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# Assessment of Integrated Aquaculture Intervention System in Amhara Region, Ethiopia

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***Abstract***

*Although integrated aquaculture has the potential to contribute to food security, it is still among the neglected sectors in Amhara regional state, Ethiopia. This study was designed: (1) to assess the performance of existing integrated aquaculture intervention and its contribution for farmers, (2) to evaluate the current pond management practices, and (3) to identify major obstacles that hinders integrated aquaculture practices. The data was collected from 11 purposively selected aquaculture potential districts of the region. The quantitative and qualitative data were analyzed by using descriptive statistics supported by exhaustive narrations. The study found that only 20.8% of the surveyed aquaculture ponds were functionally good. From these ponds, 25% of the aquaculture owners earned an average of 513.6 ETB per fish pond. However, these aquaculture adopters start harvesting after three to four years of fish stocking in irregular ways. Such irregularities in harvesting arises from farmers' minimal knowledge on post-harvest processing and lack of fishing nets. In this regard, 80.4% of the surveyed pond owners felt as they had not benefited from aquaculture adoption compared to their expectations. Based on the level of inputs used and degree of management, the current aquaculture practice in Amhara region inclined towards extensive type. In conclusion, aquaculture development remains at an infancy stage despite years of adoption in the region.*

**Keywords:** Aquaculture, pond management, stunting growth, knowledge gap, income generation

**JEL Code:** O44, Q00 and Q22

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## 1. Introduction

Ethiopia is a land-locked country with approximate 7400 Km2 surface area of water body and 7185 Km of river network (Eshete and Zemenu, 2012; Erkie et al., 2016). In addition, water harvesting dates back to the pre-Axumite period (560 BC), Lalibela Rock hewn churches (over 800 years ago), and castles in Gondar (15th and16th century) with a strong attachment to the ancient Orthodox churches (Habtamu, 1999) (Habtamu, 1999). During these periods, water was harvested and stored in ponds and tanks for agriculture, water supply and ritual purposes (Habtamu, 1999; Fitsume et al., 2014).

In Ethiopia, fishery has been subject to some funny and impressing incidences. First, fisheries have been organized under the Ministry of Defense, when most of the fish production relied on the Red Sea. Later, it joined the Ministry of Agriculture, and now the Ministry of Livestock and Fisheries. Second, even if Ethiopia is rich in diverse fish resources, water and environmental resources, it is found at the bottom of the aquaculture producers list (Abebe, 2016). A study by Gordon et al. (2007) has estimated aggregated demand growth for fish in Ethiopia to be 44% over ten years. As cited in Hussein et al. (2012), the early documents of FAO (1990) indicated that the national per capita fish consumption is about 0.21 kg/person/year. However, in fish producing areas of Ethiopia this figure changes and is estimated about 8.5 kg/person/year.

Although Ethiopia has huge fresh water and fish resources, conducive climatic conditions, huge labor and unsatisfied local demand for fish, aquaculture development in the country is lagging behind compared to other agricultural activities (Zewdie, 2016). In the country, the demand for fish grows exponentially every year, while the supply from the capture fisheries has consistently lagged behind the growth rate of demand for fish (Rothuis et al., 2012). Thus, the current increasing market demand for fish in Ethiopia can be met only when the capture fishery is supplemented by the culture fishery (Ashagrie et al., 2008; Berihun and Goraw, 2010). Therefore, aquaculture adoption is clearly necessary to bridge such gaps (Olaoye et al., 2014).

Aquaculture serves as a best alternative for over-exploited natural aquatic resources (Agbebi, 2011). It can reduce the pressure on the natural ecosystem and maintain ecological balance (Kassahun, 2012). Thus, aquaculture is carried out not only for increasing the availability of fish for food, but also to conserve the natural stock and thereby protect the biodiversity (Dereje et al., 2015).

Disappointingly, given favorable physical and hydrographic conditions (suitable geographic relief, good rainfall, and sufficient freshwater availability), aquaculture production is negligible in Ethiopia. In addition, it remains more potential than in actual practice (Sileshi, 2015), despite the fact that the country's environmental and socio-economic conditions support its development (FAO, 2014).

Although different agents in Amhara region have constructed a number of aquaculture ponds, there is no updated information or documentations on their performance. In addition, the successes or bottlenecks of the currently implemented integrated aquaculture system have not been well articulated. This study has therefore aimed to assess the status of the existing integrated aquaculture intervention system; to identify farmers' practice of integrated aquaculture; and to identify major constraints affecting their integrated aquaculture practices.

## 2. Research Methodology

### 2.1 Description of the Study Area and Site Selection

Amhara regional state is located in the north western and north central part of Ethiopia. It consists of 12 administrative zones with one special zone and most have the necessary physical and hydrographic conditions to provide for aquaculture practice. From these zones, 6 of them were selected for integrated aquaculture intervention assessment (Table 1). Based on the presence of integrated aquaculture practices and their potentials, 12 districts were purposively selected for the study.

**Table 1: Sampled zones and their respective districts**

| **Sampled study areas** | |
|---|---|
| **Zone** | **District /s** |
| South Gondar | Dera |
| West Gojjam | Jabi-Tehinan and South Achefer |
| Awi | Dangla |
| East Gojjam | Awabel, Enemay, Gozamen and Machakel |
| North Shewa | Angolela-ena-tera, Menz Mama and Menz Lallo |
| South Wollo | Mekane Selam |

### 2.2 Sampling Procedure and Data Collection

The sampled zones and districts were purposively chosen to collect data related to integrated aquaculture. In this regard, the main criteria used for site and respondent selection were the existence of aquaculture practices. In the region, the number of aquaculture ponds are not substantial and almost all aquaculture ponds were sampled. Once the pond owners are identified, the required data were collected by preparing a semi-structured questionnaire, direct observation, focus group discussions (FGD), and key informant interviews. The questionnaires were designed to solicit information about the existing integrated aquaculture intervention system; farmers' practices on pond fish farming; and the major challenges for integrated aquaculture.

After pre-testing the validity of the questionnaire and the checklists, the data from 72 aquaculture pond owners (farmers) were thoroughly collected. In addition, many of the qualitative and supplementary data were collected from 36 key informants (including fishery experts) and 16 focus group discussions (FGD). In order to identify major constraints that affect aquaculture production in the area, 29 potential constraints were drawn up from FGD, personal discussions and literature review during pretesting. All these constraints focused from site selection to consumption and marketing. During data collection, respondents were asked to rate the extent of each problem using three scales Likert scale (severe, low and not a problem).

### 2.3 Methods of Data Analysis

Descriptive statistics such as mean, percentage, and standard deviation were computed on different characteristics of fish ponds and challenges encountered by aquaculture adopters. On the other hand, qualitative method of data analysis was used to narrate and supplement the quantitative data.

## 3. Results and Discussion

### 3.1 Pond Characteristics

Of the surveyed aquaculture ponds, the majorities (90.2%) were rectangular, and the remaining 9.8% were circular and triangular. According to Alayu (2011), all pond shapes can produce fish, but the rectangular ponds are

more suitable compared to the circulars. This is mainly due to the fact that rectangular ponds can be easily fertilized within a short period of time. In addition, large surface area of the pond (rectangular) water can easily be exposed to sunlight and this facilitates the photosynthesis process. The size of rectangular fish ponds ranges from a minimum of 9 $m^2$ to a maximum of 2400$m^2$. In addition, the average size of the pond was about 282.9$m^2$ with a mean depth of 1.9m. However, there was a statistically significant mean difference in pond size and depth between North Shewa zone and other sampled zones. Specifically, the average size of the ponds in North Shewa is about 700.94$m^2$ with an average depth of 2.9 m.

Due to differences in physical and hydrographic conditions across the zones, the bottom of the ponds were covered in different ways. For instance, in North Shewa, East Gojjam and South Wello, most of the constructed ponds were earthen ponds. Whereas, in South Gondar, West Gojjam and Awi Zones almost all the ponds were covered by black polyethylene geo-membrane. In this regard, most of the constructed aquaculture ponds in the region are earthen pond (79.2%) and geo-membrane (20.8%). This result reveals that earthen ponds are more common in the study area than any other type of ponds. A study by Ifejika et al. (2007) recommended earthen ponds as a means to ensure maximum utilization of pond resources and increasing production. Similarly, Abbas and Ukoje (2009) asserted that earthen ponds are more common due to their high level of zooplankton and phytoplankton productivity.

The water sources for the ponds comes from the ground (48.6%), from streams (30.6%) and rivers (20.8%). Among the surveyed ponds, especially in North Shewa and East Gojjam zones, the pond water is recharged from the ground and the water is available year-round. Based on the agro ecology of the area, most of the ponds were stocked by Oreochromis niloticus or Nile Tilapia and common carp. In the mid- highland or temperate area of the region, O. niloticus is the main fish species preferred and recommended for aquaculture. Whereas, in the highland areas like, North Shewa and South Wello Common carp and O. niloticus are cultured in combination (polyculture) or separately (monoculture). Here, the main sources of fingerlings were BFALRC[2], Geray reservoir and Lake Haik in their order of appearance. In addition, ponds were stocked by BFALRC[3] (31.9%),

[2] Bahir Dar Fisheries and Other Aquatic Life Research Center
[3] National Fisheries and Other Aquatic Life Research Center

agriculture office with the recently separated livestock and fishery resource development agency (27.8%), NFALRC with zonal experts (11.1%) and district with zonal fish experts (16.7%).

**Table 2: Different attributes of the ponds (N=72)**

| Attribute | | Frequency | Percent |
|---|---|---|---|
| Shape of the ponds | Rectangular | 65 | 90.2 |
| | Circular | 3 | 4.2 |
| | Triangular | 4 | 5.6 |
| Water source of the pond | Stream | 22 | 30.6 |
| | Diverted from rivers | 15 | 20.8 |
| | Ground | 35 | 48.6 |
| Bottom seal of the pond | Earthen | 57 | 79.2 |
| | Geo-membrane | 15 | 20.8 |
| Who stocked the pond | BFALRC | 23 | 31.9 |
| | Agriculture office | 20 | 27.8 |
| | District with Zonal fish experts | 12 | 16.7 |
| | NFALRC with zonal expert | 8 | 11.1 |
| | Agriculture Office and BFALRC | 9 | 12.5 |
| Fish species stocked (N=66) | Nile Tilapia | 29 | 43.9 |
| | Common carp | 17 | 25.7 |
| | Tilapia and common carp | 17 | 25.8 |
| | Tilapia and catfish | 3 | 4.6 |
| Functionality of the pond | Good | 15 | 20.8 |
| | Medium | 19 | 26.4 |
| | Low | 15 | 20.8 |
| | Non-functional | 23 | 31.9 |

## 3.2 Benefits from Integrated Aquaculture

Aquaculture can be integrated with animal husbandry and irrigation practices for better utilization of resources and ultimately for higher production and profits. If integrated aquaculture is properly executed, it can serve as a means for livelihood diversification. Therefore, such integration of fish farming with the existing agricultural practices is reputable in improving water management and generating additional income from fish farming. In this regard, there are farmers in East Gojjam (Enemay district) who get multiple benefits from integrated aquaculture.

**Table 3: Amount of fish harvested and total earning**

| | N | Minimum | Maximum | Mean | Std. Dev. |
|---|---|---|---|---|---|
| Amount harvest in kg/ year | 20 | 3 | 87 | 26.60 | 25.970 |
| Amount consumed at home/kg/ | 20 | 2 | 56 | 13.28 | 16.442 |
| Amount sold in kg/year | 18 | 2 | 58 | 21.06 | 17.792 |
| Total earned in ETB/ year | 18 | 60 | 1700 | 513.61 | 410.064 |
| Amount of fingerlings sold | 7 | 100 | 600 | 374.17 | 231.093 |
| Income from sale of fingerlings | 7 | 100 | 350 | 214.29 | 85.217 |

Given these multiple benefits, however, only 25% and 27.8% of the pond owners try to harvest fish for sale and home consumption respectively. In addition, these farmers harvested an average of 13.28 and 21.06 kg/year/pond for home consumption and market respectively. As a result, 25% of the pond owners earned an average of ETB 513.61 per year per fish pond. However, due to poor pond management and stunted fish growth (see section 3.4 and 3.5), farmers start harvesting after three to four years of stocking. Such stunting fish growth probably came from fish reproduction in the ponds due to mixed-sex stocking. This over population through reproduction increases the competition for feed and space. Thus, most of the aquaculture pond seems as a multiplication pond than production. In desperation, farmers (75%) decided to discontinue their pond management practices once they had harvested their fish. The reason for this discouragement arises from farmers' financial comparison between the costs incurred from pond construction to harvest and its actual returns.

In the study area, most of the farmers originally aimed to sell their harvested fish than consuming them at home. In the absence of any fish markets, farmers become forced to harvest their fish for home consumption. However, these farmers have little knowledge about post-harvest handling and fish dish preparation. Because of these skill gap, farmers harvest their fish in an irregular or seldom way. Consequently, 80.4% of the aquaculture pond owners perceived as they have not been benefited from aquaculture adoption. Hence, sustainability of integrated aquaculture practice in Amhara region is now in question. However, there is one fascinating thing in Enemay district (East Gojjam Zone) that some farmers purchase fishes from pond owners. But these farmers are not basically purchasing fishes for the sake of consuming like other dishes, rather it is due to the belief that "eating fish serves as a medicine" for different diseases. In contrast with the case in Amhara region, Ifejika et al. (2007) asserted that in countries such as Nigeria and Egypt aquaculture is found to be profitable in terms of income generation and food security as well.

On the other hand, only 9.7% of the aquaculture pond owners sold fish fingerlings (when over-populated) as a seed for other aquaculture users and mostly aspired by government. These (9.7%) fish farmers sold about 257 fingerlings per year per fish pond and generated ETB 214.29 per year per pond on average from fingerling selling (Table 4). This return might not be simple, but there is no private fingerling buyer in uninterrupted way. In the area, most of the farmers caught their pond fish in a labor-intensive way by using a net (locally called Zanzira) that has been distributed by health centers for malaria protection in rural area. The reason is that all aquaculture pond owners in the region have no any type of standardized fishing net. More surprisingly, some farmers totally drain out their ponds to harvest their fish without considering the fate of non-market sized fishes and fingerlings.

### 3.3 Is Aquaculture in the Region is Well Integrated?

In the study area, the aim of integrating aquaculture with other agricultural practices was to benefit smallholder farmers and to increase their water productivity at the backyard. In addition, it was also proposed to integrate aquaculture into the irrigation systems for more efficient water resource utilization. In this regard, a lot of water harvesting ponds and dams were constructed for this purpose. During this, there was a mistake that the constructed

ponds/ dams were not prepared in a design that fish farming required like inlet, outlet and possibility to integrate. Rather, the constructed ponds were merely designed for water storage, supplementary irrigation and livestock watering (Figure 1).

**Figure 1: Performance and design of aquaculture ponds**

A study conducted by Akalu et al. (2010) confirmed that water from these ponds are largely used for domestic purposes, livestock watering and supplementary irrigation, particularly for horticultural crops. The study also asserted that about 45% of the water was used for seedling and fruit production, 50% for livestock watering and 5% for domestic use. As depicted in Figure 1 the aquaculture ponds are constructed at a site difficult to integrate with horticulture and livestock. Therefore, when the pond's water becomes drained out, the water merely drained either to the rivers or to idle land, which are difficult to plough. Similarly, there are also many potential aquaculture ponds (Appendix 1) in North Shewa, which are constructed on communal lands. These ponds have no any properly constructed inlet and outlet and makes the future integration practices troublesome. Based on the surveyed aquaculture ponds, it might be misleading if we say 'there is integrated aquaculture practices in Amhara region'.

### 3.4 Pond Management and Current Status of Aquaculture in the Region

Fish feed types that farmers frequently used are poultry and cow manure (55.6%), residuals from human feed and grinded maize (19.4%), non-marketable residue of horticulture crops (12.8%), and nug cake and wheat bran (8.2%).

However, our study also found that 76.1% of the pond owners feed their fishes irregularly. This is also exacerbated by the fact that ponds are constructed far from home, while, some others are constructed on communal lands in a communal basis like, ponds in North Shewa (Appendix Figure 1) and South Wollo. Due to such problems of communality and discouragement, 23.1% of the sampled aquaculture ponds did not get any type of fish feed. In addition, most of the farmers do not regularly monitor the overall performance of their ponds. Because of these, farmers do not know whether there is market sized fish in their ponds or not.

On the other hand, some ponds are not exposed to direct sunlight due to the shades of trees and their branches around the ponds (Figure 2). In addition, there are ponds that are full of grass, frog and submerging plants due to drastic reduction in volume of water and siltation during runoff. As Table 2 shows, out of the surveyed fish ponds only 23.7% of them were functionally good (Appendix Figures 1, 2, and 3), whereas more than 31% of the ponds became totally nonfunctional and discontinued. According to the FGD and key informant discussions, poor fish consumption habits and weak pond management are the two contributing factors to the failure of aquaculture in the area. Based on the level of input used, feeding frequency and type and the degree of management, the current aquaculture practice of the region inclined towards extensive type. Such extensive type aquaculture practices are known for their poor pond management and poor integration and consequently negligible returns. However, this finding is in contrast to the finding of Berihun and Goraw, (2010) that semi-intensive aquaculture has been developed in the Amhara region.

**Figure 2: Pond management in West Gojjam zone**

## 3.5 Major Challenges for Integrated Aquaculture Development

A serious problem observed in one zone might not be a problem for the others due to its locational sensitivity. Given the strong endeavor of the government towards aquaculture development in Amhara region, the most commonly observed determinants of integrated aquaculture development are discussed below.

### *3.5.1 Site Selection*

As Table 4 shows, 38.8% of the aquaculture adopters said that site selection and inlet/outlet related issues are among the severe problems, which negatively affects the performance of their ponds. In this regard, the site of some aquaculture ponds are not selected based on their physical and potential suitability for integrated fish farming. Rather, these sites are selected based on their convenience for the experts. Therefore, farmers start pond construction without any critical consideration of the suitability of the site for pond construction, its possibility to integrate with other agricultural practices and its water sources. In addition, some ponds have been constructed without any outlet and inlet; therefore, farmers are forced to fill their pond by renting and purchasing a water pump and fuel respectively. Such recklessly constructed ponds become a curse for the barefooted farmers by accruing an extra cost. There is also an evidence from Korata kebele in South Gondar zone that, out of the 10 constructed ponds since 2010, all ponds become dried or out of service at this time.

### *3.5.2 Farmer Selection*

The successes and failures in aquaculture depend on the real purposes that farmers prepare their ponds. In fact, there are many farmers who construct fish ponds as a means to generate cash income from fish sale, for home consumption, and to integrate with other agricultural practices at their backyard. In this situation, farmers are found to be very much dedicated to pond management and monitoring to maximize benefits from their ponds. However, there is also a situation where "opinion leader"[4] farmers to be selected by fishery experts. As defined by Rogers (1983), these farmers are more exposed to all

[4] *Opinion leadership* is the degree to which an individual is able to influence other individuals' attitudes or overt behavior informally in a desired way with relative frequency.

forms of external communication, more educated, have somewhat higher social status, wealthier, owning large landholding and more innovative. However, they might not be devoted for managing their ponds because of the fact that they do not worry about the risk of losses. Therefore, they merely dig the ponds for the sake of financial and equipment support like geo-membrane, cement and water pump from the government as an incentive.

Moreover, farmers adopt aquaculture without convincing their family members and themselves about its advantages. They rather adopt aquaculture for the purpose of getting public acceptance and reward either in kind or cash like, local leadership and other benefits. However, when they could not get what they immediately stop their pond management practices (Figure 3). During the study, we also found ponds that are full of frogs, debris and overcrowded fingerlings with a stunting growth without giving any benefit up to six years. The existence of such frogs creates feed competition among the fishes and the frogs, which in turn causes stunting in the fish growth.

**Figure 3: Pond's geo-membrane used as a thatch for home at Awi Zone**

### *3.5.3 Input Availability*

The crucial aquaculture inputs in the study area are geo-membrane, fingerlings and fishing nets. In this regard, there is a lot of geo-membrane dumped at every agriculture office, but farmers strongly complain on the shortage of this input. However, the dumped geo-membranes are not given for pond owners either free or low cost. Therefore, most of the ponds, especially in South Gondar and West Gojjam become nonfunctional because of water shortage and leakage.

There are also two contradictory things that shortage of fish fingerling for aquaculture and at the same time, stunted fish growth due to over population. For instance, there are a lot of huge ponds and dams, which have not been stocked with fish yet in the region due to shortage of fingerlings. On the other hand, the other ponds are suffering from stunted fish growth because of overpopulation (Table 4).

Out of the sampled aquaculture adopters, 40.3% and 43.3% of them are facing with a problem of fish over population and stunted fish growth respectively. In addition, 55.2% of pond fish farmers reported that fingerlings are not technically transferred to other ponds to solve the problem of over population. On the other hand, fishing net is among the determinant factors for aquaculture development in the region. As Table 4 shows, 74.6% of the pond fish farmers categorized fishing net as a severe problem. Except Enemay district in East Gojjam, all farmers have adopted aquaculture without having fishing net. Therefore, if farmers want to harvest fish for home consumption or market, they have two options: the first option is catching their fish by using mosquito net locally called Zanzira and rickety clothes. The second option, which is practiced by most pond owners, is not to harvest until they get their own fishing net or until the water drained out or dried.

**Table 4: Major challenges for aquaculture**

| **Problems for integrated aquaculture** | **Extent of the problem** | | | | | |
|---|---|---|---|---|---|---|
| | **Severe** | | **Low** | | **Not a problem** | |
| | **N** | **%** | **N** | **%** | **N** | **%** |
| Site selection and outlet problem | 26 | 38.8 | 19 | 28.4 | 22 | 32.8 |
| Overstocked fish population | 27 | 40.3 | 14 | 19.4 | 26 | 36.1 |
| Fingerlings transfer problem | 37 | 55.2 | 17 | 25.4 | 13 | 19.4 |
| Have not appropriate fishing gears | 50 | 74.6 | 7 | 10.4 | 10 | 14.9 |
| Nonexistence of fish feed | 17 | 25.7 | 28 | 42.4 | 21 | 31.8 |
| Stunting fish growth | 29 | 43.3 | 20 | 29.9 | 18 | 26.9 |
| Low farmer's and expert's interest | 43 | 63.2 | 24 | 35.3 | 1 | 1.5 |

### 3.5.4 *Fish Feeding Habit*

Even though some farmers add fish feeds to their ponds in a seldom ways, there are many farmers who do not totally feed their fishes due to lack of awareness. Surprisingly, these farmers also perceived as fish will grow as long as they are in a pond water. They do not even realize that best performance would be obtained if the fishes have a balanced diet. Among the fish feeders, they frequently used cow manure as a fish feed but the way they apply was not efficient. These farmers put a sack with a full of cow dung at a side in the pond for lots of months without replacing and refreshing the water. This might produce fish pathogens, bad smell, reduced water quality, diminishing phytoplankton and zooplankton abundance and depleted oxygen as well. In one or the other way, all these problems can directly affect the growth of fish at the pond.

**Table 5: Challenges for aquaculture**

| Problems for integrated aquaculture | Extent of the problem | | | | | |
|---|---|---|---|---|---|---|
| | Severe | | Low | | Not a problem | |
| | N | % | N | % | N | % |
| Low return | 35 | 52.2 | 22 | 32.8 | 10 | 14.9 |
| Weak extension and follow-up | 40 | 58.8 | 25 | 36.8 | 3 | 4.4 |
| Market problem | 41 | 60.3 | 17 | 25 | 10 | 14.7 |
| Skill and knowledge gap | 51 | 75 | 13 | 19.1 | 4 | 5.9 |
| No immediate benefit | 48 | 71.6 | 18 | 26.9 | 1 | 1.5 |
| Aquaculture is not profitable | 19 | 47.5 | 20 | 50 | 1 | 2.5 |
| Non-existence of role model aquaculture ponds | 42 | 72.3 | 12 | 18.5 | 6 | 9.2 |

### *3.5.5 Experts' and Farmers' Interest towards Aquaculture*

Despite the fact that there are some motivations and attempts to promote aquaculture, it is still the neglected sector compared to other agricultural activities. For instance, the budget, equipment and human resource allocated for this sector is very low. Unlike the situations observed in crop related activities, trainings and extension support related to fishery sectors is negligible. This finding is also consistent with the report of Akpabio and Inyang, (2007). In addition, Kurwijila (2004) also illuminate how the government itself marginalize the fisheries sectors in the context of food and nutrition security.

During data collection, extensive discussions were held with livestock and fishery experts about the attentiveness of the government towards the fishery sector. In almost all the surveyed districts, fishery experts have no fishery specific background; rather they were delegated from either animal production or natural resource disciplines. In addition, the key informant interview shows that most of the delegated fishery experts are either those who have poor performance on the other disciplines or pregnant women, who are prepared to get birth.

On the other hand, most of the farmers selected to adopt aquaculture had no any previous fisheries related experiences. In the region, farmers might learn a skill on how to handle cattle from their environment. However, aquaculture adopters could not acquire a fish farming experiences from its neighbors. A study by Ifejika, et al. ( 2007) also emphasized how fishing experience is crucial to the success of aquaculture by reducing management problem. On the other hand, the endeavors on skill and awareness creation related to aquaculture were insignificant and this hinders aquaculture development. Similarly, there is no model farmers who are benefited from aquaculture. Moreover, farmers were not benefited as they expected before the intervention. All these factors make farmers less committed to pond management and hence expansion of aquaculture becomes steady.

### *3.5.6 Extension and Follow-up*

The monitoring and follow up on the progress of aquaculture is not beyond stocking ponds by fingerlings. However, the activities from pond construction to consumption and marketing are left for farmers who do not have any technical knowledge about fish farming. Due to these problems, farmers have stopped the pond management to the extent that the ponds become dried up and fishes become feed of birds (Figure 4). Due to this, some farmers in Dangla and Dera districts use their pond's polyethylene geo-membrane as a thatch for their house by drying up their ponds (Figure 3). In addition, most of the experts hurry for crop and livestock related activities, however, in the extension system, aquaculture has lesser attention. This might associate with the local experts' knowledge gap about fisheries related issues. There was also an evidence from the field day that some farmers (non-adopters who were invited to visit aquaculture ponds) were surprised when they saw fishes in the ponds because they only know that fish can survive only in lakes and rivers and not in ponds.

### *3.5.7 Capacity Building on Aquaculture*

The newly established fisheries and livestock development office, especially at the district level is not well equipped with budget, human resources, and equipment. In addition, farmers do not get adequate theoretically and practically trainings before and after pond construction. Therefore, many of the farmers start fish farming without having knowledge from pond management to fish dish preparation and consumption. Such unplanned and baseless adoption makes farmers reliant of fish experts for every simple thing that could work by the farmers themselves.

**Figure 4: Aquaculture pond affected by leakage**

The district level fishery experts themselves could not get a hands-on training. As a result, these fishery experts might not be capable in providing technical supports for the aquaculture adopters. In addition, districts' fishery experts do not involve through the whole procedures of demonstration researches and this hinders them from updating themselves.

### *3.5.8 Market and Consumption*

As Table 5 shows, 60.3% of the sampled aquaculture owners reported that market is a severe problem for them to intensify aquaculture. The problem is that strong market linkage for those aquaculture adopters who do not consume fish is not available. This finding is also in consistent with the finding of Akpabio

and Inyang, (2007). These authors reported that pond fish farmers are mostly located in rural area, whereas about 95% of the customers with adequate purchasing power are around the urban areas. In addition, poor roads, poor electricity and lack of vehicles with refrigerated compartments, are the problems for effective marketing of fishes from aquaculture. The other challenge for aquaculture development is that farmers have no adequate experience or skill to eat fishes. Thus, even for small catches, farmers start looking for market elsewhere. However, as mentioned above, the market for such small and irregular catch does not exist when required. Thus, farmers become discouraged to continue in such a manner.

#### *3.5.9 Rewards from Aquaculture*

Most of the sampled fish ponds were constructed and stocked in between 2002 and 2016 but 83.4% of the pond fish owners could not harvest fish yet. Hence, the majority (71.6%) of the aquaculture pond owners considered absence of immediate benefits from pond fish farming as a severe problem. In this case, households become more committed to the activity that have immediate returns. There is also an evidence from Dera, North Achefere and Dangila districts that farmers fill their ponds with soil and growing amazing banana. Therefore, it poses a great discouragement for pond fish farmers and for aquaculture development in the region.

### 3.6 Aquaculture and its Bright Prospects

The estimated potential land for large and medium scale irrigation in Amhara region is about 650,000 - 700,000 hectares. In addition, there is about 200,000 - 250,000 ha of land, which have the potential for small scale irrigation (less than 10% has been develop). All these indicates the magnitude of water resources available for irrigation and aquaculture development (Mohammed et al., 2006). Thus, the potentials for aquaculture development in Amhara region are readily available. One of the best indicators of the Government's preparedness to develop the fisheries sector is the recently established Ministry of Livestock and Fisheries as a standalone organization (Abebe, 2016).

In the second growth and transformation plan (from 2016 to 2020), the focus area of the government is irrigation and aquaculture-based development. In addition, the current trend in floriculture development creates an opportunity for

integrating fish farming with floricultures' water harvesting pond. There are also many man-made dams or ponds for supplementary irrigation and floriculture sites that require hundred thousand of fish fingerlings at once. Therefore, the current declining catch from capture fishery and increasing demand for fingerling opens the room for aquaculture expansion. Moreover, the unreserved effort of Bahir Dar fisheries and other aquatic life research centre on hatchery multiplication, production and demonstration can also be considered as a good prospect (Appendix Figures 1, 2, and 3).

## 4. Conclusions and Recommendations

Amhara region has a great potential for aquaculture development but it remains as an opportunity than a tangible benefit for the farmers. In the region, integrated aquaculture was introduced starting from 2002 by using O. niloticus and common carp fish species. The aim of the intervention was to integrate aquaculture with other forms of agricultural practices. However, it could not become successful and expanded as planned due to some technical and management related inefficiencies. Thus, the development of integrated aquaculture practices in the region is still at its infancy stage. Such stagnant growth in aquaculture can be attributed to various constraints starting from site selection to fish consumption and marketing.

Among the bottlenecks for integrated aquaculture, the extension and follow up system has serious problems and the involvement of experts is not beyond stocking the ponds. In addition, pond management and fish consumption habits are the two limiting factors for integrated aquaculture in the region. Due to such skill gaps, farmers' pond became overcrowded by fish fingerlings with a stunting growth. Thus, most of the aquaculture pond seems like a multiplication pond than production ponds. In general, most of the constructed fish ponds are not functional and the most of them are on the way to discontinue. Owing to these facts, the current practice of aquaculture system in Amhara region can be categorized as an extensive type with poor management and poor integration. Therefore, due to inefficient intervention system (mostly due lack of commitment), the returns from integrated aquaculture intervention in Amhara region is not promising. In addition, if the current intervention system does not revamp, the sustainability of integrated aquaculture practice in Amhara region will be in question.

Thus, if aquaculture is expected to provide a high-quality food, self-employment and cash income for the smallholder farmers, the following issues require due attention:

- Before starting pond construction, adequate pre-intervention trainings from site selection to consumption must be provided
- The initial cost of pond construction may not be affordable for subsistence smallholder farmers. Therefore, giving pond construction inputs like geo-membrane and other equipment either as an incentive or on a loan basis is necessary.
- Use locally available feed staffs such as poultry excreta, animal manure, wastes after human consumption and others should be used to cutoff feed costs.
- Intensive follow up and endeavor for pond management are vital to minimize problems of the ponds.
- Promoting a multipurpose extension by integrating aquaculture development with other forms of agricultural practices
- Transfer fingerlings to fish production ponds to reduce feed competition and over population of the ponds.
- Proper promotion and marketing of harvested fish will attract farmers and guarantee its future sustainability.
- Build capacities of pond fish famers through training on pond management
- Assign appropriate and knowledgeable fishery professionals to support farmers from pond site selection to fish production and consumption.

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# Appendices

**Appendix Figure 1: Aquaculture ponds constructed at communal lands in North Shewa Zone**

**Appendix Figure 2: Aquaculture ponds at South Gondar Zone**

**Appendix Figure 3: Aquaculture ponds at East Gojjam Zone**

Criteria for identifying Level of Aquaculture Intervention and Its stage of Development
Level of Aquaculture Intervention
Limited Aquaculture Intervention (Extensive Aquaculture)
Human intervention is concentrated on reproduction of the stock
Simple ponds affected by leaking
Mainly fill during rainy season
Water control is difficult
Stocking density is too low

Fish production relies merely on the natural productivity of the water which is only slightly or moderately enhanced
The production is only for local use
Fishes' health is not under control
Quantity and quality of the stock is unpredictable
The number of harvested fish is variable and based on the:
Climate conditions (water temperature, dissolved oxygen, salinity, pH etc), and
Available field for the aquaculture activity
Costs are kept low and capital investment is restricted
Low yields of approximately 250 kg/ha
Intermediate Aquaculture Intervention (Semi Intensive Aquaculture)
Fingerlings and food-fishes are produced separately
If mixed fingerlings transferred
Fingerlings received high quality feed daily
Fishes' growth is at predictable rate
Ponds are filled by pumping
Significant intervention in all aspects of production process
Harvesting is more predictable and efficient
Processing is managed to produce high quality product
Production cost is usually moderate
Yield is higher than the case in the extensive system, above 10,000 kg/ha/year
High Aquaculture Intervention (Intensive Aquaculture)
Water could recirculate continuously
12% of the water replaced each day
More or less constant internal and external environment
High level of intervention with low uncertainty
commercial feeds

Stages of Aquaculture Development
There are three stages of aquaculture development namely,
Low (infancy) stage of aquaculture development
Intermediate stage of aquaculture development and
High stage of aquaculture development
The level of intervention is an indicator for the stages of aquaculture development. Therefore, if the level of aquaculture intervention is limited, the stage development becomes low stage of aquaculture development.

Sources: Adopted and modified from (Altan, n.d.; Kaleem & Sabi, 2020; Shell, 1993)

# Impact of Credit Constraints on Agricultural Productivity in the face of Climate Variability: Panel Data Evidence from Rural Ethiopia

**Hailu Elias**[1]

***Abstract***

*Increasing agricultural productivity is a major step towards transforming the rural economy and ensuring food security. This paper uses household level panel data linked with climate data to examine the impact of different credit constraint conditions on agricultural productivity under changing climatic conditions. A propensity score matching (PSM) and a difference-in-differences (diff-in-diff) methods were employed to provide unbiased estimates of the production impacts of credit constraints on crop productivity. After controlling for potential selection bias, it found that relaxing credit constraints increases agricultural productivity by Ethiopian Birr 169 per hectare, while the real crop revenue for discouraged and quantity constrained farmers declined by Ethiopian Birr 443 and 275 per hectare respectively. These results suggest that relaxing credit constraints by improving performance of the rural credit market could significantly increase agricultural productivity in rural Ethiopia.*

**Key words:** *Credit constraints, agricultural productivity, PSM, Climate variability, Ethiopia.*
**GEL Codes:** C23; G29; Q12; Q16; Q18; Q54

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## 1. Introduction

African agriculture is characterized by low productivity and harsh weather conditions including erratic rainfall and high average temperatures (Di Falco et al, 2011; Mulwa et al. 2017). Among African countries, Ethiopia is the most vulnerable country to climate change with the least adaptive capacity (Thornton et al., 2008). This is mainly because rain-fed subsistence agriculture is the primary source of food and income for more than 80 percent of Ethiopians and hence, climatic factors present a great risk to agricultural productivity and food security. This calls for the adoption of effective climate adaptation strategies and agricultural technologies to improve productivity and achieve food security. Climate adaptation actions, like any other investment, require financial resources and access to an affordable source of credit could be expected to relax the liquidity constraints of farmers.

However, performance of the rural credit market in developing countries is generally poor due to imperfections including weak contract enforcement, underdeveloped information systems, imperfect property rights, and unstable political institutions (Andersen, 2012). Contract challenges and problems related to information asymmetries about borrower type and behavior leave poor households in a credit constraint condition (Jack, 2011). Lenders often use collateral as a strategy to offset problems related to asymmetric information and moral hazards. Farmers however, lack the required loan collateral and face credit constraints during crucial periods such as peak planting seasons. This forces them to use minimal amounts of productivity-enhancing technologies, leading to lower yields (Morduch, 1995; Moser and Barrett, 2005).

Despite the immense literature on the links between climate change and choice of different adaptation strategies in the African context (see: Kurukulasuriya, 2008; Hassan and Nhemachena, 2008; Deressa et al, 2008; Di Falco et al., 2011; Bezabih and Di Falco, 2012), the effect of different credit constraint conditions on agricultural productivity under changing climatic conditions has not been studied in depth, especially within a panel framework. Previous studies did not assess this link in the context of rural Ethiopia in general, or use household level panel data particularly from our study area.

In filling this gap, the current study is set out to examine the agricultural productivity trend in the study area; identify key variables which determine the probability of a household to fall into a given credit constraint category; evaluate

the impact of multiple credit constraints on agricultural productivity under changing climatic condition; and generate policy-relevant information on approaches to enhance agricultural productivity by improving performance of the rural credit market.

Section 2 of this paper describes the data and variables used in the analysis and the methodological approach consisting of a theoretical model on the productivity effects of credit constraints. The econometric strategy is presented in section 3 and discussion of the results is provided in section 4. Section 5 concludes with some policy implications.

## 2. The Dataset and Variables used in the Study

The data used for this study were drawn from two waves of panel survey conducted by the Ethiopian Project on Interlinking Insurance and Credit in Agriculture (EPIICA) designed by the Ethiopian Economics Association/Ethiopian Economic Policy Research Institute (EEA/EEPRI) and implemented jointly by the Ethiopian Economics Association, the University of California San Diego, the University of Athens, Greece, Dashen Bank and the Nyala Insurance Company. While the first survey was conducted in 2011, the second round was conducted two years later in 2013. This study is based on the data drawn from both rounds.

The farm households were selected from four zones (north Shewa, south Wollo, north Wollo and west Gojjam) of the Amhara National Regional State located in the northern and central highlands of Ethiopia (Figure 2). About 33 percent of the 1,200 sampled households resided in north Shewa zone, 31 percent in west Gojjam, 23 percent in south Wollo, and the remaining 13 percent in north Wollo zone.

This unique panel data contains quantitative information on agricultural production, agricultural input use, access to credit, consumption expenditure and household's socio-economic characteristics. The household socio-economic characteristics contain demographic information (e.g. age, education, and marital status), household borrowing and lending behaviour, food consumption items, consumption and non-consumption expenditure, income from different sources, risk, food security, and asset holdings of farm households. The agricultural production section contains detailed information on crop production, cultivated

land area, types of inputs used, types of crops grown, total crop production and sales, as well as livestock production and marketing of farm households.

## 2.1 Constructing the Panel Data Set and Linking it with Climate Data

Even though the measurement for most of the variables used in the analysis was straight forward, the data cleaning process required explanation for some of the variables. Farmers reported the cultivated area of land using different local units of measurement and these local units were converted into a standard measure of hectares, using EPIICA's standard conversion factors collected during the survey periods. The plot level information was aggregated into household level and quantity of crop produced was also converted into standard units (kilograms) using the local unit conversion factors. The quantity of production (cereals, root crops and fruits) was converted into value in ETB. To account for inflation, the nominal values of production were converted into real values using the CSA's 2011 production price as a base year data. Finally, a balanced panel of 1,189 households consisting of 2,378 observations over the two rounds of data collection was created.

Monthly rainfall data were obtained from the National Meteorological Agency of Ethiopia, from stations close to the study districts (woredas) for the years between 1983 and 2013. The rainfall measure was constructed by taking the sum of monthly rainfall for each year and averaging it over 30 years. The temperature average was also calculated as the monthly temperature average, also averaged over 30 years. The coefficient of variation (CV) for rainfall was calculated as the standard deviation divided by the mean for the respective periods. These climate variables were linked with the household survey data using the latitude, longitude and other relevant geographic information such as the zone and districts of the households (Wahba, 1990; Wood, 2003).

## 2.2 Dependent Variable: Agricultural Productivity

The outcome variable of interest in this study is real crop revenue per hectare, since crop production is the major agricultural activity in the study area and provides the largest share of agricultural production. Various annual crops (cereals, pulses, oil seeds, fibers, cotton and root crops) and perennials are grown in different parts of the Amhara region based on the suitability of agro-ecological

conditions. Because farmers in the study area are engaged in the production of several different types of crops, monetary values were used instead of quantities to measure productivity and make it comparable across households. Productivity was measured as real crop revenue per hectare after accounting for inflation.

## 2.3 Explanatory Variables and Hypothesis

Variables explaining agricultural productivity were categorized into measures of climate variability; indicators of credit constraint status; household demographic characteristics; ownership of physical assets, and social capital.

### *2.3.1 Credit constraint categories*

Farm households were classified into four credit constraint categories based on responses to the specific questions raised in relation to willingness to participate in the rural credit market. The first category included unconstrained borrowers who applied for credit and received the amount they requested and did not want to borrow more. The other three categories, quantity-constrained, risk-rationed and discouraged borrowers, were identified using a direct (survey-based) elicitation strategy. Quantity-constrained borrowers are characterized by an excess effective demand for credit and they face a credit limit due to supply-side problems. It means that these households have applied for additional funds, but given the available contract terms, their request is partially or completely rejected. The risk-rationed sub category includes those who do not want to participate in the credit market even if the market is available because they do not want to risk their assets and hence are not willing to provide the necessary collateral, or simply do not want to incur debt. The discouraged households are those who do not want to borrow because of the high transaction cost of borrowing. These costs include, among others, the cost of preparing the loan application, evaluating viability of the project and value of the loan collateral, and monitoring the periodic loan repayment. These costs are independent of the loan amount and discourage farmers who apply for smaller amounts of loan (Kon and Storey, 2003; Guirkinger, 2008; Ayalew and Deininger, 2014).

### *2.3.2 A measure for climatic factors*[2]

Climatic factors were captured using rainfall variability and the incidence of drought. Monthly rainfall data were obtained from the National Meteorological Agency of Ethiopia, from the stations close to the study districts (woredas) for the years between 1983 and 2013.

Among the rainfall stations, Gudoberet and Haik represent two major climate zones or patterns in the study area. Haik station represents the more arid and drought prone zones including south Wollo and north Wollo, while Gudoberet has comparable rainfall pattern as in west Gojjam zone, which gets relatively higher total annual rainfall.

The rainfall and temperature data collected from Gudoberet station in Basona Worena Woreda (district) of north Shewa zone, for instance, shows that there is an increasing but highly fluctuating trend in the rainfall. Even if there is an increase in the mean annual rainfall (by about 30 mm per year), the rainfall was more or less constant during the period 1994 to 2004. In the remaining years, specially, before 1994 and after 2004, there is high fluctuation (anomaly) from the mean annual rainfall in this station. Such high variability may adversely affect agricultural activities in general, and particularly, crop production and productivity in the study area. The mean annual maximum temperature in this site has also been slightly increasing over the last three decades. The regression model for the mean maximum temperature tells that the annual temperature is increasing by 0.023$^{o}$C per year while, the mean minimum temperature is declining by 0.04$^{o}$C per annum. This suggests that days are becoming hotter while nights are becoming cooler over the years.

Variation of the mean maximum temperature from its mean value was 0.5$^{o}$C in 1995 and this has increased by 1.5$^{o}$C in 2013, showing an enormous change in the atmospheric temperature in this woreda within about a decade (Figure 5). This agrees with the general global warming phenomenon. Global climate models predict that a higher upward variation of the temperature is a disaster both for plants and animals (Brooks, 2006; Moorhead, 2009). Plants, for example, are very sensitive to high temperatures during their decisive flowering and seed development stages, while livestock die due to reduced feed, lack of water, and incidence of animal diseases.

[2] Although we analyzed the climate data from all the nearest stations of the study area, detailed discussion of the results is not presented in this section to keep the document more compact. The full set of tables and graphs are available on request for interested readers.

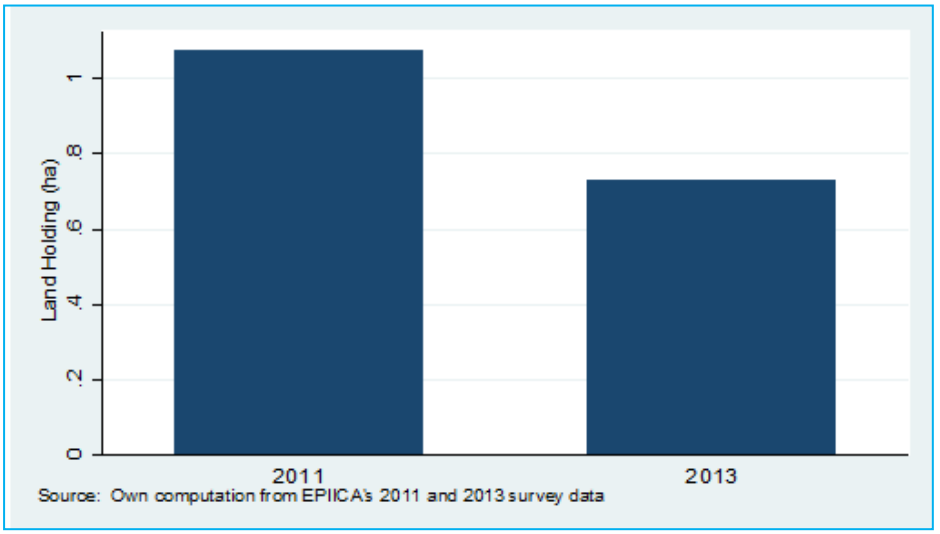
Similar analysis was conducted for the data from Haik station, but detailed discussion of the results is not presented in this section to keep the document more compact. As noted in the foot note, the full set of tables and graphs are available on demand for interested readers.

The subjective responses also show that about 39 percent of the households had faced drought shock during the two survey periods.

### *2.3.3 Ownership of physical assets and social capital*

Land holding is the major productive physical asset that determines the social and economic status of farmers in the study area. The data reveals that the mean land holding was about 1.07 hectares (ha) in 2011 and it had declined to about 0.73 in 2013 (Figure 1). A major reason for this might have been fast population growth in the country in general, and that of the region in particular. As the population grows, the demand for farm land increases while the land size is fixed. Among the farming communities surveyed, farmers in west Gojjam owned relatively larger amounts of land in 2011 followed by north Shewa and south Wollo. Estimates indicate that an average household with 5 members would require about one hectare of land for subsistence production (Alemneh, 1990), and the decline in land holdings observed in the study area is a major cause of concern in terms of feeding an ever-increasing population, especially given the low levels of productivity.

**Figure 1: Land holding (ha) by year**



The social capital variables included in the analysis as explanatory variables are trust and participation in farmers' primary cooperatives, and membership in a rotating saving and credit association (ROSCA). These are important social assets enjoyed for their own sake, used for material gain, and called upon in times of shock or crisis (Woolcock and Narayan, 2000). Trust in cooperatives is represented by a dummy variable with a value of 1 if respondents trust their cooperatives and 0 otherwise.

#### *2.3.4 Socio-economic characteristics*

Household socio-economic characteristics such as age, gender, marital status, and level of education of the household head were included in the analysis as control variables. The average age of household heads in the sampled zones was about 50 years, with heads in west Gojjam zone being relatively younger than those in the other three zones. The average household size was approximately five. About nine percent of the households in the study sites were headed by females in 2011, with this figure increasing to twelve percent by 2013. About 22 percent of the household heads have around 5 years of formal education; 27 percent had attended some informal education in 2011 and 24 percent in 2013.

## 3. Methodology

### 3.1 Quantifying the Productivity Effects of Credit Constraints and Climatic Factors: A Theoretical Framework

To increase crop production and to cope with the changing climatic conditions, rural farm households use both modern and traditional technologies including multiple cropping on one field, mixed farming of crops and livestock, using improved seeds (e.g. drought resistant crop varieties), irrigation, selling valuable assets, reducing household consumption, and other related mechanisms (Teklewold et al., 2013). However, credit constraints have an adverse impact on the adoption of such strategies to deal with a multitude of agricultural production constraints. This implies that useful information can be obtained by analyzing the link between financial constraints and agricultural productivity, both theoretically and empirically.

### *3.1.1 The set up*

Following the theoretical literature on producer-consumer models (e.g. Singh et al., 1986; Sadoulet and De Janvry, 1995; Petrick, 2004; and Briggeman et al., 2009), the impact of credit constraints on agricultural productivity under changing climatic conditions was conceptualized as below.

Assume a farm household which maximizes its utility by consuming $c_0$ and $c_1$ amounts of goods and services in periods 0 and 1, given a set of household characteristics $z^h$. The utility function is assumed to be inter-temporally additive, twice differentiable and quasi-concave such that:

$$u = (c_0, c_1; z^h) \qquad [3.1]$$

Agricultural production in period 0 requires purchase of variable inputs (x) such as seeds and fertilizer at a given price p and harvest occurs in period 1. These inputs can be purchased either with own resources (w) or with a borrowed capital (k) that will be repaid back with k (1 + r) in period 1 where r is the loan interest rate.

Let the agricultural production follow a twice differentiable and concave function:

$$y = f(x, z^y) \qquad [3.2]$$

where $Z^y$ represents fixed and exogenous production inputs such as land and major farm tools.

Under this setup, a farm household tries to maximize the following utility function:

$\max u(c_0, c_1; z^h)$ subject to:

$$w + k - c_0 - px = 0 \qquad [3.3]$$

$$f(x, z^y) - c_1 - (1+r)k = 0 \qquad [3.4]$$

$$\bar{k}(z^h, z^y) - k \geq 0 \qquad [3.5]$$

where equations (3.3) and (3.4) state the household budget constraints in periods 0 and 1, while equation (3.5) describes the credit[3] constraint condition in period 0 where $\bar{k}(z^h, z^y)$ denotes the upper bound of credit that the household can obtain. In the rural areas of developing countries like Ethiopia, this constraint is compulsory due to a number of reasons. These include: the problem of adverse selection, moral hazard, and costly state verification due to information asymmetries as discussed in Stiglitz and Weiss (1981); screening, monitoring, and enforcement problems in under developed rural credit markets (Hoff and Stiglitz, 1996; and the problem of a lack of collateral. Lenders usually consider collateral as an important means of reducing default risk and hesitate to grant credit to the poor who lack the required collateral. This makes credit constraints binding for the poor (Ghosh et al., 2001).

To solve the above utility maximization problem, set the Lagrangian as:

$$L = u(c_0, c_1; z^h) + \psi(w + k - c_0 - px) + \zeta[f(x; z^y) - c_1 - (1+r)k] + \gamma[\bar{k}(z^h, z^y) - k] \qquad [3.6]$$

The first order conditions (FOCs) of the optimal solution can be expressed as:

$$\frac{\delta L}{\delta c_0} = \frac{\delta u(.)}{\delta c_0} - \psi = 0 \qquad [3.7]$$

$$\frac{\delta L}{\delta c_1} = \frac{\delta u(.)}{\delta c_1} - \zeta = 0 \qquad [3.8]$$

$$\frac{\delta L}{\delta x} = -\psi p + \zeta \frac{\delta f(.)}{\delta x} = 0 \qquad [3.9]$$

$$\frac{\delta L}{\delta k} = \psi - \zeta(1+r) - \gamma = 0 \qquad [3.10]$$

$$\frac{\delta L}{\delta \gamma} = \bar{k}(z^h, z^y) - k \geq 0, \gamma \geq 0, \gamma \frac{\delta L}{\delta \gamma} = 0 \qquad [3.11]$$

[3] We took the Kuhn-Tucker conditions for equation (3.5) because it is an inequality constraint

where equation (3.9) represents optimal production, while equations (3.7) and (3.8) represent optimal consumption. Equations (3.3), (3.4) and (3.11), on the other hand, are conditions which must be satisfied by an optimal solution, while $\psi, \zeta and \gamma$ are the lagrangian multipliers.

The subsequent section discusses how credit constraints affect household's production decisions under changing climatic conditions, first, by finding an optimal production decision when credit constraints are not binding[4]. Inserting equation (3.10) in to (3.9) given that $\gamma = 0$ yields[5]:

$$\frac{\delta f(.)}{\delta x} = p(1+r) \qquad [3.12]$$

This shows that the household production function does not depend on the utility function or on any of the household characteristics and that household production and consumption decisions are now, separable. Hence, removing credit constraints by allowing farm households to have access to credit can ensure separability of production decisions from consumption decisions, allowing standard recursive household models to work. This in turn means that household resource allocation decisions will be efficient as the standard neo-classical household models predict (e.g Singh et al., 1986; Sadoulet and De Janvry, 1995).

Equation (3.12) is similar to the standard resource allocation rule. However, it was assumed that household production and input purchase decisions are made in period zero, while income is earned in period one and hence input prices are inflated by the interest rate (r).

On the other hand, when credit constraints are binding, equation (3.5) will hold with equality and hence $\gamma > 0$ in equation (3.11) above. To show the effect of this constraint on input use, it is possible to rewrite equation (3.10) as: $(1+r) = \frac{\psi - \gamma}{\zeta}$. Solving for ψ and substituting this expression in equation (3.9) yields:

[4] In the above setting, it is clear that credit constraints are not binding when gamma is zero ($\gamma = 0$)

[5] Given that $\gamma = 0$ in equation (3.10) means that $\psi = \zeta(1+r)$ and inserting it in equation (3.9) gives equation (3.12).

$$\frac{\delta f(.)}{\delta x} = [(1+r) + \frac{\gamma}{\zeta}]p \qquad [3.13]$$

If the optimal input and agricultural technology demand which can be derived from equation (3.12) for credit unconstrained (cuc) households be denoted by $x^*_{cuc}$ and the optimal input and agricultural technology demand for credit constrained (cc) households (which can be derived from equation (3.13)) by $x^*_{cc}$, then it is possible to note that the opportunity cost of the optimal input for the credit-constrained household $(x^*_{cc})$ is greater than the opportunity cost for the credit-unconstrained household $(x^*_{cuc})$ because it is inflated by$\left(\frac{\gamma}{\zeta}\right)P$ amount for credit-constrained households (see equation 3.13). This implies that credit-constrained households will lower the purchase of production inputs and agricultural technology (x) to increase the value of the marginal product.

From the above theoretical analysis, it can be noted that total agricultural production and productivity of a credit-constrained household will be lower than that of a non-constrained household because of credit constraints and one objective of this study is to show the effect of this constraint on agricultural productivity under changing climatic conditions. The next section will focus on an econometric strategy to test the above theoretical model empirically.

## 3.2 The Econometric Model

In relation to credit constraint conditions, farmers are not randomly assigned in different credit constraint categories. The probability of a given farmer falling in a constrained (treatment) or unconstrained (control) category depends, among other things, on the personal characteristics of that individual. In estimating the impact of credit constraints on agricultural productivity, it is crucial to take note of this potential selectivity bias.

Prior studies used different methods to control for such selection bias. Petrick (2004), for instance, used the Heckman estimator to show the effect of credit constraints on agricultural output while, Foltz (2004) used the switching regression technique to estimate the effect of credit constraints on agricultural investment. In another study, Briggeman et al., (2009) used the propensity score matching (PSM) method to control for a potential selection bias in estimating the impact of credit constraints on the value of the production for farm and non-farm

sole proprietorships. This method was first suggested by Rosenbaum and Rubin (1983), and it has become a common impact evaluation tool. Using the PSM method can reduce the potential bias by making productivity comparisons between farmers who are credit constrained and those who are unconstrained. The main purpose of using the PSM method is to find a group of non-treated (unconstrained) farmers similar to the treated (constrained) groups in all relevant observable characteristics with the only difference being that one group is constrained and the other unconstrained.

Here, the PSM method is used to control for the possible selectivity bias in estimating the effect of credit constraints on agricultural productivity in rural Ethiopia (For more details, see: Smith and Todd, 2005; Briggeman et al., 2009; and Kassie et al., 2009).

The outcome of interest (which is the real crop revenue per hectare) is identified from the following equation:

$$E[Y_1 - Y_0 \mid D = 1] = E[Y_1 \mid D = 1] - E[Y_0 \mid D = 1] \qquad [3.14]$$

where Y is the real crop revenue (rcr) per hectare and D indicates to which credit constraint category the household belongs. D takes the value of 1 for credit constrained farmers (treatment group) and it takes the value of 0 for unconstrained borrowers (control group). Thus, the outcome of interest is the average difference in $Y_1$ and $Y_0$. However, this matching exercise tries to estimate only $E[Y_0|D=1]$ which is the counterfactual or the unobservable case, since one farmer falls only in one state (either in the treatment group or in the control group) at a time. It means trying to estimate the impact of being credit constrained on the real crop revenue for those farmers who are actually unconstrained.

Had there been experimental data in which the farmers are randomly assigned to the treatment and control groups, it would have been possible to estimate the average treatment effect as:

$$E[Y_1 \mid D = 1] - E[Y_0 \mid D = 0] \qquad [3.15]$$

However, the data at hand is only observational and hence, it is a must to follow the Rosenbaum and Rubin (1983) approach to solve the selection bias by estimating the equation below:

$$E[Y_1 - Y_0 \mid Z, D = 1] = E[Y_1 \mid Z, D = 1] - E[Y_0 \mid Z, D = 1] \qquad [3.16]$$

where Z is set of covariates which determine the credit constraint status of farmers. If the probability of being credit constrained is determined by Z, then it is possible to establish a control group of unconstrained farmers that are similar in Z relative to the constrained farmers (the treatment group). Thus, from equation (3.16), it is possible to estimate the average treatment effect on the treated (ATT) as:

$$ATT = E[Y_1 - Y_0 \mid P(Z), D = 1] = E[Y_1 \mid P(Z), D = 1] - E[Y_0 \mid P(Z), D = 0] \qquad [3.17]$$

where P(Z) is the probability of selection conditional on Z or is the propensity score (Pscore) which is: $P(Z) \equiv \Pr(D = 1 \mid Z)$.

The PSM was, therefore, done in two stages. First, the propensity scores (pscores) were calculated using Stata's "pscore" command, which are the conditional probabilities that a given farmer is credit constrained. Calculating the propensity score is crucial since it is difficult to do the matching on each explanatory variable when there are many covariates. The main purpose of the propensity score estimation is to balance the observed distribution of covariates across the constrained and unconstrained groups. Following Lee (2008), a matching test was also conducted after matching to check whether or not the differences in covariates in the two groups in the matched sample have been eliminated. In the second stage, the ATT was estimated using Stata's "psmatch2" command, a sensitivity analysis was conducted and the results are discussed below.

In addition to the PSM, the difference-in-differences (diff-in-diff) method was also used as a robustness test and the result is provided in Table 2A in the Appendix.

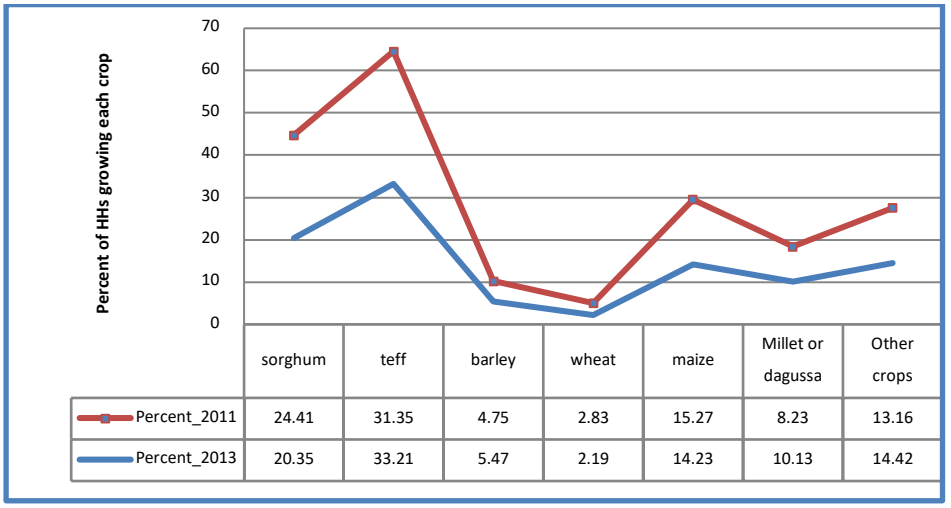
# 4. Results and Discussion

## 4.1 Descriptive Evidence

Agricultural production in the study area is dominated by 6 major cereals that account for about 86 percent of the total crop production (Figure 2). Among the cereals, teff, sorghum, and maize are the three major crops grown in the study area and they account for 31, 24, and 15 percents respectively in 2011. The last column in Figure 2 shows that the production of other crops such as oil seeds, pulses, perennials, and fruits and vegetables accounts for less than 15 percent over the survey period.

Agricultural productivity also remained very low over the years. Although there was a slight increase in productivity in north Shewa and north Wollo zones, the overall real value of output per hectare has been below ETB 1,500 during the study period (Figure 3). As in the case in Ethiopia in general, climatic shocks, deforestation and land degradation, as well as lack of access to credit have been among the major causes for the lower agricultural productivity in the study sites.

**Figure 2: Major crops grown in the study area by year**



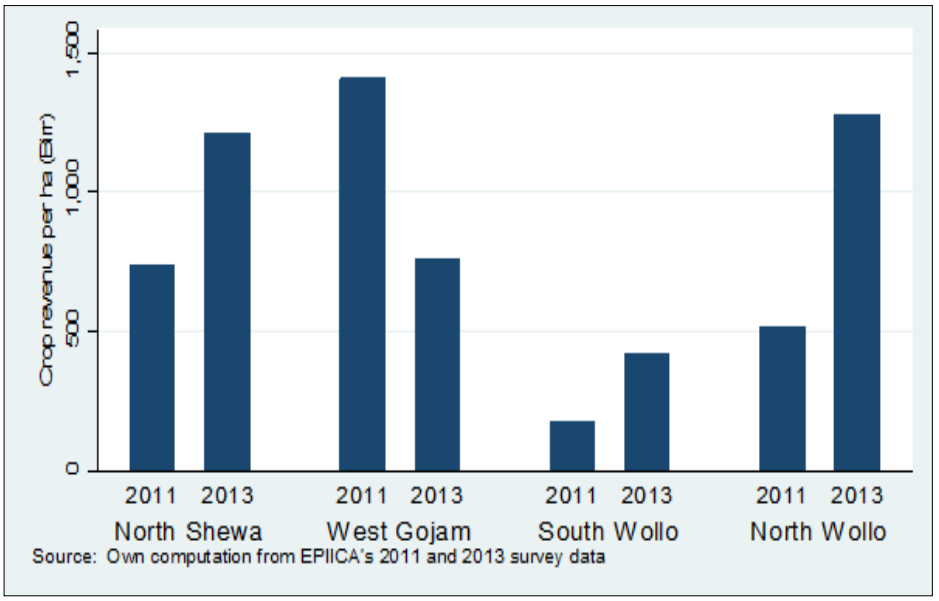

| | sorghum | teff | barley | wheat | maize | Millet or dagussa | Other crops |
|---|---|---|---|---|---|---|---|
| Percent_2011 | 24.41 | 31.35 | 4.75 | 2.83 | 15.27 | 8.23 | 13.16 |
| Percent_2013 | 20.35 | 33.21 | 5.47 | 2.19 | 14.23 | 10.13 | 14.42 |

Land expansion to increase agricultural production is no more a feasible option because of the high population pressure and scarcity of suitable farm land. Improving agricultural productivity must be the way out and this requires more investment in sustainable adaptation strategies, improved farming systems and

adoption of agricultural technologies such as high-yielding, drought resistant varieties, chemical fertilizers, and soil conservation measures (Kassie et al., 2011). Nevertheless, adaptation efforts have been very weak and technology adoption has remained very low in the Amhara region. There are a number of reasons including a lack of information and know-how about different agricultural technologies, and weak integration of research with agricultural extension to learn from day-to-day problems of farmers and incorporate these in designing better agricultural technology policies as well as minimal access to innovative and reliable credit facilities to purchase recommended agricultural technologies that could improve productivity (BoFED, 2013).

Future climate Predictions using General Circulation Models (GCM) also show that the mean maximum temperature will increase by 2.3 ºc in north Shewa, south Wollo and north Wollo zones in the 2080s while it will rise by 1.8 ºc in west Gojjam zone. In addition, rainfall is expected to decrease by 27.2 percent in the first three zones while reducing by 12.2 percent in west Gojjam zone (Ayalew et al., 2012). This implies that climate change will continue to be a major threat for the study area leading to increased exposure to rainfall variability, recurrent droughts and shortage of water. In the future, this can be expected to further reduce agricultural productivity of the study sites.

**Figure 3: Average real crop revenue per hectare (Productivity)**



## 4.2 Econometric evidence

### *4.2.1 Impact of being an unconstrained borrower on agricultural productivity under changing climatic conditions*

The determinants of being an unconstrained borrower is estimated in the first stage of the propensity score matching method (Table 1), checked whether the balancing property is satisfied, and then the impact estimated on the average crop revenue per hectare in the second stage. Climatic factors, membership in social networks and associations such as rotating saving and credit associations (ROSCA), socio-economic condition of the household, and location are found to be correlated with the probability of being an unconstrained borrower. The result shows that experiencing drought shock reduces the probability of being an unconstrained borrower by about 17 percent. This might be because of the dependence of agricultural production in the study area on rainfall, and lenders do not want to take uninsured risk of loan default in the case of crop failure caused by various climatic shocks including drought.

The probability of being an unconstrained borrower is found to be higher for female-headed households, and married farmers in the study area. The possible reason for this may be because married heads are more likely to be stable, trustworthy and abide by rules and regulations compared to the unmarried or separated heads; financial institutions view them as more reliable and may allow better access to credit (Mpuga, 2008).

In terms of location, farmers living in west Gojjam zone are less constrained while those in south Wollo are more constrained compared to households residing in north Shewa zone. This implies that the credit constraint conditions of farmers vary across the study sites.

From the second stage regression, it was found that being an unconstrained borrower significantly increases the average crop productivity or crop revenue per hectare. Controlling for the effects of several covariates and the selection bias, having full access to credit is associated with significant crop revenue improvement. Unconstrained borrowers tend to enjoy Ethiopian birr 169 higher crop revenue per hectare compared to constrained borrowers (Table 2). This is the average treatment effect on the treated (ATT) and it is statistically significant.

### *4.2.2 Impact of being a discouraged borrower on agricultural productivity under changing climatic conditions*

Adopting various agricultural technologies is a common strategy used by farm households to insure themselves against uncontrollable climatic factors. It also ensures their food security, and helps them to adapt to different agro-ecological production conditions, and to meet market demands (Winters et al., 2006). However, credit constraints have significant negative effects on technology adoption since such investments require substantial cash outlay.

In this paper, before estimating the impact of being a discouraged borrower on real crop revenue per hectare, key factors influencing the probability of being discouraged were identified. Climatic factors such as drought and rainfall variability, and year dummies were found to have a significant positive effect on the probability of being discouraged (Table 3).

Table 2 shows the average effect of being discouraged over agricultural productivity in the study area. The estimated average treatment effect on the treated (ATT) shows that discouraging credit market conditions significantly reduce real crop revenue per hectare by about ETB 443, which is much lower than the productivity of unconstrained borrowers. This indicates the serious adverse effect of credit constraints on agricultural productivity in the study area.

### *4.2.3 Impact of being quantity constrained borrowers on agricultural productivity under changing climatic conditions*

The result in Table 4 shows that climatic factors, membership in social networks and associations, socio-economic condition of the household, the year dummy, and location of residence are correlated with the probability of being quantity constrained borrowers, though some variables are insignificant. Table 2 shows the average effect of quantity constrained borrowers on agricultural productivity in the study area. Quantity constrained borrowers would have earned crop revenue in real terms of about ETB 275 higher had they not been constrained in the credit market. In other words, the estimated average treatment effect shows that quantity constraint has a negative and statistically significant effect on crop revenue per hectare for constrained farmers.

These results agree with micro-level studies from different countries which show that household crop income and welfare is significantly reduced when credit constraints are intertwined with climatic shocks. Rosenzweig and Wolpin (1993) and Jacoby and Skoufias (1997) found that credit constraints caused by

imperfections in the credit market have long-term welfare effects on farm households when they are entangled with climatic shocks. The effect is most severe on poorer households because such shocks can destroy their lifetime wealth directly and also reduce their current and future agricultural income. It may also reduce their earning potential through forced sales of productive assets.

#### *4.2.4 Impact of being risk rationed borrower on agricultural productivity under changing climatic conditions*

Experiencing drought shock and rainfall variability found to significantly increase the probability of being risk-rationed borrower (Table 5). This might be because such farmers do not want to borrow from the formal credit market not to take the risk of loan default in the case of crop failure. After controlling for the potential selectivity bias, it was found that being risk-rationed borrower has a negative but insignificant effect on agricultural productivity in the study area.

#### *4.2.5 Sensitivity Analysis: Matching Quality and Rosenbaum bounds*

***Matching Quality check***

Figure 4 in the Appendix shows the plausibility of the confoundedness and overlap assumption which is necessary for the impact identification with the propensity score-matching method. The figure depicts the propensity distributions of the treated and control households for the model. In both cases, the distributions are similar and there is good overlap except only a few cases which are off the common support.

***Rosenbaum bounds***

A sensitivity analysis is performed using the Rosenbaum bounds (rbounds) to check how strongly unobserved variables affect the matching results. Result of the analysis for the outcome variable (real crop revenue) is shown in Table 6 in the Appendix. In conducting the analysis, we assume that there was no unobserved confounder due to selection bias and all relevant characteristics were matched so that the treatment group and the control group both had the same basis for analysis.

When gamma equals one, both the upper and lower bounds remained the same for the real crop revenue variable and this implies that there is no hidden bias due to unobserved confounder. However, if the gamma is increased to two or if the odds of a household being in the treatment group are doubled because of

different values of unobserved factors, there may be a slight effect on the outcome variable.

According to Becker and Caliendo (2007), one should be cautious in interpreting the results obtained from different gamma values. It should be noted that the result obtained by calculating with different gamma values shows the level of sensitivity of the produced results and it does not imply that unobserved heterogeneity exists and there is no effect of treatment on the outcome variables. Result of the sensitivity analysis shows only the confidence interval of the treatment effect would include zero if the odds ratio of the treatment assignment differs between the treatment and control groups by the gamma value.

## 5. Conclusion and Implications

The main objective of this paper was to investigate the effect of different credit constraint conditions on agricultural productivity among smallholder farmers in selected zones of the Amhara Regional State in the northern highlands of Ethiopia. Household level survey data were used to estimate these effects. To mitigate biases stemming from heterogeneity, the propensity score matching (PSM) method was applied to measure the effect of the treatment (being credit constrained) on the treated farmers.

The results provide evidence for the adverse effects of being credit constrained (falling within discouraged or quantity constrained borrower groups) in improving agricultural productivity in the study area. Farmers want to invest in fertilizers, improved seeds, and drought-resistant crops which can increase productivity in the face of changing climatic conditions. However, adoption of such technologies is hampered by credit constraints and, as we have seen, this has a direct and negative effect on agricultural productivity in the study area.

The result from the impact estimates using the propensity score matching method indicated that relaxing credit constraints has a significant positive impact on agricultural productivity, while higher transaction costs and discouraging credit market policies were found to reduce productivity significantly. At the household level, the average treatment effect (ATT), which is the actual effect that constrained households experience, are ETB 443 and ETB 275 lower real crop revenue (productivity) for discouraged and quantity constrained borrowers, respectively.

The results also suggest the importance of climatic variables in explaining the probability of farm households falling into different credit constraint categories. Discouraged and risk averse farmers are not willing to participate in the credit market to avoid losing assets in the case of crop failure. A feasible strategy to encourage these farmers to participate and benefit from agricultural loans is linking credit with crop insurance to manage the uncertainty in agricultural production. Designing "productivity-based credit" (PBC) products might also help both lenders and borrowers in two ways. First, it could motivate farmers to work hard, easing the moral hazard problem; and secondly, it could also reduce the probability of adverse selection, allowing lenders to target the right borrowers who really need the loan to invest in productivity-enhancing agricultural technologies.

In relation to these findings, governments of some developing countries give due attention to the performance of the rural credit market given its role in improving productivity, household food security and reducing vulnerability to climate change. In Brazil, for instance, the official rural credit portfolio covers about a third of the annual financial needs of the agricultural sector (Assunção et al., 2013). Although this is a good step forward, the solution to the low productivity and credit constraint problems of farm households is not a mere injection of loanable funds into the rural credit market. Instead, government interventions should focus on improving the institutional setup of lending institutions, investing in human capital formation and building the capacity to innovate new loan products and efficient ways of serving genuine borrowers. This involves designing creative and climate-smart credit policies and procedures which can tackle the information asymmetry problem entailed in rural lending without reducing the welfare of borrowers.

To help farmers better adapt to changing climatic conditions, it is, for example, crucial to think of a flexible climate adaptation loan product. Among the study sites, south Wollo and north Wollo zones are more vulnerable to drought and climate variability, and this calls for designing climate-smart loan (CSL) products so that farmers in these zones have better access to the rural credit market and can build their adaptive capacity. Relaxing collateral requirements for small loans and increasing the loan repayment period to more than a year may also encourage farmers to participate in the rural credit market.

Generally, the results suggest that credit constraints are significant determinants of participation in the adoption of various technologies and adaptation strategies that can improve agricultural productivity. This highlights the need to recognize the complex relationships between financial provision and climate change policies, and the implications for situation–specific policy design regarding rural credit and adaptation to climate change in the study area.

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## Appendix 1

**Table 1: Determinants of the propensity to be unconstrained borrowers**

| Variables used for the PSM regression | Pscore (PSM Stage 1) | |
|---|---|---|
| | coefficient | std.err. |
| *Dependent variable: Probability of being unconstrained borrowers* | | |
| Rainfall variability (CV) | 0.078 | (0.123) |
| HH experienced drought shock | -0.170** | (0.081) |
| Market-related shocks | 0.123 | (0.118) |
| Idiosyncratic shocks | 0.096 | (0.144) |
| Participation in Productive Safety net prg (PSNP) | 0.30** | (0.132) |
| Head is member in a ROSCA (Ekub) | 1.220*** | (0.074) |
| Age of head | -0.008*** | (0.003) |
| dummy for female head of the household | 0.478** | (0.208) |
| Dummy for a married head | 0.448** | (0.199) |
| Household size | 0.001 | (0.020) |
| Head has no education | 0.087 | (0.090) |
| Head attended some formal education | 0.033 | (0.106) |
| Dummy for west Gojjam | 0.365*** | (0.097) |
| Dummy for south Wollo | -0.603*** | (0.151) |
| Dummy for north Wollo | -0.072 | (0.155) |
| Constant | -1.457*** | (0.282) |
| Diagnostic tests | | |
| Number of observations | 2,146 | |
| Log likelihood | -816.64 | |
| LR chi2(15) | 502.75 | |
| Prob > chi2 | 0.00 | |
| Standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1 | | |

Source: Author's computation from EPIICA's 2011 and 2013 survey data

**Table 2: Effect of different credit constraints on agricultural productivity (Real Crop revenue per Hectare): Propensity Score Matching**

| Credit constraint categories | Sample | Treated | Controls | Difference (ETB)‡ | std.err. | T-stat |
|---|---|---|---|---|---|---|
| Unconstrained borrowers | Unmatched | 1275.55 | 903.29 | 372.26 | 62.85 | 5.92 |
| | ATT | 1310.42 | 1141.89 | 168.53* | 94.42 | 1.78 |
| Discouraged borrowers | Unmatched | 814.16 | 1025.18 | -211.02 | 127.23 | -1.66 |
| | ATT | 809.03 | 1252.08 | -443.05*** | 187.85 | -2.36 |
| Quantity Constrained borr. | Unmatched | 848.94 | 1158.35 | -309.40 | 92.22 | -3.36 |
| | ATT | 848.87 | 1124.02 | -275.15*** | 120.20 | -2.29 |
| Risk-rationed borrowers | Unmatched | 1027.80 | 1025.18 | 2.62 | 78.18 | 0.03 |
| | ATT | 1028.00 | 1040.91 | -12.91 | 104.79 | -0.12 |

‡ETB = Ethiopian Birr, 1 USD = 18.5 ETB as of March 2013, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: Author's computation from EPIICA's 2011 and 2013 survey data

**Table 3: Determinants of the propensity to be discouraged borrower**

| Variables used for the PSM regression | Pscore (PSM Stage 1) | |
|---|---|---|
| | coefficient | std. err. |
| Dependent variable: Probability of being discouraged borrower | | |
| Rainfall variability (CV) | 1.976*** | (0.182) |
| HH experienced drought shock | 1.289*** | (0.186) |
| Crop damage due to wild animals | -0.138 | (0.292) |
| Market-related shocks | -0.209 | (0.220) |
| Idiosyncratic shocks | -0.336 | (0.288) |
| Participation in Productive Safety net prg (PSNP) | -0.225 | (0.194) |
| Trust farmers' cooperative | -0.088 | (0.141) |
| Year effect | 0.487*** | (0.133) |
| Head is member in a ROSCA (Ekub) | -0.158 | (0.158) |
| Age of head | -0.008* | (0.004) |
| dummy for female head of the household | -0.077 | (0.292) |
| Dummy for a married head | -0.201 | (0.261) |
| Household size | -0.015 | (0.033) |
| Head has no education | -0.167 | (0.147) |
| Head attended some formal education | -0.064 | (0.173) |
| Dummy for west Gojjam | 0.037 | (0.223) |
| Dummy for south Wollo | 0.776*** | (0.206) |
| Dummy for north Shewa | -0.791*** | (0.214) |
| Constant | -1.418*** | (0.436) |
| Diagnostic tests | | |
| Number of observations | 1,412 | |
| Log likelihood | -281.51 | |
| LR chi2(19) | 233.05 | |
| Prob > chi2 | 0 | |
| Standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1 | | |

Source: Author’s computation from EPIICA's 2011 and 2013 survey data

**Table 4: Determinants of the propensity to be Quantity constrained borrower**

| Variables used for the PSM regression | Pscore (PSM Stage 1) | |
|---|---|---|
| | coefficient | std.err. |
| Dependent variable: Probability of being Quantity constrained borrower | | |
| Rainfall variability (CV) | 0.086 | (0.125) |
| HH experienced drought shock | 0.205** | (0.089) |
| Market-related shocks | -0.054 | (0.129) |
| Idiosyncratic shocks | -0.186 | (0.156) |
| Participation in Productive Safety net prg (PSNP) | 0.341*** | (0.112) |
| Trust farmers' cooperative | -0.022 | (0.087) |
| Year effect | 0.394*** | (0.081) |
| Age of head | 0.001 | (0.003) |
| dummy for female head of the household | 0.136 | (0.188) |
| Dummy for a married head | 0.008 | (0.172) |
| Household size | 0.006 | (0.021) |
| Head has no education | -0.204 | (0.160) |
| Head attended some formal education | -0.050 | (0.206) |
| Dummy for west Gojjam | -0.136 | (0.163) |
| Dummy for south Wollo | 0.359*** | (0.121) |
| Dummy for north Shewa | -0.491*** | (0.142) |
| Head has no education time avg. | -0.197 | (0.190) |
| Head attended some formal education time avg. | -0.028 | (0.238) |
| Head is member of farmers' coop time avg. | -0.003 | (0.158) |
| Land holding time avg. | -0.118 | (0.075) |
| Constant | -0.589* | (0.309) |
| Diagnostic tests | | |
| Number of observations | 1,723 | |
| Log likelihood | -866.64 | |
| LR chi2(20) | 136.38 | |
| Prob > chi2 | 0 | |
| Standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1 | | |

Source: Author’s computation from EPIICA's 2011 and 2013 survey data

**Table 5: Determinants of the propensity to be Risk Rationed Borrowers**

| Variables used for the PSM regression | Pscore (PSM Stage 1) | |
|---|---|---|
| | coefficient | std.err. |
| Dependent variable: Probability of being Risk Rationed Borrowers | | |
| Rainfall variability (CV) | 0.791*** | (0.148) |
| HH experienced drought shock | 0.247*** | (0.096) |
| Market-related shocks | 0.018 | (0.133) |
| Idiosyncratic shocks | -0.350* | (0.187) |
| Participation in Productive Safety net prg (PSNP) | 0.240 | (0.158) |
| Trust farmers' cooperative | -0.132 | (0.096) |
| Year effect | 0.181** | (0.090) |
| Age of head | 0.000 | (0.003) |
| dummy for female head of the household | -0.022 | (0.216) |
| Dummy for a married head | -0.004 | (0.196) |
| Household size | -0.003 | (0.022) |
| Head has no education | -0.085 | (0.097) |
| Head attended some formal education | -0.090 | (0.120) |
| Dummy for west Gojjam | 0.026 | (0.197) |
| Dummy for south Wollo | -0.196 | (0.183) |
| Dummy for north Shewa | 0.052 | (0.181) |
| Constant | -1.496*** | (0.338) |
| Diagnostic tests | | |
| Number of observations | 1,600 | |
| Log likelihood | -677.66 | |
| LR chi2(16) | 122.38 | |
| Prob > chi2 | 0 | |
| Standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1 | | |

Source: Author’s computation from EPIICA's 2011 and 2013 survey data

**Figure 4: Propensity score distribution for the treated and untreated**

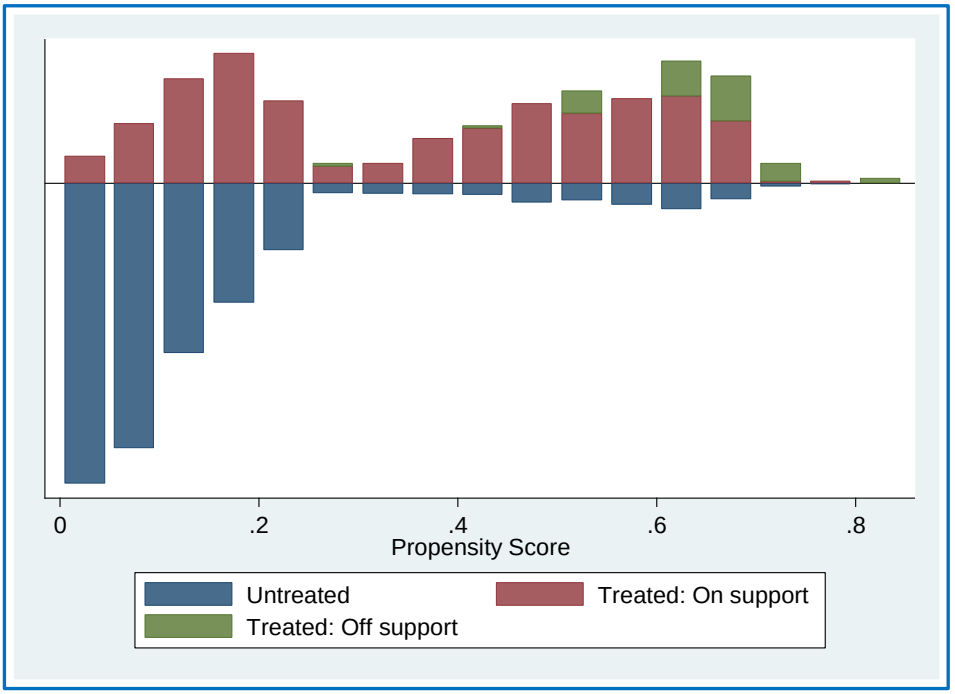



**Table 6: Sensitivity analysis-Rosenbaum bounds for the outcome variable**

| Outcome | Gamma* | Matched pairs | Significance level | | Hodges-Lehman Point estimate | | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|---|
| | | | Upper bounds | Lower Bounds | Upper bounds | Lower Bounds | Upper bounds | Lower Bounds |
| Real crop revenue | 1 | 269 | 0.0164 | 0.0164 | 0.1433 | 0.1433 | 0.0105 | 0.2715 |
| | 2 | | 0.9971 | 0.0000 | -0.1823 | 0.4690 | -0.3309 | 0.6119 |
| | 3 | | 1.0000 | 0.0000 | -0.3792 | 0.6551 | -0.5515 | 0.8189 |

**Table 2A: Effect of Credit Constraint on Agricultural Productivity (using diff-in-diff as a robustness test)**

| Credit Constraint cat. | Outcome | Control BL | Treated BL | Difference BL | Control FU | Treated FU | Diff. FU | DID |
|---|---|---|---|---|---|---|---|---|
| Unconstrained Borrower | Rcr | 1047.95 | 1131.31 | 83.36 | 1064.75 | 1397.76 | 333.01 | 249.64 |
| | Std. Error | 59.45 | 59.45 | 84.08 | 72.40 | 53.18 | 89.83 | 123.04 |
| | T | 17.63 | 19.03 | 0.99 | 14.71 | 26.29 | 3.71 | 2.03 |
| | P>\|t\| | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.00 | 0.04 |
| Quantity Const. Borr. | Rcr | 1121.27 | 972.93 | -148.34 | 1052.42 | 746.81 | -305.61 | -157.27 |
| | Std. Error | 60.35 | 60.35 | 85.34 | 73.99 | 77.70 | 107.29 | 137.10 |
| | T | 18.58 | 16.12 | -1.74 | 14.22 | 9.61 | -2.85 | -1.15 |
| | P>\|t\| | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.25 |
| Risk rationed borr. | Rcr | 1121.64 | 1146.75 | 25.11 | 922.67 | 711.43 | -211.24 | -236.35 |
| | Std. Error | 63.99 | 63.99 | 90.50 | 79.64 | 57.86 | 98.44 | 133.72 |
| | T | 17.53 | 17.92 | 0.28 | 11.59 | 12.30 | -2.15 | -1.77 |
| | P>\|t\| | 0.00 | 0.00 | 0.78 | 0.00 | 0.00 | 0.03 | 0.08 |
| Discouraged Borr. | Rcr | 1097.25 | 1225.03 | 127.78 | 895.40 | 723.48 | -171.92 | -299.71 |
| | Std. Error | 51.99 | 51.99 | 73.52 | 59.03 | 54.75 | 80.51 | 109.03 |
| | T | 21.11 | 23.56 | 1.74 | 15.17 | 13.21 | -2.14 | -2.75 |
| | P>\|t\| | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.03 | 0.01 |

‡ETB = Ethiopian Birr, 1 USD = 18.5 ETB as of March 2013, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

**Location map of the study area, Ethiopia; Amhara Regional State**

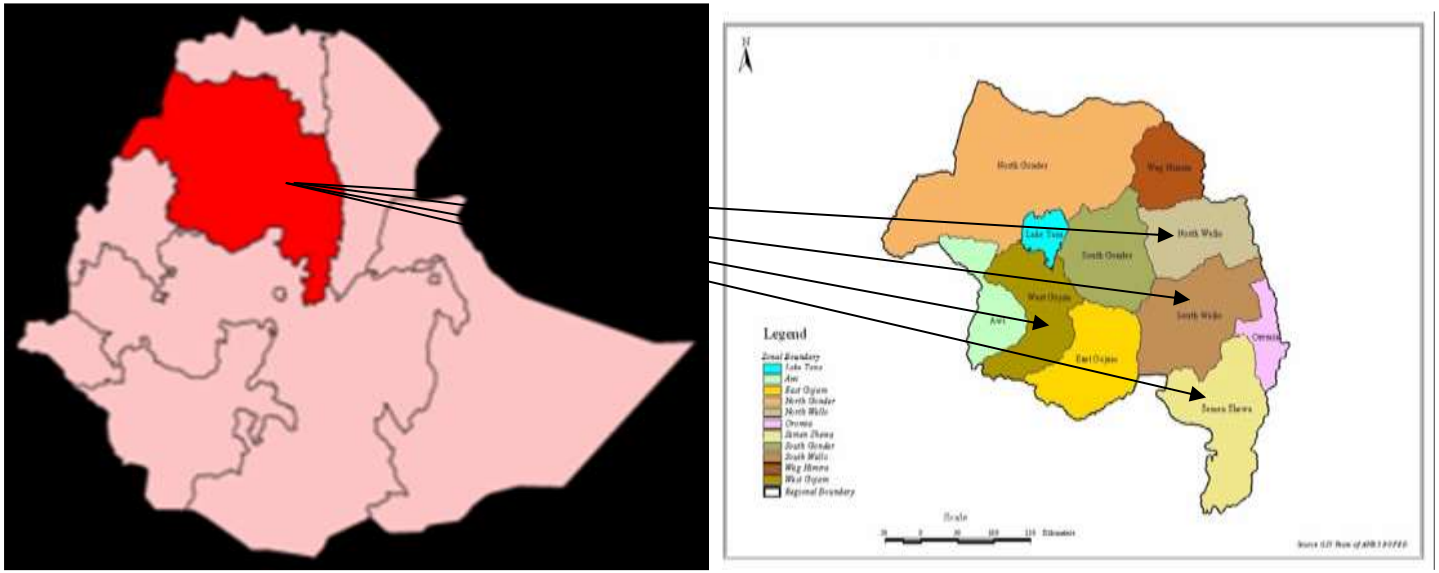
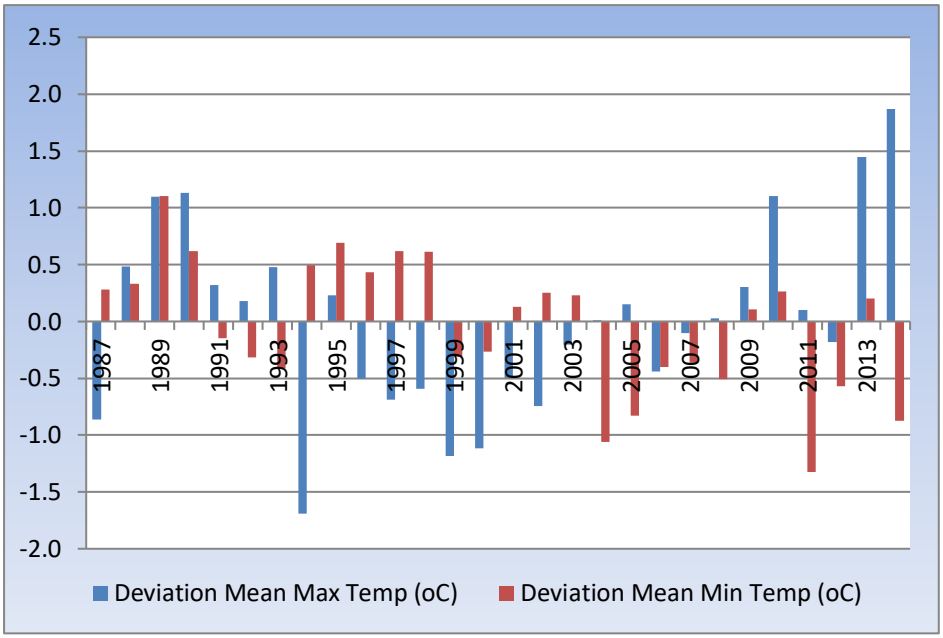


**Figure 5: Anomaly from Mean of the Annual Minimum and Maximum Temperatures (°C) in Gudoberet Station**



# Determinants of Under-Five Child Mortality in Benishangul-Gumuz Regional State of Ethiopia

**Kidist Demirew Getachew**

***Abstract***

*Under-five Mortality (U5MR) in Benishangul-Gumuz is the highest among Ethiopia's regional states, next to the Afar region. The risk of a child dying before completing five years of age in Benishangul-Gumuz region is 72.8 per 1000 live births. This paper aims to verify the main determinates, socioeconomic, demographic and environment factors, of U5MR in Benishangul-Gumuz Regional State using data from the Ethiopian Demographic and Health Survey (2016). The method of analysis is descriptive and econometric employing Probit model estimation. The result reveals that "Mother's educational level" "Preceding Birth Interval", "Duration of breastfeeding", "Income or wealth of the household" and "Married Marital Status" have a negative and statistically significant relationship on Under-five Mortality. The policy implications of the results of the analysis emphasize that empowering women through education, health and income provide very important instruments to reduce Under-five Mortality in the region.*

**Key words:** Socio-economic; Demographic; environment; Determinants; Under-five mortality; Benishangul-Gumuz Regional
**JEL Code:** I15

## 1. Introduction

Child Mortality is the main indicator of the level of health status and welfare of the population. It reflects a country's level of socio-economic development and quality of life and is used for monitoring and evaluating population and health programs and policies (WHO, 2013). There are a number of different types of child mortality rate indicators, including neonatal and post-neonatal, infant, and under 5 mortality rates. Among these the Under 5 Child Mortality Rate (U5MR) is often identified in many researches and policy

statements as the best concept for capturing mortality risks during the susceptible years of childhood. It has now been used as one of the indicators of the United Nation 2015 Millennium Development Goals.

Given the importance of child mortality, many studies have been undertaken to define its determinants. Fitsum (2011), Ayichew (2011), and Kumar and File (2010) have looked at the determinants of child mortality in Ethiopia identifying such factors as the importance of health facilities, diseases, urbanization, birth intervals, living standards and mother's education while Iram and Butt's work on Pakistan underlined the importance of household, demographic and environmental factors, including breast feeding as well as prenatal care, income and environmental contamination.

According to UNICEF's 2015 figures, about 5.9 million children worldwide still die every year before their fifth birthday, 16,000 every day. At the prevailing rate of progress, it will take to 2025 to reach the global target (UNICEF, 2015). Ethiopia, for example, has made good progress in reducing child mortality but the problem still remains serious. It is still one of the countries with the highest U5MR in the world. So, identifying and assessing factors affecting child mortality should be the first step in planning the reduction of child mortality and promoting the health of society. Understanding the determinants help policy makers to make more cost-effective interventions and policies for reducing child mortality, and the aim of this study was to investigate the determinants of U5MR using descriptive and comparative analysis and econometrics models in the Benishangul-Gumuz Regional State.

The result of this research is expected to give information about the determinants or risk factors of under-five mortality. It will also provide information to the Regional Government and other concerned bodies to make enabling environment for the intervention to reduce under-five mortality and add to the existing literature. The study also fills the gaps that are found in the earlier studies where most of them focused on national level disregarding the regional disparities in terms of cultural, social and economic differences. In particular, the study has tried to examine the determinates of under-five child mortality in the one of the least developed regions of the country, Benishangul-Gumuz Regional State. Moreover, the study is superior as it used the recently released EDHS (2016).

# 2. Literature Review

## 2.1 Empirical Review

Fitsum (2011) identified preventable and curable diseases as the main causes of death in early childhood and this is why childhood mortality is treated as a development issue rather than a simple health problem. Ethiopia is among the place where the rate of such deaths is high, which is an indicator of poor standards of living. Fitsum used descriptive statistics and Probit model regression analysis to assess the structural relation between childhood mortality and maternal, child specific and household related variables. He chose infant and under-five child mortality as dependent variables with maternal characteristics of total number of children born, maternal educational level, maternal age at first born, child characteristics of gender and twin, and household characteristics of safe water, access to toilet facility, electricity, technology and information, floor material, fuel and other variables as explanatory variables that might contribute to under-five child mortality. His results indicated that the total number of children born has a negative and significant effect on child's chance of mortality. Furthermore, maternal education, age at first birth, access to toilet, safe water, power and radio lowered the chance of mortality. However, multiple births, boys, children living in houses with dirty floors or using polluting cooking fuels faced a high chance of childhood mortality. Some variables showed a low-level significance depending on different approaches of defining childhood mortality. Fitsum recommended interventions designed to reduce child mortality should pay attention to socioeconomic factors while designing and implementing prevention and curative healthcare interventions designed to consider the peculiarities of each society and villages. The source of the data for his study was the Ethiopian Demographic and Health Survey (EDHS, 2011).

Ayichew (2011) emphasized that infant and under-five child mortality was an important indicator of socioeconomic development. His study, analyzing the determinants of interregional variation in infant and child mortality rates, indicated that although Ethiopia had registered improved infant and child health, the gain was not uniformly shared across regions. The study analyzed the determinants of interregional variation in infant and child mortality rate in Ethiopia. The main purpose of the study was thus to fill the gap of information by explaining regional infant and under-five mortality rates using regional level panel data spanning 9 years (1999/2000 to 2007/2008). He employed both

random effect and fixed effect models to address the panel nature of data, the most widely used panel data estimation method in applied economic research. The study also used econometric estimates of infant and under-five mortality. However, the Hausman test result indicated that the fixed effect model was more suitable than the random effect model for the panel data analysis. In the study, infant and under-five mortality rates were taken as dependent variables while health infrastructure variables, socioeconomic and demographic variables and regional location or geographic variables were all considered as independent variables. The data was extracted from different sources; health and health related indicators from the publications of the Ministry of Health, educational statistics from the Ministry of Education and regional location from the Ministry of Foreign Affair website. The estimated results indicated that infant and under-five child health outcomes were strongly sensitive to the availability of skilled health professionals and health facilities; increasing real per capita public health spending was important to infant and child health outcomes; and the share of population living in urban areas had strong effects on both infant and child mortality rates. These findings suggest that much of the observed regional disparities could be reduced through public policy interventions aimed to increase the supply of health resources while at the same time equalizing their distribution across regions.

Kumar and File (2010) investigated the predicators of child (0-5) mortality in Ethiopia. Their main objective was to identify the factors that reduced child mortality and suggest viable strategies to increase health services and reduce child mortality in Ethiopia. The study used a cross tabulation technique to estimate the predicator of child mortality and showed that birth intervals and the mother's standard of living index were the vital factors associated with child mortality. Although there had been a reduction of in child mortality rates, they found the level of mortality was worsened by poverty and inadequate maternal education. Education could indirectly decrease mortality rate and fertility rates by reducing desired number of children. Kumar and File examined the predicators of child mortality using secondary data from the EDHS (2005) and the interlink ages between child mortality and socioeconomic, bio-demographic and maternal health care variables. The linkages were tested by applying cross tabulation analysis using SPSS. The variables involved were the education of the mother, the standard of living index, place of residence, birth order, sex of child, birth intervals, and mother's age at birth of child. Their findings suggested that the

most important socioeconomic predictor of child mortality was a mother's education, with the mortality rates decreasing along with increases in mothers' education levels. Birth intervals also played a significant role in reducing the risk of child mortality. Other characteristics that effected child mortality were the place of residence and mother's age at birth. A mother's standard of living index was found to have a significant effect. So, attention should be given to mothers' education, birth intervals and the standard of living index factors to reduce the risk of child mortality in Ethiopia.

Iram and Butt (2008), undertook a study to identify and quantify the relative importance of various socioeconomic factors and maternal care practices in determining child mortality at different ages in Pakistan. Using a sequential probit model that took into account the cause of death they examined the role of household, demographic and environmental factors as determinants of early child mortality. A number of individuals, household and local characteristics related to the probability of child mortality and they identified mother feeding as a protection from early exposure to disease and ill-health in different ways. The result of the analysis also indicated that the mother's education was strongly related to a reduction of neonatal mortality, infant mortality as well as child mortality, through improved child caring practices and through other proximate determinants such as prenatal care, income and environmental contamination.

## 2.2 Literature Gap

Fitsum (2011), though the study has relatively used good methodology and delivered expected results, the following can be mentioned as the limitation of the study. First, it has given an aggregated overview of the children mortality of under-five for Ethiopia as a whole. For a big sized county, Ethiopia, which has diverse culture, demographic and standard of living across different regions, the result may not uncover the main factors that contributed for children mortality in a specific region and not identified in his paper, like Benishangul-Gumuz region. Thus, specific study on Benishangul-Gumuz region will have a value addition in this regard. Secondly, the study used 2011 EDHS which is relatively old as compared the new data set of 2016 EDHS. Thus, using the latest data set, it is possible to come up with better result.

Ayichew (2011), though this study has tried to address regional variation in the incidence infant and under-five child mortality, still it has some limitation.

The study is mainly focused on the variation in health and education infrastructure that existed across region as explanatory variables disregarding the behavioral differences such as cultural and demographical. Moreover, the study used different administrative data sources. It would have been better if the study employed survey data such as EDHS which is compressive and tested.

Kumar, P. and File, G. (2010), It has some limitations. First it is crude generalization using SPSS tabulation analysis. If it is supported with econometrics analysis, it would have been relatively more accurate and acceptable. Secondly, it employed old data (EDHS 2005) as compared with the new EDHS (2016). Moreover, since the study is focused on Ethiopian as a whole, its conclusion cannot be taken for granted for regions which have differences in the explanatory variables of child mortality.

Iram and Butt's (2008), the study appears useful but it has a limitation by not incorporating social policies that promote early initiation of mother feeding and utilization of prenatal care which have major contribution to the reduction of under-five years mortality. Whereas our research has tried to absorb, advocate and clarify the problems for better understanding for policy implementation.

## 3. Data and Methodology

Data obtained from complete registration of births and deaths is the best source for direct estimation of child mortality. Unfortunately, this is unavailable in Ethiopia, and estimation of child mortality has to be based on cross-sectional surveys collecting complete birth histories from respondents. This study is based on a database compiled as part of the 2016 Ethiopian Demographic and Health Survey (EDHS). The data set consists of a national representative sample of household level data. The EDHS was conducted by the Central Statistical Agency (CSA) in collaboration with the Ministry of Health. Prior to the 2016 survey, EDHSs were conducted in 2000, 2005 and 2011. Here, we have used intensively the 2016 EDHS. In addition to EDHS data, we have also used World Bank, UNICEF and other reports.

As we are dealing with determinants of U5MR, there are households which lost their child/children and others which did not. The dependent variable under investigation is therefore a dichotomous variable that takes values 0 and 1 only. This research employed the Probit model, one of the estimation methods of binary variables. The model takes the form

$$\Pr(Y = 1/X) = \phi\ (X^T \boldsymbol{\beta})$$

Where Pr denotes probability and $\phi$ is the cumulative distribution function (CDF) of the standard normal distribution. The parameters $\boldsymbol{\beta}$are estimated by maximum likelihood.

Structurally, the Probit model can be described as follows. Let the observed outcome (whether the child is alive or not in this case) be yi. As referred from Fitsum (2011), there exists an unobserved threshold level that marks a child's survival (or not) to his/her fifth birthday. This underlying latent variable, say $\boldsymbol{Y_i^*}$ i, is assumed to be a function of several observed personal and socioeconomic factors, say a vector of $X_i{}'S$ and unobserved characteristics, say $\varepsilon_i$ for individual i, this can formally be expressed as:

$$\boldsymbol{Y_i^* = x_i' \beta i + \varepsilon_i, \quad \varepsilon_i \sim NID(0, \sigma_\varepsilon^2)} \qquad i=1, 2, 3, \ldots 13 \qquad \textbf{(1)}$$

If this threshold level is set to zero, without loss of generality, then the Probit model can be fully described as;

$$y_i^* = x_i^{'} \beta i + \varepsilon_i, \varepsilon_i \sim NID(0, \sigma_\varepsilon^2) \qquad i=1, 2, 3, \ldots 13 \qquad \textbf{(2)}$$

And

$$y_i = \begin{cases} 1 \ \ if \ \ y_i^* > 0 \\ 0 \ \ if \ \ y_i^* \le 0 \end{cases} \qquad \textbf{(3)}$$

This model assumes that $E[\varepsilon / x] = 0$ . In otherwords it means that the independent variables are exogenous.

The variables in this study include the Dependent Variable with the response (outcome) variable in this study Under-five mortality; Independent (predictor) Variables, that might be expected to be associated with under-five mortality rate. These include:

- Mother's Educational Level (with additional categories of No Education, Primary, Secondary and Higher),
- Duration of Breastfeeding,
- Birth Interval,
- Marital Status,
- Income/Wealth of the Household,
- Mother's Age at First Birth,
- Getting medical help for self and distance to health facility,
- Family Size in Number,
- Place of Residence (Urban or Rural),
- Sex of Child,
- Source of Drinking Water,
- Sanitation, and
- Type of Birth (Single/Multiple)

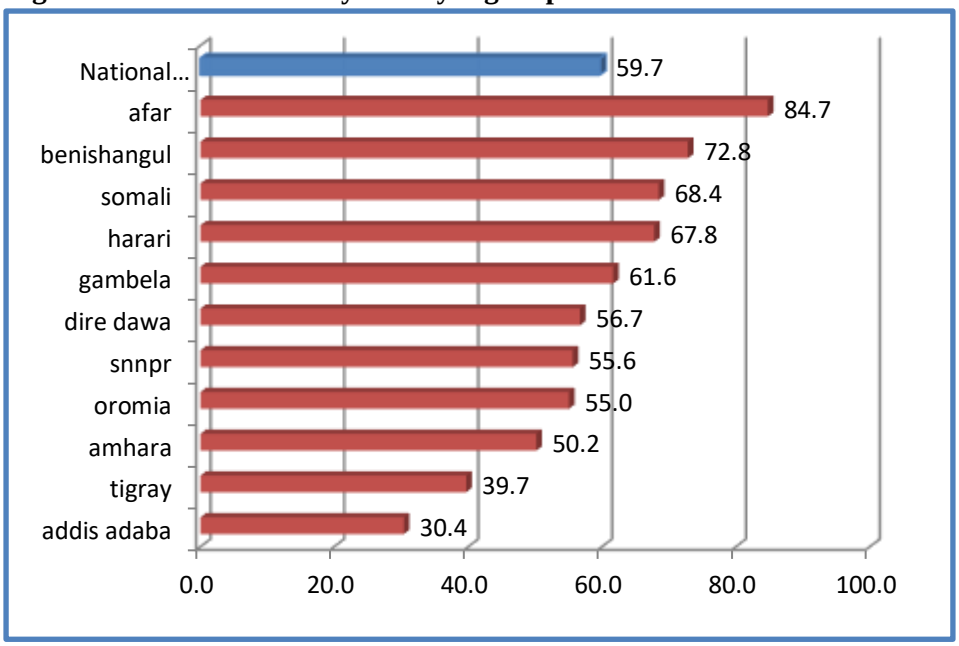
## 4. Data Analysis

### 4.1 Descriptive Analysis

Generally, the risk of a child dying before completing five years of age is still high in less developed countries. WHO Global Health Observatory (GHO) data (2016) indicated that African U5MR was 76.5 per 1000 live births, almost 8 times higher than the European Region (9.6 per 1000 live births). In addition, imbalances in child mortality between high-income and low-income countries remain large. In 2016, U5MR in low-income countries was 73.1 deaths per 1000 live births, almost 14 times the average rate in high-income countries (5.3 deaths per 1000 live births).

In Ethiopia, although U5MR has reduced over the years, it remains high with significant regional variations. At the national level, U5MR is about 59.7 per 1000 live births (Figure 1). Looking at the regional comparisons, the highest U5MR are found in the most underdeveloped regions, Afar, Benishangul-Gumuz, and Somali. The lowest mortality rate has been observed in Addis Ababa which has better health and socio-economic infrastructure. After Addis Ababa, the more developed regions, Tigray, Amhara, Oromia, SNNP and Dire Dawa, show U5MR below the national average.

**Figure 1: Under 5 mortality rate by region per 1000.**



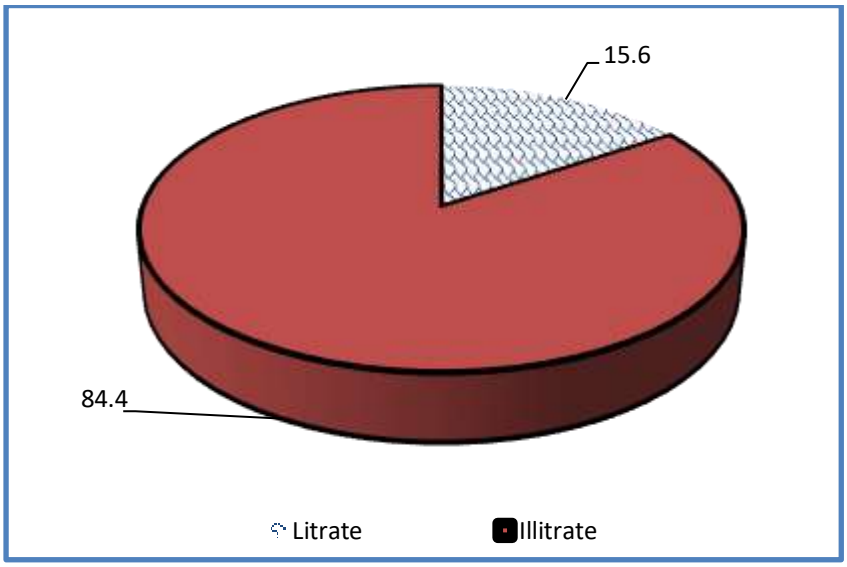

Source; EDHS (2016)

U5MR in Benishangul-Gumuz is second next to Afar. The risk of a child dying before completing five years of age in Benishangul-Gumuz is 72.8 per 1000 live births, almost 22 percent higher than the national average. This raises the question of why the U5MR in Benishangul-Gumuz region is so high; and this study assesses a range of possible contributing factors. These include the mother's educational level, birth interval, duration of breastfeeding, income/wealth of household, family size, mother's age at first birth, marital status, types of birth (single/multiple), place of residence, sex of the child, source of drinking water, sanitation, and distance from health facility. Among these, the variables most closely linked with mothers' empowerment for child care are the main focus of this research - mother's educational level, birth Interval, duration of breastfeeding, income/wealth of the household, family size, mother's age at first birth, and types of birth (single/multiple). Other variables are included to make the model complete and stable.

### *4.1.1 Mothers' Education Status*

Mothers' educational status is a very important factor to reduce child mortality rate. Better educated mothers can take care of children more effectively; the risk of a child dying in an educated mother's family is very low. Using the EDHS (2016) data, we can see the negative correlation of mothers' educational status and child deaths in Benishangul-Gumuz region, with a correlation coefficient of -0.11. Figure 2 shows that 84.4 percent the total under-five child deaths, came from families where the mothers were illiterate; only 15.6 percent of deaths were from the families of literate mothers. Literate mothers have better capability to raise their children and provide healthy living compared to illiterate mothers

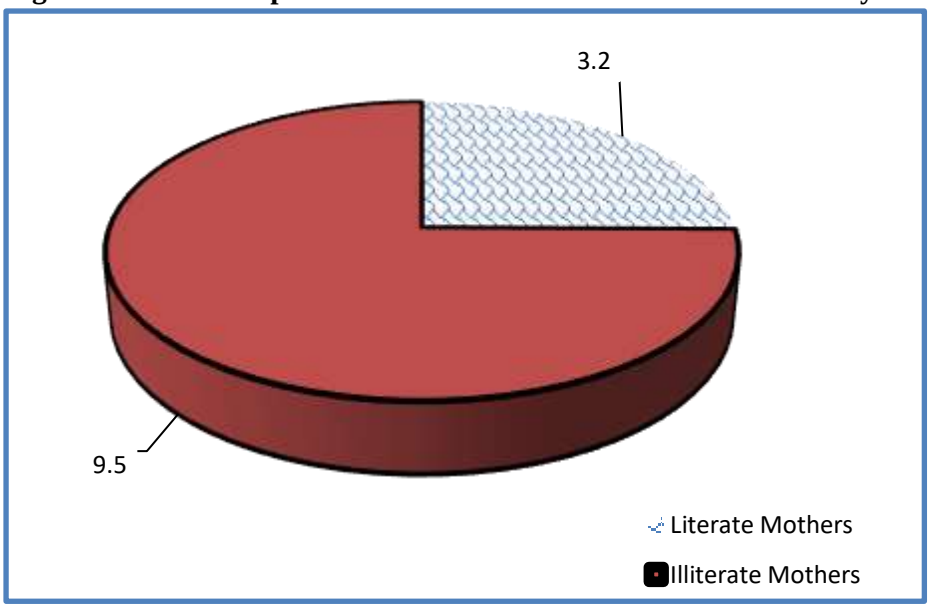
**Figure 2: Mother's literacy by U5M (in %)**




Source: *Author's* computation based on EDHS (2016)

Figure 3 demonstrates the correlation that exists between mothers' education and Under-Five Mortality in relation to total births. Out of 100 births in educated mothers' family, 3.2 percent of the children died before their fifth birthday; the figure for families of illiterate mothers was nearly 10 percent. It is clear that as mothers become educated, Under-five Mortality tends to decline.

**Figure 3: Relationship between Total Birth and Under Five Mortality**

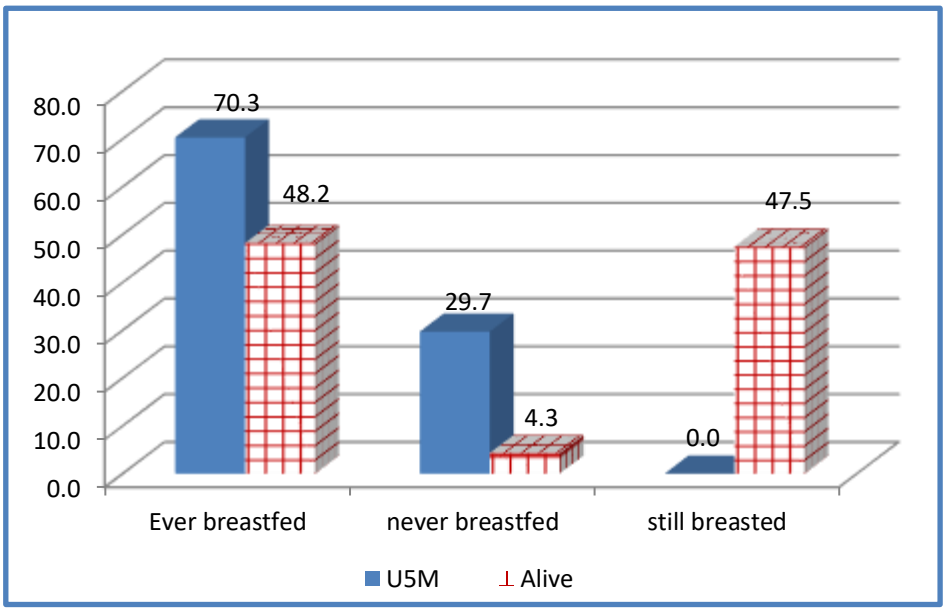



Source: Author's computation based on EDHS (2016)

### *4.1.2 Duration of Breastfeeding Status*

Figure 4 shows the highest mortality rate is found among those who never practiced breastfeeding; about 35 percent of children who were never breast-fed died. Of those breast-fed for the first six months, only 10 percent died, while from the cohort that still breastfed almost none died. Mothers' breast milk contains antibodies to help children fight off viruses and bacteria and, as health workers attest, it also lowers the risk of having asthma or allergies, ear infections, respiratory illness or bouts of diarrhea. Children who never get breast milk do not receive minerals, vitamins, proteins or immunity against many diseases. The correlation of the duration of breast feeding and U5M is negative with a correlation of coefficient of -0.19. This means that as the duration of breastfeeding increases, the Under-five Mortality tends to decrease.

**Figure 4: Duration of breastfeeding with under-five mortality and alive children**

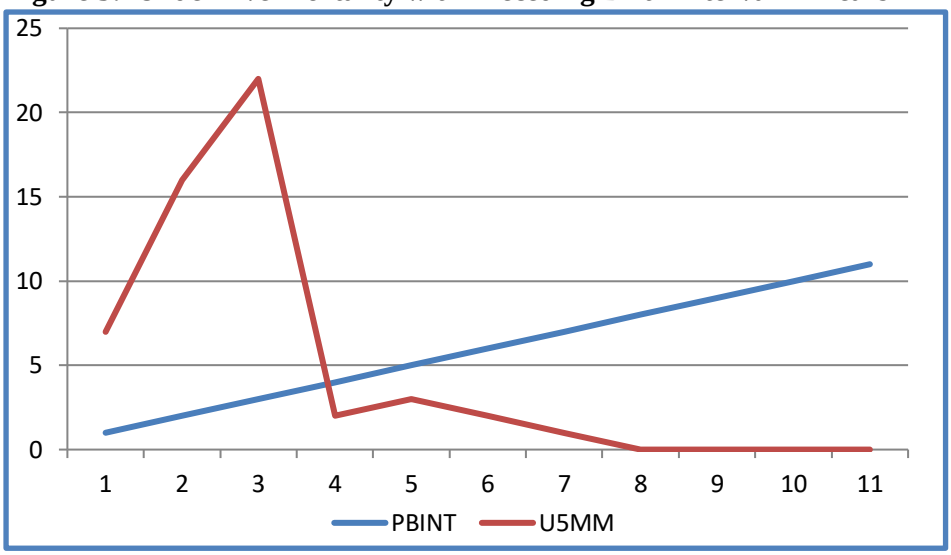



Source: Author's computation based on EDHS (2016)

### *4.1.3 Preceding Birth Interval*

The length of a Preceding Birth Interval is one of the determinants of the Under-five Mortality in Benishangul-Gumuz region. The relationship between the Preceding Birth Interval and Under-five Mortality is negative; the correlation coefficient of the two variables is -0.13. Figure 5 shows that when as the birth interval is low, the Under-five Mortality Rate is relatively high, and as the interval increases, the chance of children below five dying declines. A birth interval of two years appears to be the most dangerous.

**Figure 5: Under-five Mortality with Preceding Birth Interval in Years**




Source; Author's computation based on EDHS (2016)

### *4.1.4 Marital Status*

Figures 6 and 7 demonstrate that about 95.9% of the total of 879 observations are married families; 4.1% are of single parent or divorced families. In married families, about 7.1% of children died before their 5$^{th}$ birthday; in single or divorced families about 11.1% died. Respondents make it clear that marriage is highly valued in the Benishangul-Gumuz region and an unmarried woman who has a child is out-caste and a shame to her parents. The percentage of woman's either never married, or living with parents, widowed or divorced is 4.1%. Interviews underline the culture of Benishangul-Gumuz encourages couples to remain together in marriage and single or divorced families are limited in number. Under-five mortality in married families is relatively low, compared to single or divorced families.

Figure 6 shows the distribution of the population with regard to marital status among married people or single/divorced/widower. Figure 7 shows the percentage of under-five mortality among married mothers (11.1 percent) and single mothers (7 percent.).

**Figure 6: Marital Status**

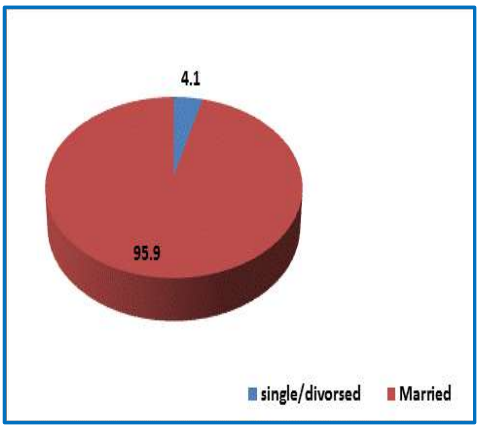
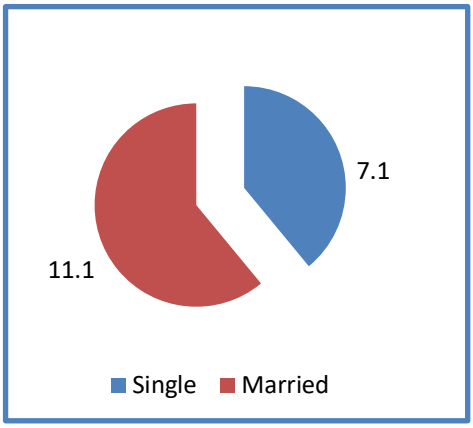



**Figure 7: Under-five Mortality/Marital Status**

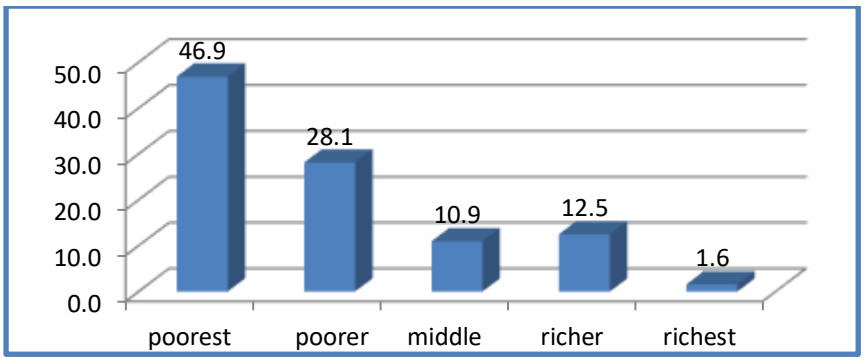



Source; Author's computation based on EDHS (2016)

### *4.1.5 Income/wealth index*

We used the wealth index as a measure of income as one of the key variables that have a positive impact on the welfare of children. The wealth index is calculated from a score given to households on the basis of the number and kind of consumer goods. Figure 8 shows that as the income of the family increases, the incidence of child death decreases. 46.9% of child death occurred in the poorest families while only 1.6% of deaths occurred in the richest families. The correlation coefficient between the wealth index and Under-five Mortality is negative at -0.08, showing the treatment, value and care given to children rises as income increases.

**Figure 8: Relationship between Wealth Index and U5M**

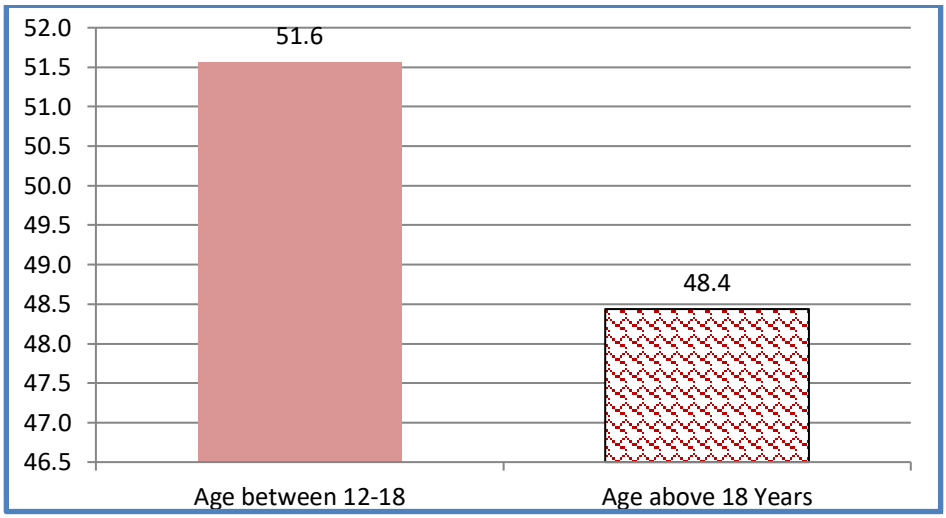



Source; Author's computation based on EDHS (2016)

### *4.1.6 Mothers' age at first birth*

The age of a mother at first birth is an important variable to determine the cause of high mortality because mothers, at a first birth, are often not mature physically or mentally; informants make it clear the survival rate of both mother and child is relatively lower as compared to matured mothers. That is why health workers as well as the government and NGOs which work with children and mothers argue strongly against early marriage. It is also forbidden in the Constitution (Article 34, 1995) with the aim of protecting mothers' and preventing child mortality. Despite this, as Figure 9 shows, out of 879 mothers, 53.3% first gave birth between 12-18 years and nearly 52% of Under-five Mortality is associated with these mothers. For cultural reasons, early marriage in Benishangul-Gumuz is a common practice and it certainly contributes to a higher U5MR in the region.

**Figure 9: Relationship between age of mother at first birth and U5MR**



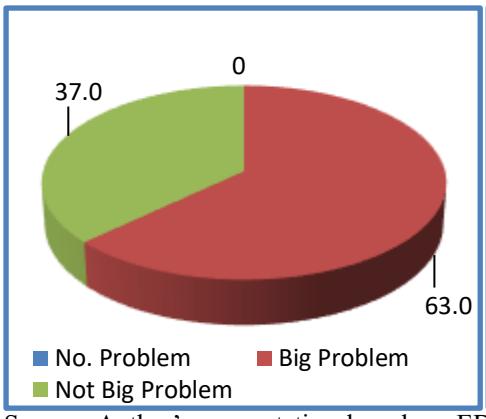

Source; Author's computation based on EDHS (2016)

### *4.1.7 Access to Health Facilities (HFs)*

Access to Health Facilities is another key variable to address Under-five Mortality and access in the Benishangul-Gumuz region is a crucial problem. As Figure 10 demonstrated, out of a total of 879 respondents, none agreed that they had good access to HFs. 63 percent of respondents said they had severe access problems; and the other 37 percent classified problems in accessing the HFs as

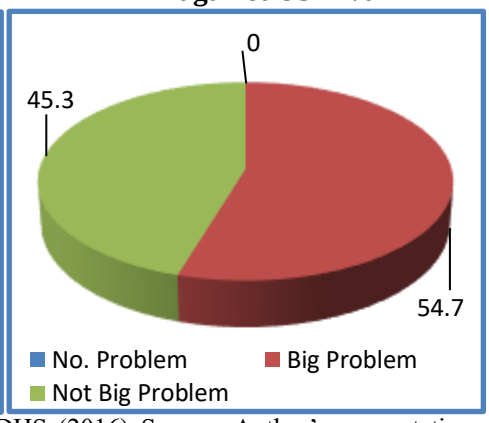
mild. Figure 11 relates Under-five Mortality associated with severs and mild problems to HFs access, underlining that the access to HFs is very poor and Under-five Mortality was directly linked to the problem of access. Benishangul-Gumuz region's access to health facilities is one of the least in the country.

**Figure 10: Response to HFs Access in %**




Source: Author's computation based on EDHS (2016)

**Figure 11: Response to HFs Access against U5M %**

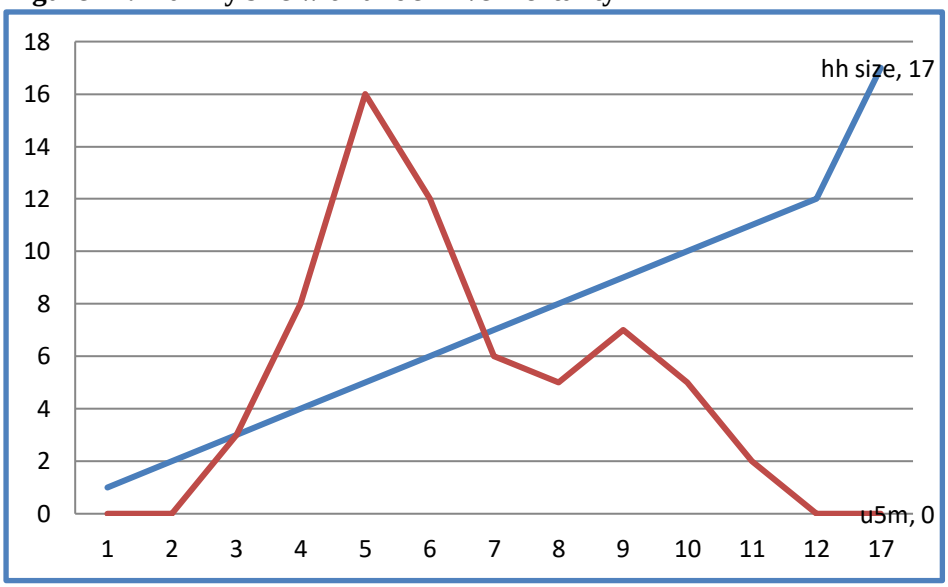



Source: Author's computation based on EDHS (2016)

### *4.1.8 Family size*

As the size of a family increases up to 5 (Figure 12), Under-five Mortality also increases. Above five U5M tends to decline. This may be because of the difficulty of managing the family and provide the domestic protection required to raise healthy children. Women have the responsibility to cook, clean and provide for the household, and it is hard to perform all these activities along with raising many children. When the number of household members is greater than five, there are likely to be other grownups to help to siblings or share responsibilities for domestic activities.

**Figure 12: Family size with under-five mortality**




Source: Author's computation based on EDHS (2016)

### *4.1.9 Place of residence (urban/rural)*

Benishangul-Gumuz region is largely rural Health and education facilities and other socio-economic infrastructures are very limited and there is high probability of child illness leading to death. Out of the total sampled children, 5.7 percent lived in urban areas (Table 1), the remainder in rural areas, and most Under-five Mortality occurred in rural areas. In Benishangul-Gumuz region, Under-five Mortality is largely a rural phenomenon.

**Table 1: Children by Residence**

| Description | Urban | rural | Total |
|---|---|---|---|
| Under-five Mortality (U5M) (%) | 1(1.6%) | 63 (98.4%) | 64 (100%) |
| Alive Child | 49 (6%) | 766 (94%) | 815 (100%) |
| Total | 50 | 829 | 879 |
| **% of** | **5.7%** | **94.3%** | |

Source: Author's computation based on EDHS (2016)

### 4.1.10 Sex of the Child

Sex preference may be one of the contributing factors to higher Under-five Mortality in Benishangul-Gumuz region. The analysis of both dead and alive children found 53.1% of deaths were of male children and 46.9% female (Figure 13). In addition, out of the total children who reached their fifth birthday 48.6% were male and 51.4% are female. Of total births, 7.9% of those who died were male, 6.7% female (Figure 14). This raises the suspicion of existence of a cultural preference for female children in Benishangul-Gumuz region. Interviews with native residents note that the family of the groom is obliged to provide cattle to the family of the bride, which means female children are considered as a source of wealth to their family.

**Figure 13: Sex Composition in relation to U5M and living from Total Birth**

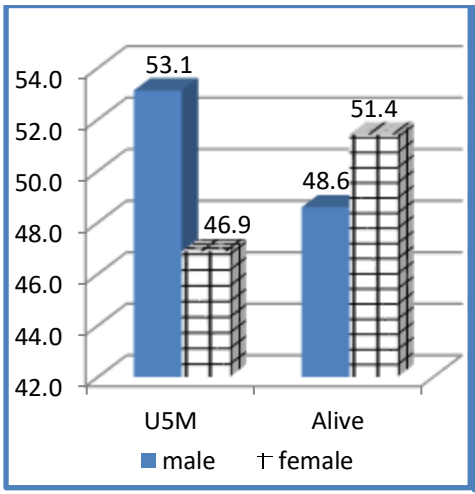
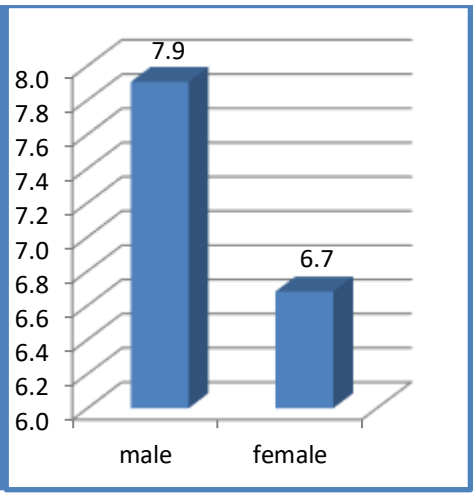



**Figure 14: Percentage of death**



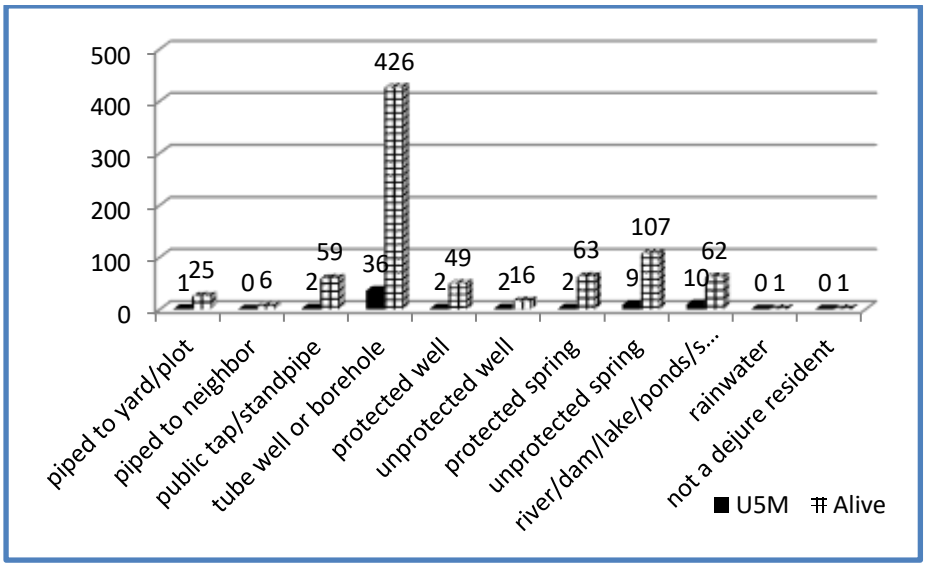

Source: Author's computation based on EDHS (2016)

### 4.1.11 Source of Drinking Water

Rural areas in Benishangul-Gumuz region have low standard infrastructure with limited clean water access. Figure 15 shows many families use unsafe sources of drinking water. Access to piped water (private or public) is limited while unsafe sources of drinking water, rivers, dams, lakes, ponds, streams, irrigation canals, unprotected springs, tube wells or boreholes are common. It is observed that

families of both dead and living children used more unsafe sources of drinking water though there were differences between the two groups. Higher mortality was found where the sources of drinking water were tube wells or boreholes and other unprotected sources which can carry different kinds of diseases like diarrhea, cholera, guinea worm, typhoid, dysentery and others and under-five children have low fighting capacity.

**Figure 13: Sources of Drinking Water**



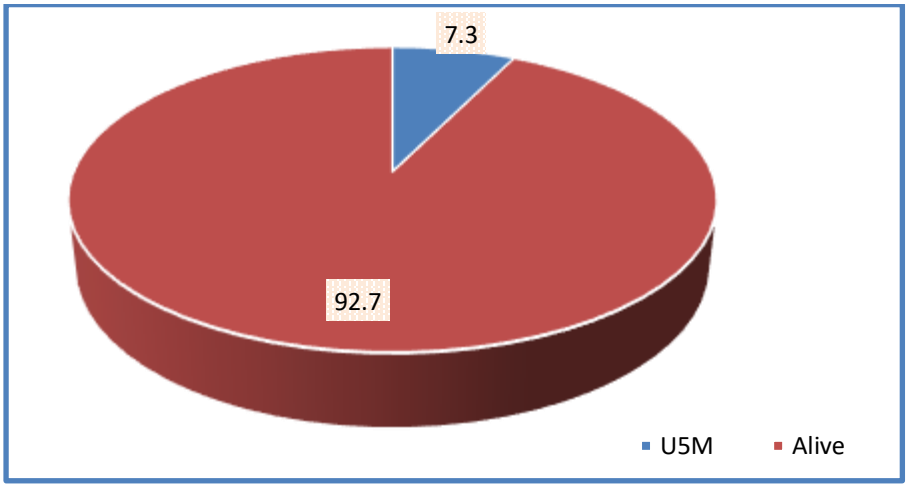

Source: Author's computation based on EDHS (2016)

### *4.1.12 Access to Toilet Facilities and Sanitation*

Sanitation is another variable that can determine the health status of children and their families. Families follow a unsafe hygiene system. Because of their toilet facilities, they are likely to be exposed to illness or death. The major types of toilet facilities used by U5M families are open pit and open field, classified as traditional, or flush or pit latrines, ventilated and improved pit latrines or pit latrines with slab defined as modern facilities and rarely available. The situation of families with living children is not much different but those families do have relatively better access to safer sanitation. 92.7% of the under-five deaths occurred in families using traditional and unhygienic facilities (Figure 16) which allow for numerous contagious diseases, including cholera, typhoid, infectious hepatitis, polio, cryptosporidiosis, ascariasis, pneumonia, and worm

infestations. Children under the age of five are particularly susceptible to such infections.

**Figure 14: Access to traditional Sanitation Facilities by U5M and living children's Families**




Source: Author's computation based on EDHS (2016)

### *4.1.13 Type of Birth*

Under-five Mortality appears higher in multiple rather than single births. Of total multiple births, about 25% of children passed away before they celebrated their fifth birthday while only 7% of single birth children died before their fifth birthday (Table 2). This shows the probability of Under-five Mortality is higher in multiple-birth than in single birth.

**Table 2: Children by Type of Birth**

| *Type of Birth* | Single Birth | Multiple Birth | Total |
|---|---|---|---|
| Alive | 797 | 18 | 815 |
| U5M | 58 | 6 | 64 |
| Total | 855 | 24 | 879 |
| **% alive from total** | **93.21637** | ***75*** | **92.719** |
| **% dead from total** | **6.783626** | **25** | **7.281001** |

Source: Author's computation based on EDHS (2016)

## 4.2 Econometrics Analysis

### *4.2.1 Variables Definition and Hypotheses*

The econometric analysis was made using a Probit model where a dichotomous dependent variable takes the values of 0 and 1. "1" stands for the under-five mortality and "0" stands for alive and breathing under-five children. The Probit model works for a binary dependent variable, assuming that the probability of a positive outcome is determined by the standard normal cumulative distribution function. It can compute robust and cluster-robust standard errors and adjust results for complex survey designs.

In addition, to investigate the partial effect of each explanatory variable on the dependent variable, assuming other things remain the same, we have also estimated the marginal effect of explanatory variables on the dependent variable. (Stata Manual, version 14).

Margins are statistics calculated from predictions of a previously fitted model at fixed values of some covariates and averaging or otherwise integrating the remaining covariates. The estimates margins of responses for specified values and present the results as a table. Capabilities include estimated marginal means, least-squares means, and conditional marginal and partial effects (which may be reported as derivatives or as elasticities), average and conditional adjusted predictions, and predictive margins

The types and definitions of variables and related hypotheses are presented in Table 3.1 below. They show the relationship, positive or negative, that the explanatory variables have with the dependent variable, Under-five Mortality.

**Table 3.1: Variable Code, Type and Definition of Variables, and Hypotheses**

| Variable code | Variable Type | Definition of Variables | Hypotheses |
|---|---|---|---|
| EDUM | Discrete | Mother's educational level (Categories: no education, primary, secondary and higher) | Negative |
| DOB | Continuous | Duration of breastfeeding | No breastfeeding - positive Breastfeeding – negative |
| PBINT | Continuous | Birth interval | Negative |
| MSS | Dichotomy | Marital status | Single - Positive<br>Married – Negative |
| WEALTH | Discrete | Income/wealth of household | Negative |
| AGEHH | Continuous | Mother's age at first birth | Negative |
| ACCESS | | Getting medical help; distance to health facility | Major problem - positive Minor problem/ no problem - negative |
| HHSSTOCK | Continuous | Family size by number | Positive |
| RES | Dichotomy | Place of residence (urban or rural) | Urban - positive<br>Rural - negative |
| SEX | Dichotomy | Sex of the child | Male - positive and<br>Female - negative |
| DRINK11 | Dichotomy | Source of drinking water | Non-potable water - positive Potable water - negative |
| TOILET11 | Dichotomy | Sanitation | Traditional - positive<br>Modern - negative |
| CHNO22 | Dichotomy | Types of birth (single/multiple) | Multiple - positive<br>Single - negative |

Source: Author's computation based on EDHS (2016)

### *4.2.9 Results and Discussion*

As mentioned in the descriptive analysis above, the focus of econometric analysis is on key variables, either closely linked to mothers' child care characteristics or those which empower women directly or indirectly in child care. With the introduction of key and controlled variables, the model is found to be stable, as a whole. The sensitivity of model stability can be seen as follows:

$H_0$: $\beta_1=\beta_2=\beta_3=\ldots=\beta_n=0$
$H_0$: $\beta_1\neq\beta_2\neq\beta_3\neq\ldots\neq\beta_n\neq0$

The Ch2 test results shown on the Table 3.2 tends to accept the null hypo which indicates that at least one variable is statistically different from zero; that is the model is stable, having at least one coefficient different from zero.

**Table 3.1: The Maximum Likelihood Estimates of the Probit Model**

| Variables | Coefficient | Std. Err. | Z | P>z | Marginal effect |
|---|---|---|---|---|---|
| EDUM | -0.30951 | 0.1762 | -1.76* | 0.079 | -0.02599 |
| DOB | -0.52566 | 0.0710 | -7.41*** | 0.000 | -0.04414 |
| PBINT | -0.01194 | 0.0060 | -1.98** | 0.047 | -0.00100 |
| Mss | -0.8146 | 0.3392 | -2.4** | 0.016 | -0.12799 |
| WEALTH | -0.12714 | 0.0660 | -1.93* | 0.054 | -0.01068 |
| AGEHH | -0.01571 | 0.0228 | -0.69 | 0.491 | -0.00132 |
| Hhsstock | 0.008274 | 0.0394 | 0.21 | 0.834 | 0.00069 |
| RES | -0.25303 | 0.5155 | -0.49 | 0.624 | -0.02125 |
| SEX | -0.03571 | 0.1515 | -0.24 | 0.814 | -0.00300 |
| drink11 | 0.339704 | 0.3579 | 0.95 | 0.343 | 0.02242 |
| toilet11 | 0.349683 | 0.4169 | 0.84 | 0.402 | 0.03909 |
| Access | 0.112626 | 0.1559 | 0.72 | 0.47 | 0.00946 |
| chno22 | 0.459071 | 0.3404 | 1.35 | 0.177 | 0.05590 |
| _cons | 49.55037 | 7.0389 | 7.04 | 0.000 | |
| dy/dx is for discrete change of dummy variable from 0 to 1 | | | | | |
| **Number of obs= 736** | | **Log likelihood= -159.292** | | | |
| **Wald Chi2(13) = 70.1** | | **Prob>Ch2=0.0000** | | | |

***, **, & * indicates the level of significance of variables at 1%, 5% & 10% respectively
Source: Author's computation. Model output based on EDHS (2016) using Stata 14

Using the estimated results of the Probit model and the marginal effect results shown in Table 3.2, discussion and possible explanations for the five significant independent variables follow here:

i. ***Mother's Educational Level:*** Mother's educational level is statistically significant at 10 percent in affecting Under-five Mortality negatively, a result in line with our hypothesis. This implies that changing the educational status from no education to some level of education, lowers the probability of under-five mortality. This shows that in educated families, we find less under-five mortality than in uneducated families. Educated mothers are better informed about mother and child health care and also more willing to adopt new technologies, accept advice from extension services, diversify income, become visionary in educating their families, or producing marketable crops. It all contributes positively towards a healthier life for children. This result is in conformity with the findings of other studies (Ramakrishna, G. and Asseffa, D., 2002) and (Haile et all., (2005). Analysis of changes in educational status reveals that the probability of Under-five Mortality decreases by approximately 2.6 percent with every additional unit of mothers' educational level. The coefficient and marginal effect of education indicates that empowering women through education is key to addressing the Under-five Mortality in the region. The result suggests that the region should expand formal as well as informal education especially for females. Females constitute around 50 percent of the population so investing on female education will have a pivotal effect in improving the socio-economic status of half the population as well as reduce Under-five Mortality;

ii. ***Preceding Birth Interval (month):*** Preceding birth interval negatively affects Under-five Mortality in conformity with our expectation and it is found statistically significant at less than 10 percent significance level. The marginal effect of the preceding birth interval reveals that the probability of Under-five Mortality decreases approximately by 0.10 percent as the preceding birth interval increases by one unit (year). This indicates that wider birth interval will lessen the mortality rate in the study area. Thus, encouraging women to widen birth intervals through the promotion of Family Planning by the Regional Government and NGOs will have dumping effect on under-five mortality.

iii. ***Duration of Breastfeeding (Month):*** The Probit output result revealed that the duration of breastfeeding negatively influences the Under-five Mortality in agreement with our hypothesis and is statistically significant at 1 percent level.

The marginal effect of duration of breastfeeding indicates that the probability of the Under-five Mortality Rate will decrease by approximately 4.42 percent when breastfeeding increases by 1 unit (month). The coefficient and the marginal effect of breastfeeding indicate that breastfeeding brings about a more substantial reduction in Under-five Mortality than any other intervention. All stakeholders in the region are therefore advised to encourage mothers through awareness and other training programs to increase breastfeeding and reduce Under-five Mortality.

iv. ***Income/Wealth of the Household:*** The income or wealth of the household has a negative relationship with Under-five Mortality at 10 percent significance. This again agrees with our hypotheses. The marginal effect of household income reveals that the probability of occurrence of Under-five Mortality decreases by approximately 1.03 percent when the level of household income increases by 1 unit. In addition, the absolute value of the coefficients of income increases as the income category of the society changes from poorest, to poor, middle, richer and richest family groups. This indicates that programs that target to increase the income of households and bridge income disparities in favor of the poor will result in reducing Under-five Mortality substantially.

v. ***Marital Status:*** Marital Status is the final major determinants of Under-five Mortality. It is statistically significant at less than 5% probability level and has a negative relationship with Under-five Mortality in conformity with our hypothesis. The marginal effect of marital status reveals that the probability of occurrence of Under-five Mortality decreases by approximately 1.3 percent when the marital status changes from single to married. This shows that the welfare of children is relatively better in married families than in single or divorced families. The culture of Benishangul-Gumuz is in favor of keeping traditional norms where marriage is respected and the bonds that keep couples together is powerful. A woman who is unmarried and has a child is regarded as shameful by both society and her family. Treatment of the child in such circumstances is likely to be as good as in married families.

All other variables included in the model were statistically insignificant but the signs of the coefficients were in line with our hypotheses as noted in the descriptive analysis.

## 5. Conclusions and Recommendations

### 5.1 Conclusions

The Under-five Mortality Rate in Benishangul-Gumuz is relatively the highest among Ethiopia's regional states, next to the Afar region. The risk of a child dying before completing five years of age in Benishangul-Gumuz is 72.8 per 1000 live births, almost 22 percent higher than the national average. Recognizing the problem, this study has tried to identify the main determinates of Under-five Mortality in Benishangul-Gumuz region using the Ethiopian Demographic and Health Survey (2016). Using a Probit model estimation, five of 13 explanatory variables were found to a negative and statistically significant effect on the Under-five Mortality Rate in Benishangul-Gumuz Regional State: Mother's Educational Level; the length of Preceding Birth Interval; Duration of Breastfeeding; Income or Wealth of a household and the income disparities of the society; and Marital Status.

### 5.2 Recommendations

These five statistically significant determinants of Under-five Mortality in the Benishangul-Gumuz region are all related, directly or indirectly, to women's empowerment in education, health and income. We would, therefore, suggest the following recommendations to tackle the problem of the excessive Under-five Mortality Rate in the region:

Taking into account the impact of mother's education on Under-five Mortality, the region should expand formal as well as informal education especially for females. Females constitute around 50 percent of the population so investing on female education will have a pivotal effect in improving the socio-economic status of half the population as well as reduce Under-five Mortality;

Encourage women to widen birth intervals through the promotion of Family Planning by the Regional Government and NGOs to expand the birth intervals will minimize under-five mortality.

Duration of breastfeeding has a negative impact on under-five mortality. Thus, it is recommended that all concerned bodies, governmental and non-governmental, should encourage breastfeeding through awareness and other training programs for the advancement of child health, and emphasize the importance of extending its duration;

Government and NGOs should target policies, programs and projects to increase the income of households and aim to reduce the income disparities of the society in favor of the poor;

The Government should make efforts to maintain the culture of the region and its emphasis on favoring marriage. This may be due to the culture of the region. Single or divorced family is discouraged in the Benishangul-Gumuz region making children treatment in the single or divorced families less favorable than that of married families. Thus, it is recommended to maintain the good culture of the society as it favors married couples for better nutriment of children.

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# Capital Flight and Fiscal Policy in Developing Countries: Evidence from Ethiopia

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***Abstract***

*This study examines the effect of fiscal policy on capital flight in Ethiopia using time series data from 1970 to 2012, employing the Autoregressive Distributed Lag (ARDL) model. The results indicate that past capital flight, changes in debt, and government expenditure had no significant impact on capital flight in Ethiopia, while external debt, taxation, and expenditure practices under different political regimes did have a significant effect. The study details policy implications emerging from the empirical results.*

**Keywords:** Fiscal Policy, Capital flight, Autoregressive Distributed Lag model, Ethiopia
**JEL Code:** K28, T56, G80

## 1. Introduction

Capital flight refers to wealth that is earned, transferred, or used, through by breaking a country's laws. It is illegal or illicit. It also refers to wealth whose origin is connected with illegal activity, such as corruption, the illicit production of goods, other forms of crime, or the concealment of a company's wealth from a country's tax authorities (The Service Centre for Development Cooperation, 2010). Capital flows are illicit if they involve illicitly acquired funds or are transferred abroad and held there without full disclosure to national authorities, or both (Ndikumana, 2015).

In past decades, many countries have experienced considerable capital flight with residents moving their wealth abroad, using different ways to accumulate foreign assets (Hermes and Lensink, 2014). Since the emergence of the Asian financial crisis of 1997–98, fiscal policy has gained considerable

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attention in the literature. At the center of this discussion has been the way fiscal policy influences economic variables, specifically the flow of funds across borders. While tax rates can be used to attract foreign capital and government spending can be used to stabilize and boost of economic growth, the extent of fiscal policy's impact on economic variables is still an open empirical question (Muchai and Muchai, 2016). The past decades have witnessed growing attention in academia and policy circles to the issue of capital flight from developing countries in general and African countries in particular. Researchers have been intrigued by the stunning paradox posed by large-scale capital flows both to and from Africa. While the continent receives a substantial amount of capital inflows in the form of official development assistance, external borrowing, and foreign direct investment, it also suffers heavy financial hemorrhage through capital flight (Ndikumana, Boyce and Ndiaye, 2014). Capital flight has become a major issue of concern for Africa because it reduces the continent's much needed investible funds.

In Ethiopia, capital flight is estimated at $31 billion over the 1970–2012 period. On average, the country lost around half a billion dollars annually under the 'Derg' regime (1974-1991). But this amount more than doubled to over 1 billion per annum during the EPRDF regime (1991-). The empirical evidence suggests that macroeconomic instability, the degree to which the financial market expanded and deepened, exports, the interest rate differentials, political instability, corruption, and debt-creating flows have been the most important determinants of capital flight from Ethiopia with the political environment also found to be crucial. Generally, capital flight was high before the violent regime changes and low in the subsequent periods, when the new regimes were in the process of establishing a firmer grip on power; after this, however, capital flight began to rise significantly again. The historical analysis points to potential causality running from political factors to capital flight. A strong improvement in economic and political governance would therefore be key to abating the problems of capital flight in Ethiopia (Alemayehu and Addis, 2016).

Despite the serious capital flight problem, few country-specific studies have investigated the size and determinants of capital flight in Ethiopia. The few that exist have generally focused on economic determinants (Alemayehu and Addis, 2016), and while several studies have explored the relationship between fiscal policy and capital flight in Africa (see for example., Muchai and Muchai 2016), no paper has systemically examined just how fiscal decisions influence

capital flight. Whether these fiscal decisions influence capital flight or not remains an issue.

This study defines fiscal policy as combined government decisions regarding a country's revenue and spending. It therefore relates to government taxation and the expenditure decisions that lead to budget deficit or surplus. In this context, the study addresses the following questions as they affect the case of Ethiopia: What is the effect of government consumption on capital flight? Do taxation practices influence capital flight? How do political regimes affect capital flight?

## 2. Capital Flight and Fiscal Policy

There are few studies of developing countries that analyze the relationship between capital flight and fiscal policy variables such as taxation, government expenditure, and debt. Alesina and Tabellini (1989), for example, state that uncertainty about which political group will be in control in the future, and uncertainty about future fiscal policies, is one of the main reasons for over-accumulation of public debt and private capital flight. Boyce (1992), using time series data from the Philippines between 1962 and 1986, finds evidence for debt-motivated capital flight and suggests foreign borrowing causes capital flight by contributing to an increased likelihood of debt crisis, worsening macroeconomic conditions, and the deterioration of general investment conditions. Eaton (1987) argues that the expectation of increased tax obligations created by the potential nationalization of private debt generates capital flight. Ize and Ortis (1987) also show that when fiscal rigidities create difficulties for servicing foreign debt, private capital flight is encouraged by foreign borrowing as there is the expectation of higher domestic asset taxation to service future debt. Foreign borrowing also provides the resources for channeling private capital abroad.

Boyce and Ndikumana (2012) examine 30 sub-Saharan African countries and show that funds borrowed abroad are often re-exported as private assets. By comparing cumulative capital flight with private net external assets, they conclude that Sub-Saharan African countries are net creditors vis-a-vis the rest of the world. In the case of capital flight driven debt, capital flight forces governments to borrow from abroad since capital flight decreases national resources by lowering domestic savings and investment. In this case, capital flight

provides the resources to finance loans to the same residents who export their capital, leading to a situation of ‘round-tripping’ or ‘back-to-back loans’, motivated by the desire to obtain government guarantees on foreign borrowing.

## 2.1 Capital Flight from Ethiopia

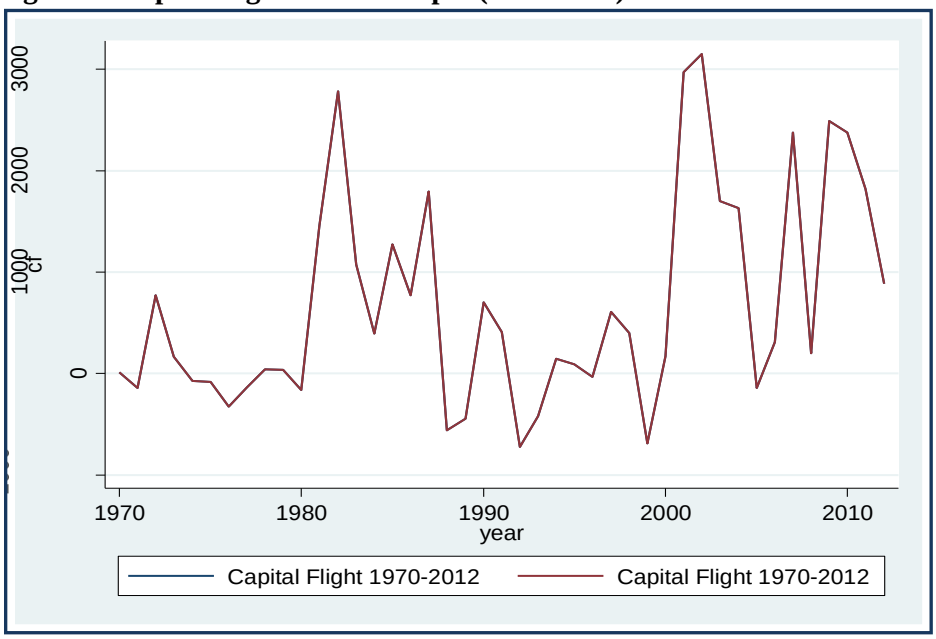
The capital flight from Ethiopian for the last 42 years is estimated and the results are summarized in Table 2 s. We find the total real capital flight during the period 1970 to 2012 to be USD 31 billion. On average, the country lost around half a billion dollars annually during the 'Derg' regime, with the amount more than doubled to over one billion per annum during the EPRDF regime. The reasons why capital flight accumulated more during the latter regime, despite being more stable and taking IMF and World Bank advice to create a more liberal market pro-private sector economy, deserves further research. Overall, capital flight amounted to about 50 percent of the country's average annual exports during the period.

**Table 1: Capital flight from Ethiopia (1970-2012): in millions of real constant US Dollar (2012)**

| Year | Capital Flight 1970-90 The Derg Regime* | Year | Capital Flight (1991-2012) The EPRDF Regime |
|---|---|---|---|
| 1970 | 10.7 | 1991 | 410.6 |
| 1971 | -140.9 | 1992 | -725.6 |
| 1972 | 771.6 | 1993 | -420.5 |
| 1973 | 163.9 | 1994 | 145.6 |
| 1974* | -72.4 | 1995 | 91.9 |
| 1975 | -84.5 | 1996 | -33.3 |
| 1976 | -324.7 | 1997 | 605.7 |
| 1977 | -138.4 | 1998 | 398.3 |
| 1978 | 41.0 | 1999 | -689.5 |
| 1979 | 37.6 | 2000 | 170.8 |
| 1980 | -160.8 | 2001 | 2969.6 |
| 1981 | 1457.5 | 2002 | 3148.6 |
| 1982 | 2784.0 | 2003 | 1700.8 |
| 1983 | 1072.0 | 2004 | 1631.3 |
| 1984 | 392.1 | 2005 | -144.5 |
| 1985 | 1272.1 | 2006 | 309.6 |
| 1986 | 771.4 | 2007 | 2376.2 |
| 1987 | 1794.8 | 2008 | 198.4 |
| 1988 | -561.0 | 2009 | 2491.2 |
| 1989 | -445.9 | 2007 | 2376.2 |
| 1990 | 702.2 | 2008 | 198.4 |
| | | 2010 | 4096.3 |
| | | 2011 | 1818.7 |
| | | 2012 | 886.7 |
| Total Capital Flight | | 9342.4 | 21437.1 |
| Average Annual Capital flight | | 444.9 | 974.4 |
| Grand Total (1970-2012) = USD 30779.5 | | | |
| Average Annual Capital Flight (1970-2012) = USD 715.8 | | | |

Source: Alemayehu and Addis, 2017

**Figure 1: Capital flight from Ethiopia (1970-2012)**




Source: Own computation

The average annual capital flight during the Derg regime was half the amount that left under in the EPRDF regime, and the EPRDF regime also accounted for about 70 percent of the whole during the entire period under analysis. Under the Derg, capital flight reached its maximum point in the 1980s and then declined up to 2000. The highest level of capital flight was registered under the EPRDF in 2003. The overall shape of capital flight shows a cyclical pattern during the period under consideration.

## 3. Empirical Evidence on Fiscal Policy and Capital Flight

Much of the contemporary literature on African capital flight has focused, inter alia, on lessons from case studies on the causes and effects of capital flight (Ndikumana, 2016). Notably, the nexus between fiscal policy and capital flight in Kenya (Muchai and Muchai, 2016), determinants of capital flight in Madagascar (Ramiandrisoa and Rakotomanana, 2016) and Ethiopia (Alemayehu & Addis, 2016), capital flight and trade invoicing in Zimbabwe (Kwaramba et al., 2016) and capital flight in Cameroon connections between tax

revenue and capital flight in Burkina Faso (Ndiaye and Siri, 2016) and the effect of capital flight on public social spending in Congo-Brazzaville (Moulemvo, 2016).

Muchai and Muchai (2016) noted capital flight has been an issue of concern for Africa because it has reduced the continent's much needed investible funds. Kenya lost US$ 4.9 billion in real terms from 1970 to 2010 through capital flight. Their study sought to provide fiscal evidence of capital flight from Kenya and the results established that previous capital flight, changes in debt, and government expenditure had no significant impact on capital flight from Kenya, though external debt, taxation, and expenditure practices under different political regimes did have a significant effect. The study also discussed policy implications emerging from their empirical results.

Alemayehu and Addis (2016 and 2017) focused on economic, institutional and political determinants to estimate the volume of capital flight, and its impact on growth and on poverty reduction in Ethiopia. With total capital flight (1970-2012) estimated at USD 31 billion, a simple ICOR-based growth model simulation found the average growth lost to capital flight to be about 2.2 percentage points per annum, between 2000/01-2012/13. Using the elasticity of poverty to income and inequality, we also found poverty would have been reduced by about 2.5 percentage points in the last decade had it not been for capital flight. We would also note that growth in Ethiopia in the last decade has been accompanied by rising inequality that wiped out the positive effects on poverty reduction. Had it not been for this inequality accompanying growth, the lost resources of capital flight would have led to around a 5-percentage point decline in poverty during the last decade.

## 4. Data and Methodology

The annual time series data for fiscal and control variables covering the period 1970–2012 uses figures obtained from the Ministry of Finance and Economic Cooperation, the National Bank of Ethiopia, and the World Bank's World Development Indicators. Capital flight was computed using the extended Balance of Payments residual method (Ndikumana and Boyce, 2010 and 2012). For this study, capital flight data from Boyce and Ndikumana (2012) were used.

Analysis in previous sections revealed a qualitative relationship between fiscal policy variables and capital flight in Ethiopia. Here, we undertake a quantitative analysis of the relationship between fiscal policy and capital flight. The fiscal policy variables included in the analysis are government expenditure, taxation, changes in the stock of debt, and external debt. For the proper specification of our model, the control variables presented in the literature are included. These are the exchange rate, which captures risk and returns on investment; political regimes; previous capital flight; financial deepening; and inflation, capturing the macroeconomic environment. To analyze empirically the fiscal policy variables that might induce capital flight in Ethiopia, we employed a regression model in the following form:

$$\boldsymbol{KF_t = \alpha_0 + \alpha_1 KF_{t-1} + \alpha_2 CD_t + \alpha_3 ED_t + \alpha_4 T_t + \alpha_5 EXP_t + \alpha_6 P_t + \alpha_7 FD_t + \alpha_8 INF_t + \alpha_9 ER_t + \varepsilon_t} \quad \textbf{(1)}$$

Where α1 to α9 are parameters to be estimated, t is time and e is the error term. Capital flight (KF): Capital flight/GDP. Change in the Stock of Debt (CD): CD /GDP. Financial Deepening (FD): M2/GDP. Inflation (INF): Annual average inflation rate (consumer price index). External Debt (ED): Total external debt/GDP. Exchange Rate (ER): Annual average exchange rate; Ethiopian Birr against the US dollar. Tax rate (T): Total taxes/GDP. Expenditure (EXP): Government Expenditure/GDP. Political Regimes (P): Dummy variable: 1 in regimes that demonstrated fiscal discipline relatively (EPRDF), 0 otherwise (Derg regime).

## 5. Results and Discussion

Since we are using time series data, the stationarity of the time series is important. Traditionally, the Augmented Dickey-Fuller (ADF) has been used to test for the stationarity of macroeconomic variables, and the results are presented in Table 1 below. However, this test does not consider the fact that the data in question could have structural breaks. To take into account the existence of structural breaks, the Clemente-Montanes-Reyes (1998) test was applied in this study.

The Clemente-Montanes-Reyes (CMR) approach has two models: an additive outlier model (AO) which captures a sudden change in the mean of a time series, and an innovative outlier model (IO) which allows for a gradual shift

in the mean of the series of the model. We employed the CMR-IO test, which is considered superior to the AO model since it can identify the long-run impact of changes (Kinuthia and Murshed, 2015). Breusch-Godfrey serial correlation LM test is presented in Appendix A3.

The diagnostic test was run on the residuals of the long-run equation presented in Appendix 6; it indicated no evidence of Serial Autocorrelation; the Breusch-Godfrey with the null hypothesis of no Serial Autocorrelation was accepted; and the white test for Hetroskedasticity also indicated no evidence of Heteroskedasticity. The test for checking the model specification, the Ramsey RESET for model specification, was conducted and the result indicated that the model had no evidence of any misspecification.

## UNIT ROOT TEST

Determining the stationarity of a time series is a key step before moving to any analysis. Customarily, the Augmented Dickey-Fuller (ADF) has been used to test for the stationarity of macroeconomic variables. Consequently, capital flight, external debt, change in debt, tax rate, government expenditure, exchange rate, and financial deepening are integrated of order (1) while inflation is integrated of order (0). Since seven (of eight) of the variables are I(1) processes, it is possible to run a long-run equation with our stationary variables.

**Table 1: Stationarity result**

| Variables | Without constant and trend | With constant only | With constant and trend | Order of integration |
|---|---|---|---|---|
| **DLNKF** | -5.240* | -5.180* | -5.115* | I(1) |
| **DLNCD** | -4.323* | -4.246* | -4.219** | I(1) |
| **DLNFD** | -4.499* | -4.485* | -5.203* | I(1) |
| **LNINF** | 3.026* | 0.406 | -1.269 | I(0) |
| **DLNED** | -3.680* | -3.638** | -3.580** | I(1) |
| **DLNER** | -2.729* | -3.319** | -3.511*** | I(1) |
| **DLNT** | -3.991* | -3.978* | -4.831* | I(1) |
| **DLNEXP** | -3.730* | -3.697* | -4.372* | I(1) |

*- significant at 1%, **- significant at 5% and ***- significant at 10%

## BOUND TEST FOR CO-INTEGRATION

Our estimated F-statistics is outside the critical value bounds at 90, 95, and 99 percent. We, therefore, reject the null hypothesis of no co-integration and no long-run capital flight equation. The ARDL bounds test, therefore, confirms the existence of a long-run capital flight equation presented in Table 2 below. The regression results are presented in Table 3.

**Table 2: Bound co-integration result**

| Test Statistics | Value | Lag | Level of significance | I0 Bound | I1 Bound |
|---|---|---|---|---|---|
| F-statistic | 5.352466 | 2 | 10% | 1.95 | 3.06 |
| | | | 5% | 2.22 | 3.39 |
| | | | 2.5% | 2.48 | 3.7 |
| | | | 1% | 2.79 | 4.1 |

**Table 3: Long Run Coefficients**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| LNT | -13.987043 | 3.297720 | -4.241429 | 0.0003 |
| P | -15.464325 | 4.581440 | -3.375429 | 0.0027 |
| LNINF | -1.162713 | 0.935439 | -1.242960 | 0.2270 |
| LNFD | 8.921147 | 3.557880 | 2.507434 | 0.0200 |
| LNEXP | 3.616109 | 3.830957 | 0.943918 | 0.3555 |
| LNER | 8.932589 | 3.266884 | 2.734285 | 0.0121 |
| LNED | -0.016644 | 0.479176 | -0.034735 | 0.9726 |
| LNCD | -0.079615 | 0.128959 | -0.617371 | 0.5433 |
| C | -16.019901 | 9.374833 | -1.708820 | 0.1016 |

Cointeq = LNKF - (-13.9870*LNT -15.4643*P -1.1627*LNINF + 8.9211 *LNFD + 3.6161*LNEXP + 8.9326*LNER -0.0166*LNED -0.0796*LNCD -16.0199)

The finding that previous capital flight had no significant effect on the current capital flight implies that there has been no habit formation. The change in the stock of debt was also found to have no significant effect on capital flight

in Ethiopia and that result confirms the results of Muchai and Muchai (2016) for Kenya, and Nyoni (2000) who focused on Tanzania, though it is inconsistent with the findings of other studies such as Hermes and Lensink (1992), Lensink et al. (1998), and Ndikumana and Boyce (2003).

External debt had no positive and significant influence on capital flight. This finding was inconsistent with the findings of Muchai and Muchai (2016) for Kenya, of Hermes and Lensink (1992), Lensink et al. (1998), and Ndikumana and Boyce (2003) but it was consistent with the findings of Nyoni (2000). Financial deepening, however, did have a positive and significant influence on capital flight.

**Table 4: ARDL Co-integrating and Short Run Form**

ARDL Co-integrating and Short Run Form

Dependent Variable: Log of capital flight

Selected Model: ARDL (2, 1, 1, 0, 2, 2, 2, 0, 0)

Co-integrating Form

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(LNKF(-1)) | 0.476432 | 0.186824 | 2.550164 | 0.0182 |
| D(LNT) | -10.446250 | 5.011589 | -2.084419 | 0.0489 |
| D(P) | -3.530503 | 3.751813 | -0.941013 | 0.3569 |
| D(LNINF) | -1.988996 | 1.655245 | -1.201632 | 0.2423 |
| D(LNFD) | -7.208446 | 5.969921 | -1.207461 | 0.2401 |
| D(LNFD(-1)) | -8.754956 | 3.528175 | -2.481440 | 0.0212 |
| D(LNEXP) | 15.816610 | 5.087023 | 3.109208 | 0.0051 |
| D(LNEXP(-1)) | 10.367885 | 3.739880 | 2.772251 | 0.0111 |
| D(LNER) | 27.958649 | 8.282047 | 3.375814 | 0.0027 |
| D(LNER(-1)) | -10.208636 | 4.565486 | -2.236046 | 0.0358 |
| D(LNED) | -0.028472 | 0.821374 | -0.034664 | 0.9727 |
| D(LNCD) | -0.136194 | 0.214934 | -0.633656 | 0.5328 |
| ECM | -0.710650 | 0.287751 | -5.944904 | 0.0000 |

Tax has a significant coefficient, implying that taxation significantly influenced capital flight. This finding is consistent with the study of Muchai and Muchai (2016), Alam and Quazi (2003) but is inconsistent with Pastor (1990) Vos (1992), Schineller (1997) and Ndikumana and Boyce (2003). While the political regimes' variable had a significant effect on capital flight, the impact of government expenditure was insignificant.

## 6. Conclusions and Policy Implications

This study examined how fiscal policy affected capital flight in Ethiopia using time series data from1970 to 2012. It defined fiscal policy as decisions taken by the government regarding the country's revenue and spending. Econometric analysis was done to ascertain the effect of tax and public expenditure on capital flight. This revealed that taxes had a negative and significant impact on capital flight from Ethiopia while external debt was found to have a negative and insignificant effect, invalidating the revolving door phenomenon for Ethiopia.

Fiscal policy regimes were also considered in the study in order to explore the effect of political regimes on capital flight and the result established that political regimes which exercised some form of budgetary discipline experienced less capital flight. Furthermore, financial deepening and exchange rates had a significant and positive effect on capital flight though government expenditure and change in the stock of debt had an insignificant impact. There was no evidence of debt-fueled capital flight. The inflation rate has always been kept within tolerable levels for economic players and this probably explains its insignificance in the econometric results. Previous capital flight had a significant effect on the current capital flight, implying that there was some habit formation.

Based on the findings from this study, we can derive some policy implications. The government should be prudent in managing public resources as fiscal discipline is shown to be a significant factor in deterring capital flight. Taxation policies in Ethiopia should be implemented cautiously, and the government should cease from a directed focus on tax incentives, rather focusing on the general tax rate in the economy.

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# Appendices

## Appendix 1: ARDL Estimation Result

Selected Model: ARDL (2, 1, 1, 0, 2, 2, 2, 0, 0)

| Variable | Coefficient | Std. Error | t-Statistic | Prob.* |
|---|---|---|---|---|
| LNKF(-1) | -0.234219 | 0.179499 | -1.304846 | 0.2054 |
| LNKF(-2) | -0.476432 | 0.186824 | -2.550164 | 0.0182 |
| LNT | -10.44625 | 5.011589 | -2.084419 | 0.0489 |
| LNT(-1) | -13.48069 | 5.208154 | -2.588382 | 0.0168 |
| P | -3.530503 | 3.751813 | -0.941013 | 0.3569 |
| P(-1) | -22.92355 | 7.412287 | -3.092642 | 0.0053 |
| LNINF | -1.988996 | 1.655245 | -1.201632 | 0.2423 |
| LNFD | -7.208446 | 5.969921 | -1.207461 | 0.2401 |
| LNFD(-1) | 13.71445 | 6.423568 | 2.135021 | 0.0441 |
| LNFD(-2) | 8.754956 | 3.528175 | 2.481440 | 0.0212 |
| LNEXP | 15.81661 | 5.087023 | 3.109208 | 0.0051 |
| LNEXP(-1) | 0.737173 | 4.990640 | 0.147711 | 0.8839 |
| LNEXP(-2) | -10.36788 | 3.739880 | -2.772251 | 0.0111 |
| LNER | 27.95865 | 8.282047 | 3.375814 | 0.0027 |
| LNER(-1) | -22.88675 | 6.796683 | -3.367340 | 0.0028 |
| LNER(-2) | 10.20864 | 4.565486 | 2.236046 | 0.0358 |
| LNED | -0.028472 | 0.821374 | -0.034664 | 0.9727 |
| LNCD | -0.136194 | 0.214934 | -0.633656 | 0.5328 |
| C | -27.40445 | 15.54777 | -1.762597 | 0.0919 |
| R-squared | 0.656537 | Mean dependent var | | -3.994351 |
| Adjusted R-squared | 0.375522 | S.D. dependent var | | 2.821711 |
| S.E. of regression | 2.229827 | Akaike info criterion | | 4.746025 |
| Sum squared resid | 109.3868 | Schwarz criterion | | 5.540119 |
| Log likelihood | -78.29351 | Hannan-Quinn criterion | | 5.035190 |
| F-statistic | 2.336304 | Durbin-Watson stat | | 2.355482 |
| Prob(F-statistic) | 0.030165 | | | |

**Appendix 2: Lag length selection**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -78.66520 | NA | 8.876170 | 5.009440 | 5.409387 | 5.147501 |
| 1 | -78.06862 | 0.852260 | 9.124594 | 5.032492 | 5.476877 | 5.185894 |
| 2 | -72.96474 | 6.999607* | 7.258143* | 4.797985* | 5.286809* | 4.966727* |
| 3 | -72.78957 | 0.230216 | 7.661290 | 4.845118 | 5.378381 | 5.029200 |
| 4 | -72.63322 | 0.196552 | 8.107191 | 4.893327 | 5.471028 | 5.092749 |
| 5 | -72.60237 | 0.037029 | 8.654916 | 4.948707 | 5.570846 | 5.163469 |
| 6 | -71.63651 | 1.103839 | 8.775189 | 4.950658 | 5.617235 | 5.180760 |
| 7 | -70.70298 | 1.013544 | 8.932353 | 4.954456 | 5.665472 | 5.199899 |
| 8 | -70.54661 | 0.160836 | 9.527952 | 5.002663 | 5.758118 | 5.263446 |

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

**Appendix 3: Breusch-Godfrey Serial Correlation LM Test**

| | | | | |
|---|---|---|---|---|
| F-statistic | 1.714259 | Prob. F(2,20) | | 0.2055 |
| Obs*R-squared | 5.999919 | Prob. Chi-Square(2) | | 0.0498 |
| **Variable** | **Coefficient** | **Std. Error** | **t-Statistic** | **Prob.** |
| LNKF(-1) | 0.179249 | 0.276551 | 0.648159 | 0.5243 |
| LNKF(-2) | 0.217664 | 0.222101 | 0.980023 | 0.3388 |
| LNT | 1.085257 | 5.106510 | 0.212524 | 0.8338 |
| LNT(-1) | 2.167350 | 5.234542 | 0.414048 | 0.6832 |
| P | 0.087684 | 3.715660 | 0.023598 | 0.9814 |
| P(-1) | 1.173019 | 7.308620 | 0.160498 | 0.8741 |
| LNINF | 0.196869 | 1.678308 | 0.117302 | 0.9078 |
| LNFD | 0.610024 | 5.915828 | 0.103117 | 0.9189 |
| LNFD(-1) | 0.910243 | 6.477481 | 0.140524 | 0.8897 |
| LNFD(-2) | -1.053817 | 3.624339 | -0.290761 | 0.7742 |
| LNEXP | -1.156514 | 5.011650 | -0.230765 | 0.8198 |
| LNEXP(-1) | -3.101341 | 5.180925 | -0.598608 | 0.5562 |
| LNEXP(-2) | 1.048366 | 3.790487 | 0.276578 | 0.7849 |
| LNER | -2.307302 | 8.180237 | -0.282058 | 0.7808 |
| LNER(-1) | 0.080981 | 6.606914 | 0.012257 | 0.9903 |
| LNER(-2) | 1.229632 | 4.673768 | 0.263092 | 0.7952 |
| LNED | 0.170081 | 0.831144 | 0.204635 | 0.8399 |
| LNCD | -0.111616 | 0.232346 | -0.480388 | 0.6362 |
| C | 2.976128 | 15.55519 | 0.191327 | 0.8502 |
| RESID(-1) | -0.478782 | 0.351707 | -1.361309 | 0.1886 |
| RESID(-2) | -0.359583 | 0.321579 | -1.118179 | 0.2767 |
| R-squared | 0.146339 | Mean dependent var | | 1.55E-14 |
| Adjusted R-squared | -0.707321 | S.D. dependent var | | 1.653684 |
| S.E. of regression | 2.160778 | Akaike info criterion | | 4.685364 |
| Sum squared resid | 93.37923 | Schwarz criterion | | 5.563047 |
| Log likelihood | -75.04997 | Hannan-Quinn criter. | | 5.004968 |
| F-statistic | 0.171426 | Durbin-Watson stat | | 2.158257 |
| Prob(F-statistic) | 0.999884 | | | |

**Appendix 4: Heteroskedasticity Test: Breusch-Pagan-Godfrey**

| | | | | |
|---|---|---|---|---|
| F-statistic | 0.410749 | Prob. F(18,22) | | 0.9701 |
| Obs*R-squared | 10.31292 | Prob. Chi-Square(18) | | 0.9212 |
| Scaled explained SS | 4.294299 | Prob. Chi-Square(18) | | 0.9996 |
| **Variable** | **Coefficient** | **Std. Error** | **t-Statistic** | **Prob.** |
| C | -17.81438 | 37.36595 | -0.476755 | 0.6382 |
| LNKF(-1) | -0.170420 | 0.431390 | -0.395048 | 0.6966 |
| LNKF(-2) | -0.430487 | 0.448994 | -0.958781 | 0.3481 |
| LNT | -8.229395 | 12.04435 | -0.683258 | 0.5016 |
| LNT(-1) | -2.004187 | 12.51675 | -0.160120 | 0.8742 |
| P | -5.547786 | 9.016729 | -0.615277 | 0.5447 |
| P(-1) | -14.90422 | 17.81394 | -0.836660 | 0.4118 |
| LNINF | -2.138080 | 3.978049 | -0.537469 | 0.5963 |
| LNFD | -0.573779 | 14.34751 | -0.039992 | 0.9685 |
| LNFD(-1) | 11.00610 | 15.43776 | 0.712934 | 0.4834 |
| LNFD(-2) | 9.000142 | 8.479261 | 1.061430 | 0.3000 |
| LNEXP | 8.573388 | 12.22564 | 0.701263 | 0.4905 |
| LNEXP(-1) | -7.810517 | 11.99400 | -0.651202 | 0.5217 |
| LNEXP(-2) | -13.41368 | 8.988051 | -1.492390 | 0.1498 |
| LNER | 10.50339 | 19.90424 | 0.527696 | 0.6030 |
| LNER(-1) | -7.704293 | 16.33447 | -0.471659 | 0.6418 |
| LNER(-2) | 10.22373 | 10.97223 | 0.931783 | 0.3616 |
| LNED | -0.092985 | 1.974007 | -0.047105 | 0.9629 |
| LNCD | 0.175977 | 0.516550 | 0.340678 | 0.7366 |
| R-squared | 0.251535 | Mean dependent var | | 2.667972 |
| Adjusted R-squared | -0.360846 | S.D. dependent var | | 4.593827 |
| S.E. of regression | 5.358942 | Akaike info criterion | | 6.499710 |
| Sum squared resid | 631.8018 | Schwarz criterion | | 7.293804 |
| Log likelihood | -114.2441 | Hannan-Quinn criter. | | 6.788875 |
| F-statistic | 0.410749 | Durbin-Watson stat | | 2.246464 |
| Prob(F-statistic) | 0.970140 | | | |

**Appendix 5: Functional form**

Ramsey RESET Test

| | Value | df | Probability |
|---|---|---|---|
| t-statistic | 1.395729 | 21 | 0.1774 |
| F-statistic | 1.948060 | (1, 21) | 0.1774 |

F-test summary:

| | Sum of Sq. | df | Mean Squares |
|---|---|---|---|
| Test SSR | 9.285845 | 1 | 9.285845 |
| Restricted SSR | 109.3868 | 22 | 4.972129 |
| Unrestricted SSR | 100.1010 | 21 | 4.766714 |

Unrestricted Test Equation:
Dependent Variable: LNKF
Method: ARDL
Date: 06/20/18 Time: 11:11
Sample: 1972 2012
Included observations: 41
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic):
Fixed regressors: C

| Variable | Coefficient | Std. Error | t-Statistic | Prob.* |
|---|---|---|---|---|
| LNKF(-1) | -0.453513 | 0.235744 | -1.923758 | 0.0680 |
| LNKF(-2) | -1.041138 | 0.444026 | -2.344769 | 0.0289 |
| LNT | -25.84933 | 12.07761 | -2.140268 | 0.0442 |
| LNT(-1) | -27.13816 | 11.03422 | -2.459453 | 0.0227 |
| P | -7.535996 | 4.661592 | -1.616614 | 0.1209 |
| P(-1) | -49.96695 | 20.69045 | -2.414977 | 0.0249 |
| LNINF | -4.279794 | 2.306617 | -1.855442 | 0.0776 |
| LNFD | -12.89054 | 7.123278 | -1.809636 | 0.0847 |
| LNFD(-1) | 27.11312 | 11.47663 | 2.362464 | 0.0279 |
| LNFD(-2) | 18.17432 | 7.581473 | 2.397201 | 0.0259 |
| LNEXP | 35.54378 | 14.98590 | 2.371814 | 0.0273 |
| LNEXP(-1) | 2.030143 | 4.973499 | 0.408192 | 0.6873 |
| LNEXP(-2) | -22.30722 | 9.305005 | -2.397336 | 0.0259 |
| LNER | 59.74629 | 24.17553 | 2.471354 | 0.0221 |

| | | | | |
|---|---|---|---|---|
| LNER(-1) | -47.00820 | 18.51933 | -2.538332 | 0.0191 |
| LNER(-2) | 20.49197 | 8.617761 | 2.377877 | 0.0270 |
| LNED | -0.277127 | 0.823724 | -0.336431 | 0.7399 |
| LNCD | -0.164502 | 0.211422 | -0.778072 | 0.4452 |
| C | -55.95215 | 25.49699 | -2.194461 | 0.0396 |
| FITTED^2 | 0.140520 | 0.100679 | 1.395729 | 0.1774 |
| R-squared | 0.685694 | Mean dependent var | | -3.994351 |
| Adjusted R-squared | 0.401321 | S.D. dependent var | | 2.821711 |
| S.E. of regression | 2.183281 | Akaike info criterion | | 4.706094 |
| Sum squared resid | 100.1010 | Schwarz criterion | | 5.541983 |
| Log likelihood | -76.47494 | Hannan-Quinn criter. | | 5.010479 |
| F-statistic | 2.411251 | Durbin-Watson stat | | 2.485346 |
| Prob(F-statistic) | 0.026646 | | | |

*Note: p-values and any subsequent tests do not account for model selection.

**Appendix 6: Diagnostic tests**

The diagnostic test run on the residuals of the long-run equation presented in the table below indicates no evidence of Serial Autocorrelation; the Breusch-Godfrey with the null hypothesis of no Serial Autocorrelation is accepted; the white test for Hetroskedasticity indicates no evidence of Heteroskedasticity.

| **Breusch-Godfrey Serial Correlation LM Test: Serial Autocorrelation** | | | |
|---|---|---|---|
| F-statistic | 1.714259 | Probability | 0.2055 |
| Obs*R-squared | 5.999919 | Probability | 0.0498 |
| White Heteroskedasticity Test | | | |
| F-statistic | 0.410749 | Probability | 0.9701 |
| Obs*R-squared | 10.31292 | Probability | 0.9212 |
| Ramsey RESET Test: Model Misspecification | | | |
| F-statistic | 1.948060 | Probability | 0.1774 |
| Log likelihood ratio | -76.47494 | Probability | 5.010479 |

As shown in the above table the test for checking the model specification, i.e. the Ramsey RESET, also indicates that the model has no evidence of any misspecification.

# Inflation and Money Growth in Ethiopia: Is there a Threshold Effect?

**Kibrom Gebrekirstos[1] and Zenebe Gebreegziabher[2]**

***Abstract***

*This study analyses money growth - inflation nexus in Ethiopia using annual datasets covering the period 1970-2009. This period was considered due to data limitations. A significant aspect of the study is that it tries to identify the optimal level of money growth using Two Regime Threshold Model. The result from the two-regime threshold model reveals that there is indeed a threshold effect in the relationship between money growth and inflation and the optimal level of money growth is estimated to be 17% which has an important policy implication. Here, money supply creates inflationary pressures only when it exceeds 17%. A percentage increase in money supply above this threshold value is expected to cause 1.47 percent increase in annual inflation indicating that monetary factors are valid sources of inflation in Ethiopia. The results imply keep the money growth below 17%. Hence, a specific monetary policy measures that could be envisaged is controlling broad money supply (M2).*

**Keywords:** Inflation, money growth, two regime threshold model, Ethiopia
**JEL Code:** E3, E4, C4

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## 1. Introduction

Some view that moderate and stable rate of inflation promotes output growth, ensures return to savers, enhances investment, and accelerates economic growth. In general, price stability is an indicator of macroeconomic stability. People dislike price hikes because higher inflation rate reduces the purchasing power of their money making them unable to buy the same quantity and quality of goods and services as before, given their income. Thus, the public views inflation as detrimental to economic performance of a country. However, though majority of economists agree with the public, there are economists who argue that inflation is positive to economic performance.

Sharing the public's view, the obvious question that comes in mind is what determines inflation? Alternatively, what are the sources of inflationary pressures? However, the answer is different according to different schools of thought. For example, the Structuralist school emphasizes supply side factors as determinants of inflation. Inflation is determined by developments and bottlenecks on the real side of the economy. In this approach, monetary factors are given less emphasis as sources of inflation because the proponents assumed that price changes largely took place on the real side of the economy, not on the monetary sector. Thus, monetary authorities have to accommodate wage and price increases (Bernanke, 2005). In contrast, the monetarist approach emphasizes, "Inflation is always and everywhere a monetary phenomenon" in the sense that an increase in money stock eventually leads to a rise in prices in the same proportion. That is, there is a positive one-to-one relationship between monetary and price growth (see for example, Roffia and Zaghini, 2007).

Price stability is recognized as primary objective of central banks. Yet the role of money in the conduct of monetary policy to achieve the said stability is debatable. Many economists believe that inflation is monetary phenomenon in the sense that money growth in excess of the growth rate of the economy is inflationary. When the monetary authority increases the money supply at a rate that exceeds the demand for cash balances at the existing price level, the higher demand for goods and services triggers a rise in the price level as the public tries to convert its excess cash holdings in to real items. There are studies that confirm this hypothesis (Gerlach, Browne, and Honohan 2004; Nelson, 2008; Dawyer, Jr, and Hafer 1999, Kulakisizoglu and Kulakisizoglu, 2009).

There are also economists who argue that money growth does not help in predicting the dynamics of inflation because either their relationship is weak or inflation and money growth are unrelated. Turnovsky and Wohar (1984) found that the causality between money supply and aggregate prices in the United States is neutral and concluded that money and inflation are unrelated. De Gregorio (2004), for several low inflation countries with very rapid growth of money, finds that money growth does not necessarily cause inflation. Roffia and Zaghini (2007), for 15 industrialized economies found that it is only in approximately half of the cases they investigate that positive relation between inflation and money growth exists.

The above mixed empirical evidence may be attributed to the inherent nonlinearities between the two variables. For example, Milas (2007), using a Markov switching regression model for the United Kingdom, finds that money growth is inflationary if it exceeds 10% threshold level. Similarly, Bachmeier, Leelahanon, & Li (2007) using a fully nonparametric model and a threshold regression model find that nonlinear models are more successful at forecasting inflation than linear models.

In Ethiopia, empirical studies are very scant on this issue. Tafere (2008), using a monetarist and structuralist model, found that the sources of inflation in Ethiopia are different for food and non-food inflation and in the short run and log run as well. However, he only considered the period 1994/95 to 2007/08. A similar study conducted by Loening, Durevall, and Birru (2009) using error correction models found that money stock does not explain inflation in the short run its but growth does. However, their analysis focuses only on the period January 1999 to November 2008.

Thus, the study contributes to this debate empirically quantifying and testing the nature of the relationship between money growth and inflation using a Two-Regime Threshold Model over extended period (1970-2009). Particularly, the study estimates the threshold level of money growth above which additional money is inflationary which has an important policy implication.

## 2. Conceptual Framework

The building block for this study is the quantity theory of money (Friedman, 1956, 1968; Cagan, 1956), which links money supply, velocity, prices, and real income. The quantity theory of money is preferred for theoretical

consistency as the study focuses on long-run behavior. The predictive power of monetary aggregates for inflation dynamics also appears to be stronger in the long-run as opposed to shorter time horizons (Assenmacher-Wesche and Gerlach, 2006; Bachmeier and Swanson, 2005; De Grauwe and Polan, 2005). This can be written as an identity:

$$MV = PY \tag{1}$$

where M stands for money supply, V velocity, P price level and Y represents real income. Money supply is assumed exogenous and income velocity of money is independent of the other variables in identity 1. Under these assumptions, identity 1 can be written as the theory of price determination as follows.

$$P = \frac{MV}{Y} \tag{2}$$

taking log of equation (2), yields

$$\log P = \log M + \log V - \log Y \tag{3}$$

differentiation (3) with respect to time yields the equation for inflation

$$\frac{1}{P}\frac{dP}{dt} = \frac{1}{M}\frac{dM}{dt} + \frac{1}{V}\frac{dV}{dt} - \frac{1}{Y}\frac{dY}{dt} \tag{4}$$

or in terms of growth rates

$$\Delta_P = \Delta_M + \Delta_V - \Delta_Y \tag{5}$$

Equation (5) shows that the rate of inflation ($\Delta_P$) is determined by the growth in money supply ($\Delta_M$), growth in velocity ($\Delta_V$), and growth in real income ($\Delta_Y$). As envisioned in the early versions of the quantity theory of money

(Fischer 1911), we assume that velocity is constant and its growth rate is zero. As could be obvious velocity changes when the institutions in the economy change. In Ethiopia, the financial system is underdeveloped and the use of different payment modalities such as credit cards is yet to flourish. Hence, our assumption is valid. Therefore, with constant velocity assumption equation (5) reduces:

$$\Delta_P = \Delta_M - \Delta_Y \qquad \textbf{(6)}$$

Note that equation (6) suggests that the growth rate in price is proportionate to the growth rate in money supply in excess of output growth.

Besides the aforementioned variables, short run cost shocks such as an oil price shock or a change in the exchange rate (Gerlach, Browne, and Honohan 2004) affect inflation even though not in the long run. Therefore, considering budget deficit, oil price shock and incorporating annual rainfall as a proxy for supply side constraints, the basic model becomes:

$$Inf_t = \beta_0 + \beta_1 gm_t + \beta_2 gdpg_t + \beta_3 loilpr_t + \beta_4 lrain_t + \beta_5 bd_t \qquad \textbf{(7)}$$

where gm is the growth rate of money supply, gdpg is the growth rate of real gdp, loilpr is the logarithm of oil price in US dollars, lrain is the logarithm of annual rainfall, bd for budget deficit and subscript t stands for time.

## 3. Econometric Models and Estimation Methods

Adding error term ( $\mu_t$ ) to capture effect of other variables, we specify the econometric model to analyze inflation in Ethiopia as:

$$Inf_t = \beta_0 + \beta_1 gm_t + \beta_2 gdpg_t + \beta_3 loilpr_t + \beta_4 lrain_t + \beta_5 bd_t + \mu_t \qquad \textbf{(8)}$$

Since there is a particular econometric issue related to the estimation and inference in empirical models with threshold effects, the study employs the methodology developed by Hansen (2000) and Caner and Hansen (2004). In particular, these authors develop tests for threshold effects, estimate the threshold parameter, and construct asymptotic confidence intervals for the threshold parameter. Their basic idea in threshold estimation is that an exogenously given

variable, called "threshold variable", is used to split the sample in two groups or regime, which can or cannot be a regressor. This method derives the asymptotic distribution of OLS or 2SLS estimates of the threshold parameter. Importantly, in addition to generating unbiased and consistent parameter estimates, it locates the thresholds, tests for their significance and constructs their confidence intervals.

Accordingly, a two-regime threshold autoregression can be formulated as:

$$y_t = \theta_1^{'} x_t + e_{1t} \qquad if \quad q_t \leq \gamma \qquad \textbf{(9a)}$$

$$y_t = \theta_2^{'} x_t + e_{2t} \qquad if \quad q_t \succ \gamma, \qquad \textbf{(9b)}$$

where qt denotes the threshold variable (in our case money growth), splitting all the observed values into two classes or regimes. The terms yt and xt are m vector dependent and explanatory variables, respectively. The eit, for i=1,2, is the white-noise or error term of property of iid (independently identically distributed) and γ denotes the threshold value or parameter. If we knew γ the model could be easily estimated by OLS. Since the threshold is unknown a priori so it should be estimated in addition to other parameters. Note that when the threshold variable is smaller than the threshold parameter, the model estimates equation (9a) and when the threshold variable is larger than the threshold parameter, the model estimates the equation (9b).

Defining a binary variable $d_t(\gamma) = \{q_t \leq \gamma\}$ where {.} is the indicator function, with d=1 if $q_t \geq \gamma$ or d=0 otherwise, and setting $x_t(\gamma) = x_t d_t(\gamma)$, then equation (9a) and (9b) can be written as a single equation as:

$$y_t = \theta^{'} x_t + \delta^{'} x_t(\gamma) + e_t \qquad \textbf{(10)}$$

where, $\theta = \theta 2$, $\delta = \theta 1 - \theta 2$, and $\theta$, $\delta$ , and γ are the regression parameters to be estimated. The residual sum of squares as a result of estimating the regression parameters can be written as follows:

$$s_1(\gamma) = \hat{e}_{1t}(\gamma)^{'} \hat{e}_{2t}(\gamma) \qquad \textbf{(11)}$$

Caner and Hansen (2004) recommend estimating equation (10) using 2SLS (two stages least squares) technique. The easiest way to implement this procedure is through minimization of the sum of squared residuals as a function of expected threshold value. Hence, we can rewrite the optimum threshold value as:

$$\hat{\gamma} = \arg\min\ s_1(\gamma) \qquad \textbf{(12)}$$

Conditional on $\hat{\gamma}$, the regression equation is linear in θ and $\delta$ ', yielding the conditional 2SLS estimates of $\hat{\theta}(\gamma)$ and $\hat{\delta}(\gamma)$ by regression of dependent variable on explanatory variables.

Following the foregoing procedure, the linear equation in equation (7) can be specified as a nonlinear equation under a two-regime threshold autoregression (TAR) model as:

$$Inf_t = (\beta_{10} + \beta_{11}gm_t + \beta_{12}gdpg_t + \beta_{13}loilpr_t + \beta_{14}lrain_t + \beta_{15}bd_t)d[q_t \le \gamma] + (\beta_{20} + \beta_{21}gm_t + \beta_{22}gdpg_t + \beta_{23}loilpr_t + \beta_{24}lrain_t + \beta_{25}bd_t)d[q_t > \gamma] + \mu_t \qquad \textbf{(13)}$$

From equation (13), the optimal threshold value can be determined by obtaining the threshold value that minimizes the residual sum of squares (RSS). Since the main objective of this paper is to investigate the inflationary threshold effects in the relationship between inflation rate and money growth in Ethiopia, the annual growth rate of inflation is employed as the threshold variable in the analysis.

The main question in equation (13) is, therefore, whether or not there is a threshold effect? This requires a careful scrutiny between the linear model, i.e., equation (7), vis-à-vis the two-regime model, equation (13). The null hypothesis of no threshold effect (H0: β1i= β2i) is tested against an alternative hypothesis where threshold effect is present (H0: β1i≠β2i). However, traditional procedures of hypothesis testing cannot be applied, because under the null hypothesis of no threshold effect exits, the threshold parameter γ will be unidentified. Hansen (1996) suggests a standard heteroscedasticity-consistent Lagrange Multiplier (LM) bootstrap method to calculate the asymptotic critical value and the p-value.

To do this, a test with near-optimal power against alternatives distant from H0 is the LR statistics.[3]

## 4. Data and Context

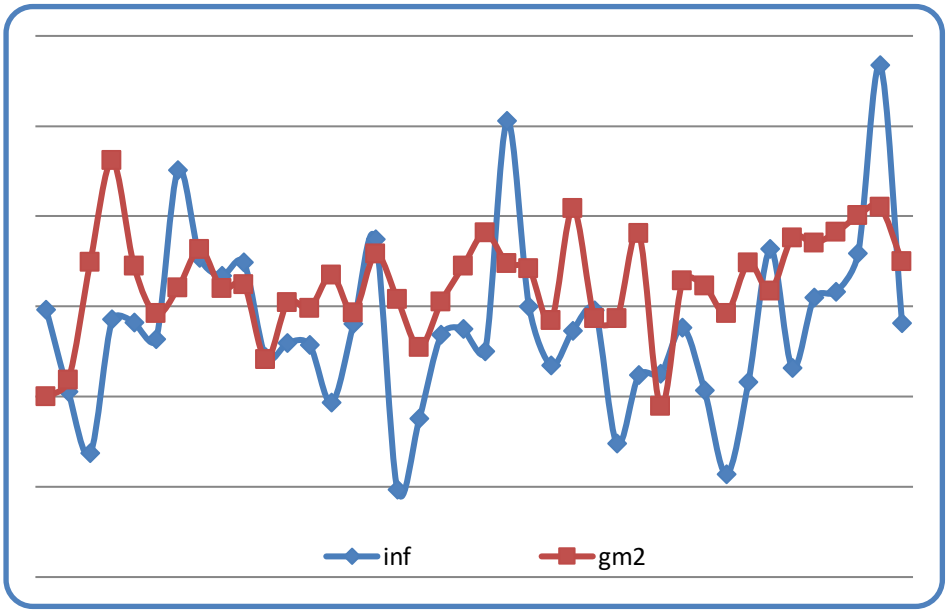
The study uses annual data for the period 1970-2009 collected from National Bank of Ethiopia (NBE), Ministry of Finance and Economic Development, Central Statistics Agency and International Monetary Fund. The period 1970-2009 was considered due to data limitations. In the endeavors directed towards achieving sustainable economic growth, the role of the monetary authority in Ethiopia is to maintain price and exchange rate stability. Hence, macroeconomic stability as proxied by price stability plays an important role in all economic decisions and fosters employment and economic growth. Moreover, exchange rate stability is meant to ensure the countries international competitiveness and to use exchange rate intervention as a monetary policy tool to influence both foreign reserve position and domestic money supply (NBE, 2009).

Specifically, the study use data on general price, money stock/supply, GDP (gross domestic product), budget deficit, oil price, and rainfall. There are different measures of money stock. However, since National Bank of Ethiopia uses broad money (M2) as a policy variable (see NBE, 2009), the study considered this variable in the estimation. Summary statistics of the variables considered is provided in the appendices (see Appendix A). The mean of inflation is about 7.7% while the mean of money growth is about 12.9%. While the standard deviation of inflation is 7.7, the standard deviation of money growth is 115.7 which is about 12 times that of the former. Further, their distribution is non normal as Jarque-Bera test rejects the null hypothesis of normality for both series.

A closer look at the behavior of the two variables- inflation and money growth during the period 1970-2009 reveals that both variables closely move together in the same direction (see Figure 1).

[3] See also Hansen (1999; 2000) and Hansen and Soe (2002) for details of the test.

**Figure 1: Inflation and money growth (1970-2009)**




Source: Authors' own analysis

The time series property of the data used in the study was also examined using ADF test due to Dickey and Fuller (1979, 1981), and PP due to Phillips (1987) and Phillips and Perron (1988). These tests are applied at level and at first difference of the variables. Test results are presented in the appendices (see Appendix B). The results show that the null hypothesis of unit root is rejected, at least at 5% level of significance, in both tests except for real GDP in the first difference. In ADF test, it turns out that real GDP is not significant even at 10% both at level and first difference. However, when PP test is applied real GDP become significant at 1% level at the first difference. Overall, these results suggest that the underlying variables are difference stationary.

Further, the test for cointegration was conducted using the maximum-likelihood test procedure established by Johansen and Juselius (1990) and Johansen (1991). Details of the test results are presented in the appendices (see Appendix C). The test shows that in the long-run, the variables are cointegrated; thus the existence of a meaningful long run relation. In the table below, the LR test indicates one cointegrating equation(s) at 5% significance level as the trace statistic 22.1195 is above the 5% critical value (29.68).

## 5. Empirical Results

As outlined in section 3, the initial step to see the existence of threshold effect is to estimate equation (13) using 2SLS as suggested by Caner and Hansen (2004) and computing RSS for different values of the threshold parameter. The optimal threshold level is the one that minimizes RSS. The test results are summarized in the following table.

**Table 1: Test Results of Threshold Effects**

| Test Hypothesis | Optimal Threshold | LR test statistic | 1% Critical Value | 5% Critical Value | P-Value |
|---|---|---|---|---|---|
| H0: no threshold | 17% | 36.7 (LR0) | 7.35 | 10.59 | 0.000 |
| H0: one threshold | | 0.125 (LR1) | 7.35 | 10.59 | 0.813 |

Source: Authors' own analysis

Applying Hansen's (2000) testing procedure, this study found evidence of one threshold in the relationship between money growth[4] and inflation. More specifically, the LR0 test statistic is 36.7, which is significant at 1% level with a bootstrap p-value of 0.000 indicating that the threshold exits. However, in an attempt to test for two thresholds, the LR1 test statistic is 0.125 which is well below the 5% critical value indicating that the null hypothesis of one threshold cannot be rejected significantly. Therefore, the test procedure implies one threshold and, thus, two regimes in the relationship between inflation and money growth in the country. The optimal threshold at which the residual sum of square is minimized is 17%. The results are similar to the findings of Milas (2007) except the magnitude of the threshold is higher in our case.

After estimating the threshold level using 2SLS and testing its significance, Caner and Hansen (2004) proposed the model parameters to be estimated by GMM. For comparison purposes, the first column in Table 2 presents estimates for a linear regression equation that ignore the threshold effect.

[4] All growth rates were calculated as the first difference of their logs. The interest rate is proxied by real lending rate, exchange rate by real effective exchange rate and credit by the total credit to the private sector.

Column two and three provide estimates of the two-regime threshold autoregressive model.

**Table 2: Regression Results of Inflation Rate and Money Growth in Ethiopia (1970-2009) a**

**Dependent variable: Inflation**

| Variables | Linear Model | Threshold Model | |
|---|---|---|---|
| | | Regime 1: ≤17% | Regime 2: > 17% |
| constant | 35.61391 | 1.785103 | -85.69495 |
| | (129.3935) | (37.96798) | (118.2563) |
| Money Growth | 2.194453 | -0.4484866 | 1.472167* |
| | (4.345978) | (0.6849215) | (.7087817) |
| GDP Growth | 0.0930879 | 0.4765417 | 0.0436404** |
| | (0.0799819) | (0.7707039) | (.0115594) |
| Budget Deficit | 0.0038652 | 0.0018692 | 0.0019319 |
| | (.0033405) | (0.0015056) | (0.0011776) |
| Oil Price | 1.141137 | 5.63862 | 11.91485* |
| | (16.47499) | (4.437037) | (3.973082) |
| Rainfall | -12.94897 | -8.535948 | 4.785771 |
| | (26.65294) | (10.14296) | (21.7275) |
| N | 38 | 29 | 9 |
| $R^2$ | | | 0.91 |

a ** and * represent significant at 1%, and 5%, levels respectively while numbers in parentheses are standard errors. (Source: Authors' own analysis)

As the above table reveals, in contrast to the results obtained in the low money growth regime and in the linear specification, in the high regime model, money growth has a significant impact on inflation. More specifically, the impact of money growth on inflation is positive and significant at 5% level with a coefficient of 1.47. That is, an increase in money stock by 1% leads to increase in inflation by 1.47%. On the other hand, under low-inflation regime and linear specification, money growth does not have significant effect on inflation. The estimated non-linear relationship between inflation and money growth is **consistent with the empirical conclusion derived in previous studies such as** Bachmeier, Leelahanon, & Li (2007) and Milas (2007). That is, under high inflation regime, money growth has a positive effect on inflation.

In the high regime, a percentage change in oil prices is expected to change inflation by 11.9% indicating that oil shocks are important sources of inflation in the country (see Gerlach, Browne and Honohan 2004). Similarly, the coefficient on real GDP growth is positive and significant at 1% significance level. On average, this model predicts that a 1% increase in real GDP leads to a rise in inflation approximately by 0.04%. Finally, rainfall is insignificant in all specifications. Thus, according to our empirical result it appears that the monetarist view is valid in the context of Ethiopia.

## 6. Conclusions and Implications

In Ethiopia empirical studies money growth and inflation are very scant. The study contributes to the debate and shed light empirically quantifying and testing the nature of the relationship between money growth and inflation using annual datasets covering the period 1970-2009. This period was considered due to data limitations. The study employs a Two-Regime Threshold Model for the empirical analysis.

The following conclusions can be drawn from the foregoing discussion. First, the probe on the link between money growth and inflation revealed that their relationship is nonlinear. Particularly, the study found the existence of threshold effect in the relationship between inflation and money growth. Money growth is inflationary only when it is greater than 17%. Hence, an important policy implication is- 'keep the money growth below 17%'. Second, as indicated by the significance of the coefficient of money growth, the monetarist view on the causes of inflation is valid in Ethiopia. Last but not least, our study analyzed the nonlinear effects of money on inflation using single equation model applying 2SLS. However, an interesting issue of further research could be employing Multivariate Threshold Vector-Autoregressive (MTVAR).

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## Appendices

### Appendix A: Summary Statistics

| Variable | Obs | Mean | Std. Dev. | Min | Max | Skewness | Kurtosis | Jarque-Bera | Prob |
|---|---|---|---|---|---|---|---|---|---|
| Inflation | 40 | 7.7 | 9.4 | -10.3 | 36.7 | 0.83 | 4.45 | 7.93 | 0.02 |
| Money Growth | 39 | 12.9 | 5.4 | -1.1 | 26.1 | -0.22 | 3.55 | 0.80 | 0.67 |
| GDP Growth | 39 | 25.2 | 115.7 | -10.2 | 711.7 | 5.61 | 33.57 | 1723.17 | 0.00 |
| Budget Deficit | 40 | -680.9 | 2388.1 | 8580.9 | 4815.0 | -0.80 | 5.00 | 10.71 | 0.00 |
| Oil Price | 40 | 3.6 | 0.5 | 2.8 | 4.6 | 0.19 | 2.03 | 1.79 | 0.41 |
| Rain Fall | 40 | 4.6 | 0.2 | 4.1 | 4.9 | -0.12 | 3.54 | 0.58 | 0.75 |

### Appendix B: Results of Unit Root tests with ADF and PP a,b

| Variables | Augmented Dickey-Fuller (ADF) | | Phillips-Perron (PP) | |
|---|---|---|---|---|
| | At Level | First Difference | At Level | First Difference |
| Lcpi | -0.093 | -3.710** | 0.170 | -4.915** |
| Lgdp | 8.854 | 14.522 | 2.056 | -6.233** |
| lm2 | 0.727 | -4.049** | 1.307 | -5.983** |
| Loilpr | -2.208 | -4.349** | -2.030 | -5.115** |
| Lrain | -2.785 | -7.906** | -3.949** | -11.792** |

a The ADF and PP tests are based on the null hypothesis of unit roots.

b **, and * indicate significant at 1%, and 5% levels respectively, based on the critical t-statistics as computed by MacKinnon (1996).

**Appendix C: Johansen tests for cointegration**

| **Trend: constant** | | | **Number of obs = 38** | | |
|---|---|---|---|---|---|
| **Sample: 1972 - 2009** | | | **Lags** | | |
| **Max rank** | **parms** | **LL** | **eigenvalue** | **trace statistic** | **5% critical value** |
| 0 | 20 | 50.935417 | . | 128.9275 | 47.21 |
| 1 | 27 | 104.3394 | 0.93984 | 22.1195* | 29.68 |
| 2 | 32 | 111.73297 | 0.32236 | 7.3324 | 15.41 |
| 3 | 35 | 115.33736 | 0.17280 | 0.1236 | 3.76 |
| 4 | 36 | 115.39915 | 0.00325 | | |