስጥ ያሉ የቤተሰብ ብዛት): ______________

1.5. Highest degree of any of your family member (ቤተሰብዎ ዉስጥ በማንኛዉም ዲግሪ የተመረቀ ሰዉ አለ?) Yes (አለ) ☐ No (የለም) ☐

1.6. Do you have engineering and technology professionals in the family (በቤተሰብዎ ዉስጥ በኢንጅነሪንግ እና በቴክኖሎጅ የተመረቀ ሰዉ አለ)?

Yes (አዎ) ☐ No (የለም) ☐

1.7. Annual Income of the Family (ዓመታዊ የቤተሰብ ገቢ) (in near '00,000) ______________

1.8. Area of original residence (የትዉልድ አካባቢ): Urban (ከተማ) ☐ Rural (ገጠር) ☐

2. Unemployment-Employment among Women Engineering Graduates (የሴት ኢንጅነሪንግ ተመራቂዎች የቅጥር ሁኔታ)

2.1. Have you got job (በአሁኑ ሰዓት በስራ ላይ ነዎት)? Yes (አዎ) ☐ No (የለም) ☐

2.2. Are you married (አግብተዋል)? Yes (አዎ) ☐ No (የለም) ☐

2.3. Your cumulative GPA (ሲመረቁ የነበረዎት አማካይ ጂፒኤ) ____________________

2.4. How is your communication skill (ከሰዎች ጋር ያለዎት ተግባቦት ሁኔታ እንዴት ነዉ)?

Good (ጥሩ ነዉ) ☐ Not good (ጥሩ አይደለም) ☐

2.5. Are you ready to go to other place for searching job (የትኛዉም ቦታ ላይ ስራ ቢያገኙ ሂዶ ለመስራት ዝግጁ ነዎት)? Yes, I will (ዝግጁ ነኝ) ☐ No, I will not (ዝግጁ አይደለሁም) ☐

2.6. Are you working the job that you are not preferred or unemployed because of not getting the job that you are looking for? (የማይፈልጉትን ስራ ነዉ እየሰሩ ያሉት ወይስ በስራ ላይ ያልተሰማሩበት የሚፈልጉትን የስራ አይነት በማጣት ምክንያት ነዉ？)

Yes (አዎ) ☐ No (አይደለም) ☐

2.7. How you are in skills like working in groups, able to negotiating things, searching information through media etc. (በመደራጀት በጋራ የመስራት፣ ከሰዎች ጋር በቀላሉ የመግባባት፣ መረጃዎችን የመከታተል እና የመሳሰሉት ላይ ያለዎት ክህሎት ምን ይመስላል)?

Good (ጥሩ ነዉ) ☐ No (ጥሩ አይደለም) ☐

Dear respondents if you are employed, please reply (give answer) questions from 2.8 to 2.13 (በስራ ላይ ያሉ ከሆኑ ከጥያቄ ቁጥር 2.8 እስከ 2.13 ላሉት መልስ ይስጡ)

2.8. Monthly salary on nearby thousand (የወር ደመወዝ መጠን በሺህ አቅራብ):

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2.9. Nature of your organization (የሚሰሩበት መስሪያ ቤት አይነት).

Government (የመንግስት) ☐ Private (የግል) ☐

2.10. Number of women engineer in your organizations (በመስሪያ ቤትዎ ያሉ ሴት ኢንጅነሮች ብዛት).

2.11. Whether there is provision of maternity leave (በመስሪያ ቤትዎ ዉስጥ የወሊድ ፈቃድ ምቹ ሁኔታ አለ)? Yes (አለ) ☐ No (የለም) ☐

2.12. Whether there is facility to get education leave (በመስሪያ ቤትዎ ት/ት ለመማር የሚያስችል ምቹ ሁኔታ አለ)? Yes (አለ) ☐ No (የለም) ☐

2.13. Please tell us challenges you faced in your working place (በስራ ቦታዎ ላይ ያጋጠመዎት ማንኛዉም ችግር ካለ ቢጽፉልን::)

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3. Publications During the Period of PhD

I. ***Addissie Melak, Seema Singh (2018) Experience of Women in Engineering Education: Literature Review. Asia Pacific Journal of Research, Vol: I. Issue LVV, February***

II. ***Addissie M., Seema Singh (2018) Factors Affecting Academic Performance of Women in Engineering Education and Their Experience of Participation in Employment: Literature Review. International Journal of Research, Volume 05 Issue 01.***

III. ***Melak, A., & Singh, S. (2020) Participation of Women in Engineering & Technology Education and Employment, International Journal of Management and Humanities (IJMH) ISSN: 2394 – 0913, Volume-4 Issue-7, March 2020***

IV. ***Melak, A., & Singh, S. (2020), The status of women participation in engineering and technology professions and their challenges in working institutions, International Journal of Management (IJM), Volume 11, Issue 11, November 2020, pp. 1489-1499.***

V. ***Melak, A., & Singh, S. (2021). Women's Participation and Factors Affecting Their Academic Performance in Engineering and Technology Education: A Study of Ethiopia. Sustainability, 13(4), 2246.***

VI. ***Melak, A., & Singh, S. (2021). Factors Affecting Women's Choice of Learning Engineering and Technology Education in Ethiopia. IEEE Access, vol. 9, pp. 83887-83900.***

<u>Paper Under Review Process</u>

I. ***The impact of economic growth on human capital formation through engineering & technology education among women: an ARDL Bound Test, International Journal of Social Economics, first submission was June 16/2020, revised version submitted on May 08/2021.***

4. Conference Participation

I. ***Melak. A & Singh. S, (2018). Assessment of Trends and Share of Women in Engineering in Ethiopia: A Study of Their participation in Education and Employment. International Conference on Innovation, Knowledge Accumulation, and Development in the Era of Fourth Industrial Revolution. March 15-16, 2018., Department of Economics, Punjabi University, Patiala, (India)***

II. ***Melak. A & Singh. S, (2019). Why women graduate in engineering and technology remain unemployed: pooled cross-sectional analysis with interaction effect Presented in the 4th International Conference on Advanced Production and Industrial Engineering on December 20-21, 2019, Delhi Institute of Tool Engineering, organized by Delhi Technological University.***

III. ***Melak. A & Singh. S, (2020). Factors influencing women's decision to study engineering and technology. XXI Annual International Conference, Achieving Excellency in Higher Education, January 4-5, 2020 in Deen Dayal Upadhayaya College.***

IV. ***Melak. A & Singh. S, (2020). Challenges of Women Working in Engineering and Technology Professions,2020 Asia Pacific Nation Network and an International Conference on Women in Science and Technology held on 24-25 October 2020, New Taipei City, Taiwan.***

5. Workshop Participation

I. ***R and Econometric Tools organized by the Humanities department at Delhi Technological University held on March 5 to 9, 2019.***

II. ***One-Week online Workshop on Panel Data Analysis Organized by Department of Humanities at Delhi Technological University, From 17th to 22nd August 2020.***