Macroeconomic Factors Affecting the Diffusion of Genetically Modified Crops Technology

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ABSTRACT

Genetic modified crop technology is one of the world subject today especially because of food security. The Food and Agricultural Organization (FAO) has food security as one of the most pressing problem found in the world due to the unexpected increase in the world population. Therefore discoveries were made on how to improve on the food security of the world and reduce hunger in the world. One of the solutions was first of all the green revolution which began in India .This revolution helped to improve on the food supply in India and reduced hunger in India as well. Following this revolution was now the genetic modified crop technology which helped to fight against pest and some insects which could destroy some crops. Also some genetic modified cops could grow in some desert areas like in Sub Sahara areas were because of the dryness and harsh weather some crops couldn’t adapt. Due to the advantages discovered from using the genetic modified crop technology, many countries there decided to adopt this technology. The question is therefore why the spread of this technology faster in some countries than other counties?

The study tries to develop and test a model which tries to explain the uneven diffusion of genetic modified crop technology across countries. We used mostly macroeconomic factors as our independent variables such as openness to trade, credit availability, GDP per capita, government size, growth rate and inflation. Genetic modified crop land size is our dependent variable. Also we used 10 countries and nine years (2004 -2012) with the help of panel data in our regression.

However, the results shows some macroeconomics factors such as credit availability, government size, growth rate were significant in explaining the uneven diffusion of genetically modified crop technology.

Keywords: Genetic modified crop technology, Government size, credit availability, openness to trade ,growth rate ,inflation , GDP per capita ,Food security.

ÖZ

Genetik modifiye kırpma teknolojisi nedeniyle özellikle gıda güvenliği, bugün dünya konularından biridir. Gıda ve Tarım Örgütü (FAO) nedeniyle dünya nüfusunun beklenmedik artış, dünyanın bulunan en önemli sorunlardan birisi olarak gıda güvenliğine sahiptir. Bu nedenle keşifler dünya gıda güvenliği geliştirmek ve dünyada açlığı azaltmak için nasıl yapılmıştır. Çözümlerden biri Hindistan'da gıda kaynağı geliştirmek için yardımcı oldu ve aynı zamanda Hindistan'da açlık azaltılmış Hindistan .Bu devrim başladı tüm yeşil devrimin ilk oldu. Bu devrim sonrasında artık haşere ve bazı bitkileri yok edebilecek bazı böceklere karşı mücadele için yardımcı genetik modifiye bitki teknolojisi oldu. Ayrıca bazı genetik modifiye polisler Alt Sahra alanları nedeniyle kuruluk ve bazı bitkileri adapte olabilir sert hava vardı gibi bazı çöl bölgelerinde büyümeye başladı. Genetik modifiye bitki teknolojisini kullanarak keşfetti avantajları, birçok ülke var, bu teknolojiyi benimsemeye karar verdi. Soru nedenle neden diğer ilçeleri göre bazı ülkelerde bu teknolojinin daha hızlı yayılması?

Çalışma ülkeler arasında genetik modifiye bitki teknolojisinin düzensiz difüzyon açıklamaya çalışan bir modeli geliştirmek ve test etmek için çalışır. Biz ticaret açıklık, kredi durumu, kişi başına düşen GSYİH, hükümet boyutu, büyüme oranı ve enflasyon gibi bizim bağımsız değişkenler olarak çoğunlukla makroekonomik faktörler kullanılır. Genetik modifiye kırpma arazi büyüklüğü bizim bağımlı değişkendir. Ayrıca 10 ülke ve bizim regresyon panel veri yardımıyla dokuz yıl (2004 -2012) kullanılır.

Ancak sonuçlar, kredi durumu, hükümet boyutu gibi bazı makroekonomi faktörler gösterir, büyüme oranı genetiği değiştirilmiş bitki teknolojisinin düzensiz difüzyon açıklayan önemli idi.

Anahtar Kelimeler : Genetik modifiye kırpma teknolojisi , Hükümet boyutu , kredi kullanılabilirliği , ticaret açıklık , büyüme oranı , enflasyon , kişi başına GSYİH , Gıda güvenliği

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INTRODUCTION

1.1 Background To The Statement

According to FAO (2014), approximately 805 million people are estimated to be chronically undernourished. This is about 11.5% of the entire world population. The continent of Asia accounts for about two third of this 805 million undernourished people while sub-Saharan Africa shows the highest prevalence of hunger where one out of every four persons is undernourished.

Lack of sufficient food causes about 45% of deaths recorded in children under the age of five; this means that about 3.1 million children die per year from poor nutrition. Also looking into the future according to FAO projections, by 2050 global population is expected to have increased by 4%. This means that food production will be required to grow by about 75% in order to adequately support the global population by 2050.

There is therefore no arguing about the fact that achieving food security is one of the most pressing challenges of the world. In an attempt to solve this problem of world hunger, the millennium summit held from the 6^{th} to 8^{th} September, 2000 at the UN headquarters in New York came up with the millennium development goals (MDGs). These goals firstly include the eradication of extreme poverty and hunger with a specific target of reducing by half the level of poverty and hunger in the world by the year 2015.

This decision to combat global hunger brings into the scene the possible role of genetically modified crops (GM crops) in boosting agricultural productivity in the world. This is because GM crops show a higher level of resistance to disease, pest, climate change etc, and are also proclaimed to be better in terms of value and nutrient components. See Arvind Singh (2013).

According to World Health Organization (WHO), GM crops are crops produced from organisms which the DNA has been altered through a process that does not occur naturally, mainly through genetic engineering. This process makes it possible to introduce new traits or to control the genetic structure of products more than ever before. It is a more productive technique of improving on agricultural output than the previous approaches such as green revolution, selective and mutation breeding. Examples of products to which GM technology have been applied include the following:

1. Fruits and vegetables: Pawpaw which has been successfully genetically modified to resist the ringspot virus.
2. Corn: Approximately 90% of American corn products are genetically modified. Corn used for food is often modified to generate a protein called Bacillus thuringensis which kills certain pest insects.
3. Soy beans: Just like in the production corn, also about 90% of the soy bean produced in the USA has gone through some form of genetic modification.

4. Vegetable oil: A large portion of vegetable oil consumed as cooking oil and magerine in the USA are produced from genetically modified crops such as corn, cotton and soy bean.

The application of genetic modification to crops is a recent phenomenon. The first attempt ever made to genetically modify crops occurred as recently as 1983 where four separate groups of scientists succeeded in creating genetically modified plants. Three groups out of the four were able to insert bacterial genes into plants while the last group was able to insert a bean gene in a sunflower plant. The commercialization of genetically modified crops did not start until much later in 1994 when Calgene, a California company obtained the license to market a genetically modified tomato named flavr savr. This product was the first commercialised genetically engineered crop ever to be granted approval for human consumption. However, since then, the adoption and acceptance of genetically modified products in the world has been met with mixed reactions. For example while countries such as Canada, USA, China, India, Brazil and Spain have embraced the use of this technology, most western European countries have refused to embrace this technology.

This study therefore wants to look at the rate at which the genetic modified technology is being absorbed in different countries agricultural sectors. More specifically, this study attempts to determine the factors that affect this speed of diffusion of technology for the following selected countries: Canada, China, Brazil, USA, Argentina India, Australia, Philippines and South Africa.

1.2 Statement Of The Problem

Despite the numerous efforts made by different governments all around the world, food insecurity still exists in the world. The Millennium Development Goal of eradicating extreme poverty and hunger is not progressing as fast as the world would like and it calls for serious concern. The coming of genetic modification technology seems to provide a faster means of combating hunger. Surprisingly, data show a big diversity among countries in terms of adopting this technology. Available data show a wide variation in the rate of the diffusion and absorption of the genetic modification technology in the world today. For example, approximately 35 million hectares (almost 1.5 times the land size of Britain) is used for producing genetically modified products mainly in USA, Canada and china while most western European countries except Spain lag behind in the use of this technology.

The question then is what is responsible for the difference in the rate of diffusion of adoption of this technology across countries?

1.3 Objectives Of The Study

Data show that there is a big diversity among countries in terms of their level of adoption of the genetic modification technology. While many countries have not experienced any genetically modified food production, some others have been strong adopters who have started to use us this technology heavily. Still, some others started using this technology but have been slow in terms of adopting the diffusion of the technology. One then wonders what may be the factors causing such divergence in the response rate of GM technology spread.

This research work tries to fill the gap in literature by attempting to identify the macroeconomic factors contributing to the diffusion of genetically modified food technology limitation.

Chapter 2

THEORETICAL LITERATURE REVIEW

A theory used to show how and at to what extent new ideas and technology spreads across cultures is termed diffusion of innovation. This concept was first studied by French sociologist Gabriel Tarde in the late 19th century and also by German and Austrian anthropologists such as Friedrich Ratzel and Leo Frobenius. The study started from the sub-field of rural sociology in the mid western United states in the 1920s and 1930s. Due to the rapid advancement of agricultutal technology, researchers started to study how farmers adopted the use of hybrid seeds with the new equipments and farming techniques at their disposal. A study carried out by Ryan & Grom (1943) on adopting hybrid corn seeds gave credence to the existing research on diffusion into a distinct paradigion that would be cited consistently in the future. Diffusion of innovation can be said to be a process whereby certain innovations are passed along over time, using specific channels to pass across these innovations to members of a social system (Mahakam & Peterson 1985).

In the ensuing paragraphs, it is seen that evidences relating to some questions asked regarding the diffusion of technology does not give a conclusive result. The reasons why new innovations or technological advancements are not completely used by all firms at the same time are too many.

Firstly, According to Manfield 1968, the first and wide spread of diffusion and new technology can be from a range of around 5-10 years and this depends on the innovation. Secondly, according to Everett, diffusion of technology follows an S-shape, that is, the sigmoid shape.

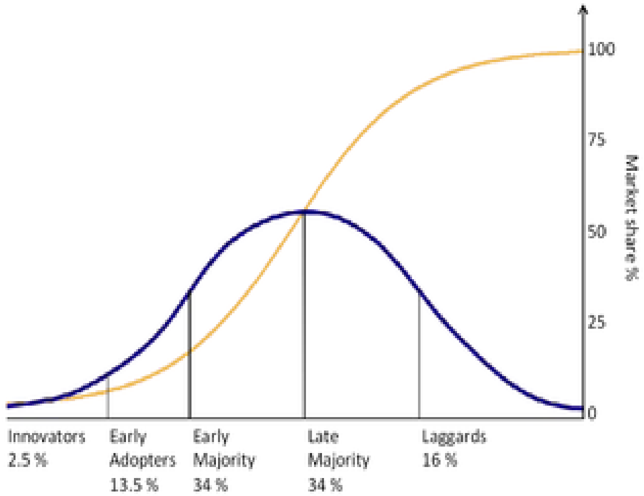

Figure 1: Diffusion of Innovation (Rodgers, 2003)

From the diagram, we discover that technology adopted expand or spread slowly from the start, increases rapidly and then reduces at a technology specific adopting ceiling. Our question therefore is why some countries adopt a given technology namely the Genetically Modified crop technology more than others.

Karshenas and stoneman (1993) discovered that that there are four theories of technology diffusion. These are (1) epidemic theory, (2) rank theory, (3) order theory and (4) stock theory.

2.1 Epidemic Theory

Epidemic theory is one of the oldest models and may be influential of these four models (Manfield). This model explains that dissemination of information regarding recent technologies leads to diffusion of that technology. The idea behind this theory is that a disease can be contacted offhand by merely coming in contact with an already infected person. The same is true with any new technology. When a country adopts a new technology and others see that it is profitable, then they also endorse the adoption of the new technology for their own region. However the probability that all non-adopters start using the technology just by coming into contact with someone already using the technology is not the same for all technological innovations. Factors like risks involved, amount of investment required and if it will be profitable in the long run may hinder the non-adopter to adopt the technology, thus leading to a slowdown in technology diffusion. This model was criticised by

2.2 Rank Theory

This model explains that diffusion is different in countries due to their net return on adoption; six factors have been advanced to explain the rank model.

1) Capital vintage: Here, the firm with older vintages of capital will quickly adopt a new technology compared to those with new vintages of capital (1960 Salter).
2) Firm size; Large firms spread risk credit access and they also like to use this opportunity of economies of scale related to the use of a new technology. All these would be easier for a new firm this speed of diffusion will slow down (Davis 1979, David 1975).
3) Beliefs about the return of a new technology; Some firms are more pessimistic about the adoption of a new technology while some that are optimistic usually grow rapidly (Stoneman 1980, Jesen 1983).
4) Search cost; Firms that will have to use a lot of funds to adopt a new technology due to where they are located, work force (human and physical)

will find it less profitable to start using the new technology as compared to those firms obtaining higher returns.

5) Input prices; varying input prices in industries and their technological input requirements show that some industries gain more from recent technological advancements or innovations as related to other firms.
6) Regulatory cost; variations in exposure of firms to costs imposed on them through regulations also affect the end result on adopting a new technology. This usually occurs in a case where the recent technology has differing regulations as compared to the old one already in place. (Millman & Prince 1989, Ecchia & Mariotti, 1994).

Therefore this model tries to explain why some firms do not adopt a new technology rapidly; also the model explains that innovation and technology diffusion can be diffused at different speed because the net return of adoption of some technologies will increase rapidly with respect to time as compared to other innovations.

2.3 Order Theory

This theory explains that some countries are faster in technology adoption than others because the net return achieved on adopting some technologies increase faster with respect to time as compared to other technologies. Also, it is used when in production processes by firms; there is a fixed critical input and since firms do not adopt innovative technologies at the same time, therefore only firms that at the initial stage of production have access to this fixed critical input finds it profitable to start using the new technology i.e. adopt.

2.4 Stock Model

Stock model is based on the concept that net return for adopting new technology by a firm will depend on all the firms that have already adopted with net return decreasing as the number of firm goes up (Quirmbacj 1986, Reinganum 1981). Stock effects arises when recent technology adopted by a portion of firms in an industry reduces the average cost of producing goods so much so that the final output price will also be affected i.e. reduce. Reduction in this output price will in turn lead to a reduction in the net return on adoption.

Thus stock model implies that innovation and diffusion of technology occurs at different speeds because the net return on adoption decreases as the number of firms adopting increases. Generally after some time, the net return increases as the number of firms adopting increases. Also, it implies that innovation diffuses at differing rates because the stock effect of some innovations is higher than that of others.

Also apart from the above theories which lay a part in the theoretical review of diffusion of technology difference, there are also some factors that affect diffusion such as; supply has to be considered, how competitive the market for the innovation or technology is and the amount of capital a firm spends on research and development of new technologies (Stoneman 1991).

Furthermore researchers have argued that firm expenditures on adopting new technology are dependent on diffusion. This is because diffusion of new technologies increases Research & Development expenditures and Research & Development on the other hand encourages diffusion of new technologies (Stoneman 1991, Cohen & Leventhal, 1993).

Network effects due to technology standards are very important for diffusion of technology because there is a high degree of interaction among technologies. A technology has a network effect when the value of the technology to a user increases with the number of total users in the network. For example, the benefit of owning a telephone set depends directly on the number of people having telephone sets in the network since the benefit will increase as more people can be reached by phone.

Chapter3

EMPIRICAL LITERATURE REVIEW

Various works in the past have tried to examine differences in technological diffusion; be it at the level of the sector, firm or country. Our work will look at why there is uneven diffusion of different types of technology in general among countries. Country level data has been used to test for the impact of macroeconomics characteristics on the speed of diffusion. Below we present previous studies which explain why diffusion of technology is faster in some countries than other countries or in some firms than other firms.

Manfield (1961) used data from 9 separate innovations for four industries. He tested for correlation between speeds of diffusion and compared with the average profitability of innovation and mean start up capital needed for adopting the innovation. His results showed that these variables were significant. Also, Davis (1979) using data on diffusion in 22 innovation processes in the UK discovered the difference in diffusion pattern with using cheap and simple innovation compared to the expensive and complex one. His results showed the simple innovation(s) was faster at the beginning of the observation period because it is easy to adopt but slow at the end. Also, some researchers carried out research on the differences in the speed of diffusion mostly at the level of firms and at the sector level. We will be discussing the causes of differences of diffusion speed in firms and different sectors below.

Many researchers such as Schumpeter in his Schumpeterian hypothesis carried out some research which resulted to the fact that bigger firms in any concentrated industry show more innovation and adopted recent technology very fast when compared to small firms. Also, other researchers such as Antonelli & Tahar (1990), Globerman (1975), Feder, Just & Zilberman (1985), Karshenan & Stoneman (1993) also supported the Schumpeterian hypothesis that large firms adopt innovations earlier than small firms. Rose and Joskow (1990) tried to carry out some tests and research on the Schumpeterian hypothesis and found out that there was a significant correlation between the size of firms and adopting new innovations. Thus, large firms adopt technology before the small firms because they are able to turn over capital faster than small ones. It is also due to the fact that large firms enjoy economies of scale and have a better chance compared to small firms.

Some researches were also carried out on the fact the market structure could lead to uneven spread of technology diffusion between firms. Some research argued for and against the fact that market structure causes uneven technology and adoption diffusion. For instance, while Hannan and Mc Dowell (1984), Sommers (1980) found out that the concentration has a positive correlation on adopting recent technologies; the reverse was observed by Romeo (1975). Davis (1979) carried out a research on market structure and his results showed that market structure could lead to an uneven spread of diffusion as well as it would lead to an even spread of diffusion. His findings showed that the amount of firms present in industries with a high concentration tends to be small and this encourages information flow and increase the rate of diffusion. While market structure could also slow down diffusion of technology due to the fact that firm sizes in concentrated industries tend to be quite variable.

Also, Javis (1981) carried out some research which resulted to the fact that increased diffusion correlates with low input prices by adopters. Also, wage rate and speed of diffusion of labour reducing innovations had a direct relationship (Antonelli and Tahar 1990). In 1991, Lin, Pitt and Sumodiningrat discovered through their work that industries having more of human capital were relatively early adopters of new technologies compared to others especially in the adoption of agricultural innovations.

Recently, several researchers discovered some empirical evidences on the relationship between formal regulatory pressure and a change to more clean technological innovation. Lanjouw & Mody (1990), Jaffe & Stavins (1995) carried out some research on this factor. They discovered that the link between regulation and technological change will no longer be there if enforcement is not properly executed as is often the case in developing nations. However, recent research carried out by numerous researchers have shown that regulators such as neighbourhood organizations, nongovernmental organization(s) and trade unions can replace formal regulatory pressure (Paragal & Wheeler, 1996). In 1998, Blackman & Bannister found out that unofficial regulation(s) correlates with adapting to clean technology. Researchers further discovered that fast adoption of technology could be due to infrastructure, research and development (R&D) expenditures. Hastings, Minam and Makino (1980s) found out that R&D expenditures and complimentary infrastructure are directly related to early diffusion of technology while capital vintage has an inverse relationship with the early adoption of technology (Oster 1982).

Several research studies were also carried out on why diffusion spreads faster in some countries than others. Some researchers tried to give some factors which caused this uneven spread of diffusion between countries.

Swan (1973), used data gotten on synthetic rubber from 12 countries and found out that increased diffusion correlates with growth of the industry and its export. Studies were carried out to try to show the relative low speed of diffusion of oxygen furnace (for steel making) in USA with some other countries e.g. Japan. It was discovered by some researchers that inefficiency resulting from trade barriers slowed diffusion (Adams & Dir Lam, 1966). Also, others such as Maddalla and Knight (1967), Lynn (1980) explained that it was due to the differences experienced in the growth rate of industries and factor prices. Otsuka et al (1988) in their studies discovered that spinning of ring diffused faster in Japan compared to India due to the differences in human capital. Nabseth & Ray (1974) brought together several studies carried out on the diffusion of ten processing technology used by 6 countries. They found that wages seemed to have the highest effect on diffusion. According to Stoneman (1983), "if anything is to come from these studies, it is that the different production programs, product mixes and institutional characteristics of firms are key factors in the diffusion process". Finally, some studies have tried to compare and show the difference in international diffusion rates using macroeconomic statistics like Gross Domestic Product and the supply of money (Lucke 1993, Blackman & Boyd, 1995). They found out that macroeconomic characteristics actually correspond with diffusion speed.

Also, according to the result of an investigation by the World Bank in a report on global economic prospects 2008; the diffusion of technology in developing countries is explained by the fact that political and macroeconomic instability have caused the recent uneven spread of technology diffusion. Also, surveys show or implies that developing countries are behind high income earning ones based on several governance indicators. For instance, how effective the government regulates and the quality of regulation quality of developing countries is shown to be about half that of the OECD standards with indicators of corruption, rule of law, voice and accountability being even lower. The quality of education is still low even though there are a large number of students enrolling in schools in the low and middle income countries. A Large number of the students fail to pass standard tests of literacy and numeracy. For example, sub-Saharan Africa has an enrolment rate that is almost 100%, but less than half of the grade six students in a few of these countries are considered to be literate.

Luque (2002) found out that the decision by the USA plants to adopt three advanced manufacturing technologies gave different results on how fast each technology was spread and used. The plants operating in industries with lower degrees, demands, technological uncertainty and a thicker rescale market (higher rescale prices for used machinery) are more likely to adopt these technologies. She therefore confirms that uncertainty is an important factor for the rapid diffusion of technology. That is, adopting new technologies correspond to the exercise of an option; it is expected that adoption of new technologies will more likely occur in industries that have reduced uncertainties and lower sunk cost.

Helen V. Milner (August 25, 2003) in the article “Global spread of the internet” tries to find out factors which helped to promote as well retard the spread of the internet evenly. Internet technology has diffused unevenly across countries. Her data from

190 countries since 1990 shows that, economic competition and sociological emulation play a significant role in affecting internet spread. She concluded that the spread of internet technology was due to economic competitors, that is, new inventions and latest models of things so that they can also copy. Also, socio-cultural neighbours play a significant part in the diffusion of internet technology. This is to say that countries that have the same native language, religion and colonial heritage seem to more attentive to each other's activities. She therefore concluded that diffusion pressures caused by the global capitalist market and imitating similar countries can have a significant impact on the choice of a country regarding new technologies.

Also, Hao Xiaming and Chow Seet Kay also tried to examine factors which could lead to the spread of internet technology. Unlike Helen V., they explained that there was no relationship between internet technology diffusion with socio cultural literacy level and English proficiency. They used secondary data gotten from samples taken from 28 Asian countries and found out that internet technology diffusion relates to the wealth of the country, telecommunications, infrastructures, urbanization and stability of the government.

Bronwyn H. Hall and Beethika in their article "Adoption of New Technology" tried to explain the factors which determine diffusion of technology and portrayed evidences of their importance. They also tried to explain that the level of skilled personnel and state of capital goods sector were also good determinants of diffusion of technology to separate or single firms. Nathan Rosenberg stressed the significance of the technical knowhow or knowledge capacity of the industry in question to be able to adopt new technology or innovation. Thus, the state of the supplying capital goods sectors are a significant determinant of diffusion since the inceptive idea behind the innovation requires the needed technical knowledge and skill to turn it into a commercially feasible end product.

Also Caselli & Coleman (2001) carried out a study on the adoption of computers by citizens in several OCED countries from 1970-1990 and discovered that work aptitude (based on the level of education), trade openness and amount of investments in the country were part of significant determinants on how much these countries invest on computers. Their findings supported that of Nathan Rosenberg which showed that a high level of education was related to high level of skilled labour and high rate of investments which in turn will results in a highly developed and sophisticated capital goods sector.

Also, in USA, Kennickell and Kwast (1997) found out that the role of education and consumer skill helped to spread the consumer adoption of electronic banking. They found out that 70% of American households used some form of electronic banking by 1995 while just a few used the recent electronic banking such as bill paying; this one was used for making direct deposits. So, as the technology developed and improved, more people became familiar and comfortable about using it.

Also customer commitment and relationship also help in the diffusion of technology. Before investing on any new innovation, firms require assurance that there will be a substantial increase in their income in the future (as a result of investing in it) so as to be able to pay for the investment and thereby reduce the risks inherited while making the decision to adopt an innovation. Due to the uncertainty of demand in the world today, firms are faced with a dilemma. They are not really certain if they will be able to recoup the money invested on adopting a new technology or the time limit required to recover the cost, thus causing the diffusion of technology to be uneven. This is faster in some places and slower in others.

In the Adoption and Diffusion of Gm crops in United States by Pasquate L.Scandizzo and Sara Savastano, tries to show the retardation of adoption and diffusion of genetic modified crops. They need panel data with 13 US states from 2000 to 2008.Their results showed that the retardation of GM cops technology in some states due to lack of information ,mistrust and exaggerated risk.

Chapter 4

EMPIRICAL SPECIFICATION

As mentioned earlier, the purpose of this paper is to investigate the impact of macroeconomic variables on the diffusion rate of GM technology in the selected countries. The macroeconomic variables which are suspected to impact technology diffusion are growth rate, income per capita, Government size, inflation, trade openness and access to credit.

GML= (CRDT, GDPPC, GOVT SIZE, GRWT, INFL, TO)

WHERE:

GML =genetically modified crop land size

CRDT = CREDIT ACCESS

GDPPC = GROSS DOMESTIC PRODUCT PER CAPITAL

GOVT SIZE=GOVERNMENT SIZE

GROWTH = GROWTH OF DOMESTIC PRODUCT

INFL = INFLATION

OPEN = TRADE OPENNESS

From the above function our:

DEPENDENT VARIABLE = GENETICALLY MODIFIED CROP LAND

The measurements of independent variables are as follows:

Availability of Credit Access: The number of household getting loans in financial institutions

Gross Domestic Product per Capita; this is the average amount each individual contributed to the gross domestic product of the country. It's the gross domestic product of a country divided by number of the population of the country.

Growth of domestic product;

Government Size; the government size expenditure divided by the gross domestic product

Inflation: Inflation is calculated by using GDP Deflator

Trade Openness: This is the import plus the export divided by GDP

Availiabity of credit access is expected to have a direct relation on genetically modified crops land size. If there is easy access to credit in the country farmers will be encouraged to use more genetically modified technology thus improving the diffusion and the spread of this technology and innovation. Also if some people know about the technology and don't have income to invest in it they will simply choose not to use this technology whereas having ability to access credit market simply encourages the producer to use the credit to import the technology.

Also, if the gross domestic product per capita of the country is high this also encourages farmers to invest on agricultural technology especially genetically modified technology, more easily thus gross domestic product per capita has a direct relationship with genetically modified land size.

Growth rate has a direct relationship with the genetically modified crop land size. An increase in the growth of the country will lead to an increase in the use of the genetic modified crop land size and vice versa. A large growth rate indicates a healthy economy where economic agents are rewarded according to their work efforts, productivities and management skills and innovative. Therefore in this healthy economy the producers will use any means to adopt new technologies to stay competitive.

Again, the size of the government also has a direct relationship with genetic modified technology diffusion. Therefore with a large government we can expect that the government assumes a role to bring a new technology to a country and spreading this is not a direct measurement but it is an approximate measurement for the role the government plays in adoption of new technology in the economy.

Similarly, we expect that trade openness has a positive impact on technology diffusion rate. We do so because people in open economies with more import are exposed to newer technologies earlier; and the earlier and the longer is the exposure, the more likely it is that the technology will be accepted. Thus trade openness has a direct relationship with genetically modified crop land size.

Finally, inflation has a negative impact in all economic activities. It makes the economy more uncertain and this uncertainty discourages all investment and the same time investment in technology.

4.1 Hypothesized Model

The estimated econometric models for this research were:

$LGML = B_O + B_1 LCRDT + B_2 LGDPPC + B_3 LGOVTSIZE + B_4 LGROWTH + B_5 LINFLATION + B_6 LOPEN + E$

Where:

LGML = LOG of Genetic Modified Land Size

CRDT = LOG of Credit Access

LGDPPC = LOG of Gross Domestic Product per Capita

LGOVT SIZE = LOG of Government Size

LGROWTH =LOG of Gross Domestic Product per growth

LINFLATION=LOG of Inflation

LOPEN= LOG of Openness to Trade

The relationship between the dependent variable and independent variable can further be summarized on the table below with their appropriate expectations.

Table 1: Apriori Expectation Signs

INDEPENDENT VARIABLES	APRIORI EXPECTATIONS
CREDIT ACCESS	+
GDPPC	+
GROWTH	+
GOVT SIZE	+
OPEN TRADE	+
INFLATION	-

Chapter 5

DATA

In the agricultural world today, several countries around the world make use of genetic modified crops technology. While these countries are involved in the use of this technology, the use of technology grows faster in some countries than in other countries. Our objective of this study is therefore to investigate if macroeconomic factors such as inflation, GDP per capita, growth rate, government size, trade Openness and availability of credit could be the reason why the GM crop technology spread faster in some countries than in other countries. In this section we are going to therefore see detail the data which is used for empirical analysis.

For this study ten countries are selected. These countries are selected because they are biotech Mega countries growing 50000 hectares or more of biotech crops and also they have sufficient data for the analysis. These countries land sizes used for GM crops have been recorded in James Clive book (2013). Our study data covers a period of nine years that is from 2004 to 2012.Countries selected for our studies are the following;

Table 2: Countries Using GM Crop Technology

USA	CHINA
ARGENTINA	INDIA
AUSTRALIA	PARAGUAY
BRAZIL	PHILLIPINES
CANADA	SOUTH AFRICA

Millions of risk adverse farmers in the world, both farmers owning large and small land of Cultivation confirmed that the gains as a result of using biotech crops are immense. Though our Studies include ten countries which planted biotech crops, generally in 2013, 27 countries were recorded to have grown biotech crops. From these 27 countries, 19 of them are developing countries; the remaining 8 are industrialized countries. Surprisingly in the top 10 of these countries producing more biotechcrops, 8 countries were developing countries which grew more of the biotech crops. They grew almost 1 million hectares. Therefore developing countries in the continents of Latin America, Asia, and Africa grew in total 94 million hectares of land compared with industrial countries that grew about 81 million hectares. These figures were contrary to some critics predictions who thought, prior to commercialization of technology; they predicted that biotech crops were going to be adopted more by industrialized countries and would not be accepted by developing countries especially small and poor farmers. Surprisingly, from 1996 to 2012, added economic benefits in developing countries stood at US $59 billion as compared to US $57.9billion generated by industrial countries (Global Status of Commercialized Biotech Crops 2013).

5.1 Variables And Source

In this our study our dependent variable is genetic modified land size (GML) of the selected countries over a time period of 2004-2012. The indicators of GML were taken from Brief 46 (Global status of Commercialized biotech\GM crops: 2013 by Clive James). The log of GML is calculated with respect with the logs of all the other independent variables.

The independent variables are; Availability of credit, government size, GDP per capita, growth rate, inflation and trade openness. The independent variables used in thisstudy were collected from the world development indicators of the World Bank (2014).

Chapter 6

ESTIMATION TECHNIQUE

The data is a panel data with 10 countries and 9 years. Panel data or longitudinal data or better still cross-sectional time series data; is made up of both cross-sectional data and time series data components. In panel data three kinds of models are used for estimation:

- FIXED EFFECTS MODELS
- RANDOM EFFECTS MODEL
- POOLED - OLS MODEL

The first two types of analyses make theoretically contrasting assumption about effect as either random or fixed:

6.1 Pooled – Ols Model

Treats all study as the same and OLS as frequent in this situation the error term captures "everything".

This does not consider time and space because it does not consider the heterogeneity or individuality that may exist in the data. The pooled model points at constant coefficients which is the normal hypothesis for a cross-sectional analysis. The model in general is described as follow:

$$Y_{it} = \beta_1 + \beta_2 X_{2it} + \beta_3 X_{3it} + u_{it} \qquad \text{[eq 6.1]}$$

Where;

y= dependent variable

X_2, X_3= independent variables

i stands for the i_{th} cross sectional unit, i= 1,......, N

t stands for the t_{th} time period, i= 1,...., T

6.2 Random Effects Model

In the random effects model, individual differences are also captured by intercept, but it is also assumed that the difference(s) across units are random and uncorrelated with the explanatory variable(s).

This model is expressed as:

$$Y_{it} = \beta X_{it} + \alpha + u_{it} + \varepsilon_{it} \quad \text{[eq 6.2]}$$

Here α is individual-specific effect while U_{it} is the normal error term. For random-effects models, α_i is included in the error term and each individual has the same slope parameter and a composite error term with 2 parts. Here, as mentioned above, error term has two components: u_i, individual error and $\varepsilon_{it,}$ random element that vary both over time and across units. The composite is the sum of two error terms.

The essential distinction linking fixed and random effects is whether the unobserved individual effect includes elements that are correlated with the repressors in the model, not whether these effects are stochastic or not.

The benefit about of random effects is that you can comprise time invariant variables (i.e. gender).While in the fixed effects model these variables are captivated by the intercept.

6.3 Fixed Effect

Fixed-effects (FE) utilized only when the researcher is concerned in analyzing the of variables that differ as time passes. Fixed effect model is a method of both pooling cross-section and time series data. In this type of models, the variables for each unit can differ as goes by while the unnoticed variables particular to each unit do not vary as time goes by. This model takes into consideration the heterogeneity or individuality in the data by allowing each individual (in this case each country) to have its own intercept value. I.e. each individual has a different intercept term but same slope parameter.

The equation of the fixed effect model:

$Y_{it} = \beta_1 X_{it} + \alpha_i + u_{it}$ (eq. 6.3)

Where;

α_i (i= 1......n) is the unknown intercept for each entity (n entity- specific intercepts)

Y_{it} is the dependent variable (DV), i=entity and

t=time

X_{it} represents one independent variable (IV)

β_1 is the coefficient for that independent variable (IV)

u_{it} represents the error term

6.4 Hausman Test For Fixed Or Random Effects

To decide when you can use fixed or random effects, you can do a Hausman test where the null hypothesis is that the preferred model is random effects vs. the alternative the fixed effect, it essentially tests if the unique errors (u_i) are correlated with the regressors, the null hypothesis is they are not.

Breusch-Pagan Lagrange multiplier (LM) Test for Random effects and Simple OLS

The LM test helps to decide between a random effect regression and a simple OLS regression.

The null Hypothesis in the LM test is that variance across entities are zero. This is no significant difference across units (no Panel Effect).

6.5 Other Tests

Also panel data can have some problems such as autocorrelation and heteroskedasticity. For autocorrelation test such as Breusch-Godfrey (BG) test is used to test for higher order serial correlation. Also the Durbin Watson test is also use to detect serial correlation.

The White test and the Breusch-Pagan test used to detect heteroskedasticity in a study.

In this our study neither of the tests was used because pooled panel data model was used for our analysis. Moreover we don’t think autocorrelation is a problem because autocorrelation would not be across the countries it would be in the data within each country given that we have only 9 years for each country and autocorrelation test within each country cannot be done. We are therefore inclined to leave this topic as it is but we are also thinking that given the numbers of countries which are 10 and only 9 years of data for each country the autocorrelation is not a serious problem.

Chapter 7

ESTIMATION RESULTS

This chapter would serve as an attempt to evaluate the relationship that exist between the dependent variable which is genetic modified food technology with her independent variables which are credit availability, growth rate ,government size, inflation ,GDP per capita and openness to trade. This shall be done through the use of regression analysis. The computational device is the econometric views (e-views) software program.

Our regression results is presented below where it shows the coefficient of our countries we used as well as our variables and many other components which will help us better analysis our regression results.

Dependent variable: LNGML

Method: Panel Least Squares

Sample: 2004-2012

Periods Included: 9

Cross Section Included: 10

Total Panel (balanced) Observations

Table 3: Regression Results

Variable	Coefficient	Std Error	t-Statistic	Prob.
CREDIT	0.009235	0.004725	1.954511	.0540
GDPPC	-1.21E-06	1.39E-05	-0.087210	0.9307
GOVTSIZE	0.326778	0.038009	8.597371	0.0000
GROWTH	0.036967	0.020058	1.842986	0.0689
INFLATION	0.088410	0.029326	3.014785	0.0034
OPENESS	0.013523	0.008822	1.532822	0.1292
TREND	0.082635	0.032926	2.509738	0.0140

R-Squared 0.944013 Mean dependent var 8.103651
Adjusted R-squared 0.933089 S.D dependent var 1.742260
Durbin-Watson stat 0.728426

From our regression credit availability has a positive relationship with the endogenous variables. Credit availability is significant at 5% with a t-statistic of 1.95.Therefore 1% change in credit access will bring about 0.000923 unit increase in GML crops. Thus credit availability will help in the spread of genetically modified food technology. This is also with confirmations with most economic references which tried to show the relationship between credit availability and expansion of agriculture. Our topic which is on expansion of genetic modified food technology is still linked to agriculture. We all know agriculture is becoming a dominant sector in most economics especially our selected economies above. Thus credit will play an important role in increasing agricultural production .Credit helps to provide sustainable and profitable farming system know that easy access to financial services at affordable cost positively affects the productivity asset formation income and food security of rural poor. Therefore easy credit accessibility will encourage a lot of farmers in many countries to employ the use of genetic modified food technology.

Growth rate has a positive relationship with the endogenous variable as well. It is significant at almost 7% from our regression results. Thus 1% increase in growth will lead to 0.0369 increase in GML crops. We know that large growth rate indicates a healthy economy and that producers in such healthy economy always try to improve on their technology production in order to have a better competitive skill and maybe try to be the monopoly of the product e can therefore conclude that a large economic growth rate will lead to a rapid spread of genetically modified food technology.

Furthermore we noticed government size was significant at 10%.I t has a positive relationship with the endogenous variable as well. Also a 1% change in government size will lead to 0.326 units increase in GML. In most economies it's the government which helps in the promotion of new technology often. This can be seen in USA and India where it's their government who encourages the use or trial of new technologies. Therefore a country with big government size will employ the use of technology faster. Thus the fast spread of genetic modified food technology can be conducive for countries which have large government size.

A gain inflation is significant at 5%.Though inflation is suppose to have a negative impact of diffusion of technology because by its nature, inflation is an economic uncertainty. In any economy, the higher is the uncertainty; the lower is the investment consequently the lower is the diffusion of technology. Thus a1% change in inflation will lead to 0.08841 units increase in GML.

In our results inflation turns out to have a positive effect and this is against our initial expectations. An alternative explanation can be that, for the given countries if the inflation number is not very high then the inflation may act as a price adjustment mechanism and thus restoring the equilibrium in real market. If so, small amount of inflation may act as working of market systems. And thus it may enhance the investment and technology diffusion.

Openness to trade thus has the expected positive sign in technology diffusion of genetic modified food but it is only significant at 13%significant level. As such there is no strong evidence for trade openness playing a role in diffusion of technology. The reason for this might be that, most of these countries in this panel data are either medium or large countries. Thus a 1% increase or change in openness will lead to a 0.013523 units increase in GML.

GDP per capita was insignificant in our regression analysis thus accepting the null hypothesis. This is explaining that GDP per capita was insignificant in explaining the rapid diffusion of genetic modified food technology across countries. A 1% change in GDP per capita will lead to a1.21E-06 units decrease in GML crops. This could be because the health of the economy is already captured by the growth rate.

The trend in our regression has a positive sign and it is significant at 1%.This shows that there is a probability that the information of genetic modified food technology will spread as time passes. The trend here is the time factor which tries to explain that the diffusion of the technology is happening on its own as time passes. Therefore with time there will b awareness of the information on genetic modified food technology and also more people will get inform about this technology especially those in the agricultural sector.

Our coefficient of determination or R-Squared is 0.944 or 94.4% shows a positive relationship between the dependent variable and the independent variables. It also shows that the model accounted for as much as 94.4% of the variability of the data and this is better explained by the Adjusted R-Square. Moreover the total variation change in the dependent variable resulted in the amount of o.944 in the independent variables.94.4% change in the dependent variable can be explained by the change in the in the explanatory variables. This means that credit. Growth rate, openness to trade, GDP per capita, government size, explain 94.4 variations in the spread of technology for genetic modified food.

USA; GML has a significant and positive effect on LNGML ($\beta=2.72$, $P<0.05$), similar Argentina ($\beta=3.11$, $p<0.01$). Also, India experienced a remarkable positive and significant effect on LNGML from GML ($\beta=2.18$, $p<0.01$). It implies that a rise in GML promoted an increase of LNGML, in the year 2012, since 2004.

However, the case with Australia was not so similar, though the effect of GML was significant, yet it impaired negatively on LNGML ($\beta= -2.58$, $p<0.01$), same with South Africa ($\beta= -2.91$, $p<0.01$). This is an indication of the decrease in LNGML as GML rises, in these countries from the year 2004 to 2012.

While in Canada, GML's effect on LNGML was insignificant and negative (β= -0.89, $p<0.05$).Meanwhile, the effect of GML on LNGML on Brazil was insignificant (β's 0.79, $p<0.05$) as β coefficient falls below the threshold. Apart from Brazil, China and the Philippines demonstrated insignificant effects of the independent variable on the dependent variable

Chapter 8

CONCLUSION

The implications of the empirical evidence obtained in this study are quite expected. Government size, credit availability, growth rate are very significant determinant for the fast spread of genetic modified food technology. Though inflation was significant we tried to explain its significance in favour of our study. Openness to trade though positive was insignificant in explaining the spread of genetic modified technology. Also GDP per capita was insignificant in explaining the spread of genetic modified technology.

This therefore means that a good government size, as seen before will help to promote the spread of genetic modified food technology. This is because a large government size will have most the facilities needed to invest on a research of a new technology in order to make her country be part of the competition going on in the world.

Also credit availability is very important factor in determining the spread of GM technology because if the country has a good credit system many farmers, producers and investors will easily employ the use of GM technology.

Again growth rate is significant in explaining the spread of diffusion of GM technology country with a good rate of growth will always do lots of investments which will help to benefit the economy of her country in order to remain in competition with the other countries or why not a monopoly.

Openness though positive came out insignificant. Again though we expected inflation to be insignificant but came out significant was not really a problem because for the given countries the inflation number is not very high thus inflation may act as a price adjustment mechanisms and thus restoring the equilibrium in real market. Finally for the GDP per capita, its was also insignificant this could be as a result to the fact that the health of the economy is already captured in the growth rate of the country and growth rate will help to develop the financial system of a country, increase competition and increases awareness in the evolution of new technologies in the world. Therefore the objective of this study was to understand why genetic modified food technology spread faster in some countries than others. The data used covered a sample period of 12 years and 9 countries.

From our literature review we discovered other factors which could hinder the spread of technologies. This study also tried to show that macroeconomic factors could as well promote or hinder the spread of genetic modified technology.

8.1 Recommendations

More rigorous panel data techniques can be applied on the same topic for further studies in order to get more accurate results. Other independent variables such as education .R&D, Real exchange rate, consumer consumption on genetic modified food can be used together with our own in dependable variables to determine better results.

Furthermore we can remove GDP per capita as our independent variable supposing that the health of the economy is already captured by the growth rate variable which has a positive sign and is also significant. Another regression (see in the appendix) was further carried using General Least Square method and excluding GDP per growth GDP per capita was positive compared to our former regression It was very significant as well.

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APPENDIX

Dependent Variable: LNGML

Method: Panel Least Squares

Date: 06/19/14 Time: 08:32

Sample: 2004 2012

Periods included: 9

Cross-sections included: 11

Total panel (balanced) observations: 99

Variable	Coefficient	Std. Error	t-Statistic	Prob.
USA	2.729639	1.179145	2.314932	0.0231
ARGENTINA	3.113788	0.310589	10.02542	0.0000
AUSTRALIA	-2.589900	0.847480	-3.056002	0.0030
BRAZIL	0.791650	0.712732	1.110726	0.2699
CANADA	-0.897137	0.893252	-1.004350	0.3182
CHINA	0.570987	0.569533	1.002553	0.3190
INDIA	2.187633	0.319566	6.845640	0.0000
PARAGUAY	1.770374	0.545229	3.247030	0.0017
PHILLIPPINES	0.055840	0.403105	0.138524	0.8902
SAFRICA	-2.916610	0.847344	-3.442062	0.0009
CREDIT	0.009235	0.004725	1.954511	0.0540
GDPPC	-1.21E-06	1.39E-05	-0.087210	0.9307
GOVTSIZE	0.326778	0.038009	8.597371	0.0000
GROWTH	0.036967	0.020058	1.842986	0.0689
INFLATION	0.088410	0.029326	3.014785	0.0034

OPENNESS	**0.013523**	**0.008822**	**1.532822**	**0.1292**
TREND	**0.082635**	**0.032926**	**2.509738**	**0.0140**

R-squared	**0.944013**	**Mean dependent**	**8.103651**
Adjusted R-squared	**0.933089**	**S.D. dependent**	**1.742260**
S.E. of regression	**0.450675**	**Akaike info criterion**	**1.398891**
Sum squared resid	**16.65482**	**Schwarz criterion**	**1.844518**
Log likelihood	**-52.24512**	**Hannan-Qcriter.**	**1.579193**
Durbin-Watson	**0.728426**		

Table 4: Regression Results without GDP Growth rate using general least square methods

Variable	Coefficient	Std Error	t-Statistic	Prob.
CREDIT	0.0194	0.008307	2.3	0.021
GDPPC	0.382274	0.0477954	8.02	0.000
GOVTSIZE	0.513138	0.1217862	4.21	0.000
INFLATION	0.016639	0.0061637	2.7	0.007
OPENESS	-0.13651	0.0494568	-2.76	0.007
TREND	0.1343850	0.006624	20.29	0.000

Without Growth rate, the regression results tend to be similar to that of the original model with the exemption of GDPPC variable. In this model, it turns out to be positively significant at 1% whereas in the original model it was insignificant.