Territorial effects of foreign direct investment in developing countries: the case of Ghana

September 27, 2023

Politecnico di Torino

Master's Thesis

Graduation Session: October 2023

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1 Acknowledgment

First of all I want to thank my supervisor Anna D'Ambrosio for the opportunity, for the help and for the advice given to me during these months.
The work done was really interesting and the opportunity to learn how to use new software made everything even more stimulating. So accept my thanks.

I want to thank all the people I have met and who have been close to me over the years.

Special thanks to my parents and sister for the support given to me, without them I would not have come this far.

And also a special memory to Filippo who has always been interested in my path. From up there you gave me the encouragement I needed to overcome my trials and never give up, for this I thank you.

2 Abstract

The concept of climate change has become increasingly important in recent years. The most developed countries with the improvement of economic conditions and the opening of new production plants have been more exposed to the increase in greenhouse gas emissions into the atmosphere.

In recent decades, national and international attention to climate issues has grown. As a result of greater involvement, agreements have been created between states or rules at national level on maximum permitted emission levels to try to reverse the trend and reduce pollutants in the atmosphere.

One of the consequences for companies subject to greater environmental restrictions in developed countries has been the relocation of production sites to developing countries where very often regulation is less stringent.
This has led to an increase in foreign direct investment, foreign investment in developing countries.
From these movements the pollution haven hypothesis was born.

This assumption implies the creation of pollution havens in developing countries. The largest amount of emissions is due to foreign companies present in the country. We will discuss this hypothesis in more detail both at a general level and more specifically for Ghana in the following sections of this work.

The objective of this thesis is to find the link between Foreign Direct Investments and the pollution externalities.
The focus is to study the number of foreign firms in Ghana, understand the evolution in the number of companies in the country and see whether the CO2 and CO emissions are affected by this evolution.
To comprehend if the two are co-related or not a regression analysis was performed.

The first period of the thesis was utilized to learn the software ARCGIS Pro. To do this I used different sources, mostly coursera and Youtube.
The initial step was to geolocalize and graphically represents the foreign firms that I had as a table on Excel on this software.

Later to plot the CO2 and CO emission data on it, NASA earth science data website was utilized to gather the emissions data.
The Goddard Earth Sciences Data and Information Services Center (GES-DISC) created Giovanni, a Web-based tool that offers a straightforward and user-friendly approach to explore, analyze, and retrieve enormous volumes of Earth science remote sensing data.
I downloaded the information on CO and CO2 in GEOTiff, a special format file that contains also geographical information.
The goal of the work on ArcGis was to build attribute tables, tables that for each point taken as a sample on the territory would store the coordinates of the point, the number of companies and the level of emission at that particular point.
A detailed description of the work done on ArcGIS and the steps required to get to the attribute tables will be done later in the work.

For the final phase of the thesis I used different sources to learn how to use the STATA IC software to perform regression analyses to detect any correlations between the variables of our interest.
Also for this phase a detailed explanation of the results obtained will be given in the following sections.

3 Introduction

The role of environmental policies in the last years increase a lot especially in developed countries. Environmental policies implemented in developed countries have an important impact on the operations of firms within their jurisdiction. The primary objectives of these policies are to:

- address environmental pollution;
- promote sustainability;
- tackle climate change.

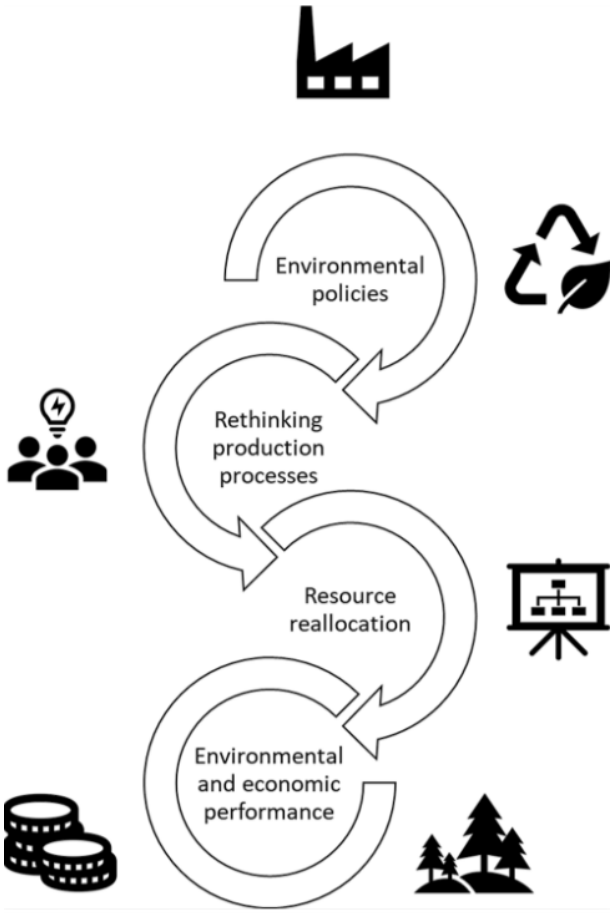


Figure 1: Process followed by firms with new policies [2]

When a new Environmental Policy comes into effect, companies can be highly affected.
A first aspect that can be affected by environmental policies is the competitiveness between companies. For the environmental policies this can happen when between different firms or between different sectors, that are competing in the same market, there is a difference in the level of regulatory stringency applied.
For example, some firms may be subject to regulations while others are exempt, certain sectors may face stricter pollution standards than others, or there may be variations in environmental stringency across jurisdictions.
A further example can be found in the climate change mitigation policies where the regions under the United Nations Framework Convention on Climate Change Paris agreement implement carbon reduction actions at different speeds.
This leads to differences between firms and the possibility that competitiveness effects arise. When two competing firms face identical regulations, competitiveness effects are not a concern. Environmental

policies may result in changes in the prices of final products. These changes derive from the effects of these policies on the cost of producing industrial product.
These regulations often require polluting facilities to engage in abatement activities, incurring costs for businesses. This changes in production costs can be direct or indirect. An example of direct cost is the European Union Emissions Trading System (EU ETS) that regulates carbon emissions for thousands of installations in Europe [1].
This institution has increased in the last years the cost of materials for some specific industries such as cement, iron, steel and for these industries it is a direct cost that increases.
This changes in production costs are known as the first-order effect for firms. Firms may respond through decisions regarding pricing, output, or investment, which represent second-order effects.
For instance, firms can choose to absorb the increased production costs or to pass them to the consumers. These firm responses, in turn, influence outcomes across various economic, technological, international, and environmental dimensions, which are considered third-order effects.
Instead, as far as investments are concerned, these can vary according to two effects: downsizing and modernization.
As for the former, when the cost of inputs increases, the output of the firm decreases (downsizing effect) and this can lead to a decrease in investments. Instead, for the latter, when the cost of inputs increases, the firm can decide to switch to new processes and new machinery, more energy-efficient. This modernization effect can raise overall investments [1].

What we want to study in depth in this work are foreign direct investments and the effects of these investments on the emissions of one country in particular: Ghana.
Foreign direct investments vary a lot according to the environmental policies in force in the various countries.
The most studied hypothesis involving foreign direct investments is the Pollution Haven hypothesis.
This hypothesis argues that countries with higher pollution regulations tend to move their industrial production to countries where regulations are less stringent.
This phenomenon is particularly relevant for pollution-intensive industries and can lead to carbon leakage, where emissions avoided through domestic environmental regulations are simply shifted to other locations [2].

4 Foreign Direct Investments

Over the past two decades, there has been a significant shift in economic policies, particularly in developing and emerging market economies. These countries have transitioned from closed, state-led growth strategies to more open, market-oriented approaches.
These changes have allowed the dismantling of trade barriers and a notable increase in private investment flows.
The amount of Foreign Direct Investment (FDI) has attended substantial growth.
Changes in foreign direct investments have been possible thanks to the change of course of the governments of emerging and developing countries. These governments have allowed a greater circulation of money to their own country and to foreign countries by reducing regulations in this regard. This trend, coupled with extensive privatization efforts and the deepening globalization of production, has resulted in an increase in private investment flows since 1990 [4].

4.1 What is a Foreign Direct Investment

Foreign direct investment (FDI) refers to the acquisition of a significant ownership stake in a foreign company or project by an investor, company, or government from another country.
Foreign Direct Investments are often associated with strategic decisions. For example, a company may decide to buy a significant share of a foreign business or buy it totally in order to expand into new regions. FDI plays an important role in facilitating international economic integration as it establishes stable and long-term connections between economies.
what an FDI investor usually does is gain a controlling position within the company in which he invests in order to have control over the decisions and strategies to be followed or he can establish a joint ventures. In any case, the approach to these investments is hands on, the investor actively takes care of managing his investment.
As top recipients of FDI in recent years two countries have distinguished themselves and these are the United States and China. Conversely, developed economies, including the U.S. and other OECD countries, have been significant contributors to FDI beyond their own borders.

The most important aspects that a project must have to attract the attention of companies or governments are: the supply of qualified workers and the ability to grow over time with a good rate of return for the investors. FDI inflows as a percentage of gross domestic product (GDP) serve as an indicator of a nation's attractiveness as a long-term investment destination. For instance, as of 2020, FDI accounted for 1.7% of China's GDP compared to 1.0% for the United States [3].

Foreign direct investment can be carried out following different paths:

- establishment of a subsidiary;
- acquisition of controlling interest in an existing foreign company;
- mergers;
- joint ventures with foreign entities.

4.2 Types of Foreign Direct Investments

There can be three types of foreign direct investments which are vertical investments, horizontal investment or conglomerate investment.
Below is a detailed explanation of the three types[3]:

- Vertical FDI : The main purpose of vertical investments is to ensure the supply of inputs or simplify the production process by integrating vertically along the value chain. To do this a business can acquire a complementary business in another country that is part of its supply chain. An Italian manufacturer that invest in a foreign company that supplies the raw materials is an example of a vertical foreign direct investment;

- Horizontal FDI : in this type of investment the aim is to expand the international presence of the company and raise the market share in the foreign market. In the horizontal type of FDI the company establishes the same business and organization already established in the home country in the foreign country. An example could be a U.S.-based cellphone provider acquiring a chain of phone stores in China;

- Conglomerate FDI : This type of FDI involves always a company investing in a foreign business but this time the foreign company business is unrelated to its core business. The investing company typically lacks prior experience in the foreign company's area of expertise. Conglomerate FDI often are a joint venture between the two companies. The companies collaborate to enter in a new market or industry. The purpose is the differentiation of investments and also the possibility to enter in new markets with the support and expertise of the foreign partner.

The classification of the different types of investment makes us understand what are the strategic reasons behind the foreign investment.

4.3 Advantage and Disadvantage of Foreign Direct Investments

Obviously, FDI can have positive or negative effects both for the country making the investment and for the country receiving it.
The receipt of an investment is always welcomed by the country, especially if it is a developing country. The positive effects are the creation of new jobs and therefore an increase in the supply of labour for the benefit of local workforce [3].

On the other hand, large companies see in foreign direct investment the possibility of expanding into new regions and increasing their influence and power.
On the negative side it's important to note that FDI also comes with challenges, including the need for regulatory oversight from multiple governments, which can increases political risk.
Another negative effect concerns the environment. In recent years, with the increase in economic activities, there has been a significant acceleration in environmental degradation. Greenhouse gas emissions have increased, especially carbon dioxide, deforestation has increased and there has been a loss of biodiversity.

In the environmental degradation the FDI can play an important role. Therefore it is extremely important to understand the effects of these investments on the environment in order to understand what actions to be taken to mitigate this phenomenon. Balancing economic growth with environmental sustainability is essential for long-term global well-being.

4.4 Recent trends of Foreign Direct Investments

In all regions globally, there was a significant increase in foreign direct investment in 2021. The global flow is estimated at 1.6 trillion. 64.5% higher than in 2020. In 2020, little foreign direct investment was made due to the COVID-19 pandemic.

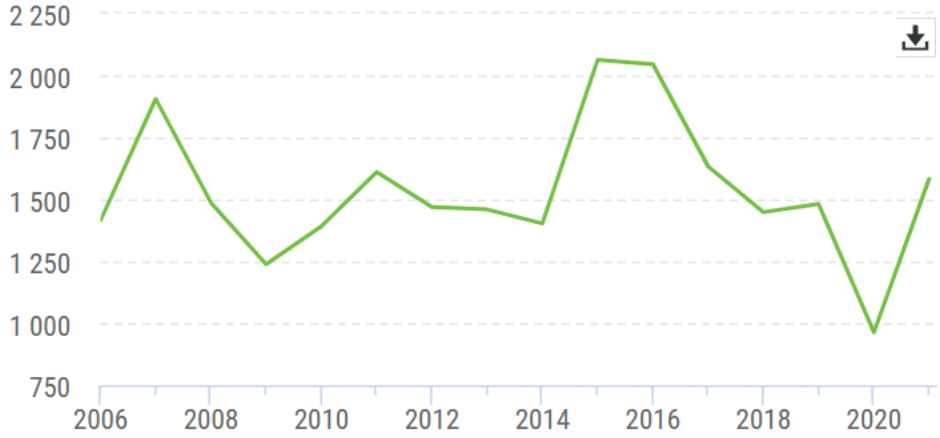


Figure 2: World foreign direct investments inflows [5]

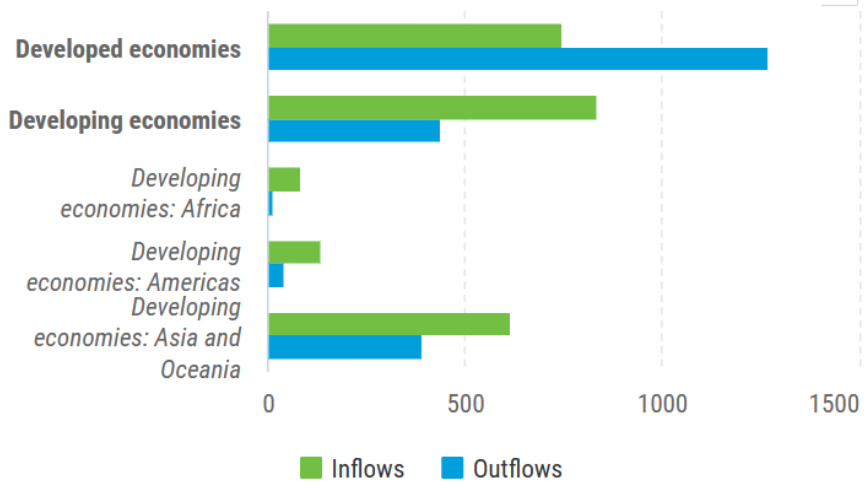


Figure 3: Foreign direct investments inflows and outflows - 2021 [5]

In 2021, in the developed economies there was a important increase in their investments abroad, more than tripling their investment with respect to the previous year. In 2021 investments were made for about 1.3 trillion while in 2020 the value stands at 408 billion.
In the same time also the value of foreign direct investment (FDI) outflows from developing economies rose by 17.8 percent, reaching US$438 billion.

As for the Outflow of the Investments, growth occurred in 2021 especially towards developed economies. Investments in Developing Economies grew by 29.9%, reaching US$837 billion. Notably, FDI flows to Africa reached a record level of US$83 billion in 2021, more than doubling the level seen in 2020, which was US$39 billion[5].

If in 2020 FDI inflows to developed economies constituted a third of the total, in 2021 the percentage has increased to about 50% of the total, a classic pre-pandemic level.
Developing Countries over the years have maintained their share of just over 50% of total inflows. FDI flows to Africa accounted for 5.2 percent of global FDI.

In terms of outward FDI flows, there was an important increase in the share covered by developed economies, their share raise from 52.3% to 74.3%.
Instead, the opposite effect occurred for Developing Countries. their share decreases from 47,7% to 25,7%.
Developed Europe emerged as the largest source of global FDI outflows, accounting for 32.3 percent, followed by developed economies in the Americas at 28.9 percent [6].

Group of economies	Inflows				Outflows			
	Value		Annual growth rate		Value		Annual growth rate	
	(Billions of US$)		(Percentage)		(Billions of US$)		(Percentage)	
	2020	2021	2020	2021	2020	2021	2020	2021
World[a]	963	1 582	-35.0	64.3	780	1 708	-30.6	118.8
Developed economies	319	746	-58.2	133.6	408	1 269	-44.6	210.9
Developing economies	644	837	-10.1	29.9	372	438	-3.8	17.8
Developing economies: Africa	39	83	-14.7	113.1	-1	3	-112.7	-526.2
Developing economies: Americas	86	134	-45.7	56.0	-5	42	-110.0	-995.6
Developing economies: Asia and Oceania	519	619	1.4	19.3	378	394	12.6	4.3

Figure 4: Foreign direct investments flows by group of economies [5]

5 Foreign Direct Investments and Emissions

There have been many studies over the years that have shown a positive correlation between foreign direct investment and greenhouse gas emissions. However one aspect to consider, especially in recent years, is that increased economic development and better regulation can contribute to a country's reduction in emissions.
Therefore, the negative effects of foreign direct investment occur mainly in developing countries, while for developed countries new investments such as new industrial processes, new technologies can contribute to the reduction of total emissions.

FDI effect on carbon emission has been a topic of study for several years mainly due to changes such as globalization and an increase in the ease of movement of capital to foreign countries.
FDI inflows, as an important international investment activity, play a determining role in economic and environmental development.
The studies about the role of FDI inflows on green house gasses emissions, especially carbon emission, have expanded over the past decade.
Different categories of studies have emerged and with the increase of the literature about FDI have also increased the points of view and perspectives on this topic.

The first hypothesis arising from the direct study of FDI on emissions was the pollution haven hypothesis.
this hypothesis holds that there is a direct link between FDI inflow and the increase in the level of emissions. The flow of investment is directed from developed to developing countries. This is because companies in developed countries have as their main purpose the increase in profits but are subject to greater environmental regulations and this involves the relocation of industrial production to less developed countries where regulation is not so strict.
This leads to increased carbon emissions in the host countries.

Another perspective on the effects of foreign direct investments stems from studies that always compare investments with emission levels but this time in more developed and highly regulated environments.
The studies confirm that higher levels of economic development and better regulatory quality provide a mitigating effect on the carbon emissions caused by FDI inflows.
These factors act as safeguards against excessive emissions trying to align the economic objectives of FDI and the objectives at the environmental level.

Another aspect that can contribute to the reduction of emissions is the transfer of technology and innovation to the host country. Foreign firms often bring advanced technologies and management practices that can contribute to more efficient and cleaner production processes.
These technologies and practices can be used by the host country's firms, leading to better environmental performance and reductions in carbon emissions. Additionally, FDI can stimulate domestic innovation and the development of clean technologies[7].

The conclusion provided by some recent studies examining the relationship between FDI inflows and carbon emissions across different income groups is that exist an inverted U-shaped association that links FDI and carbon emissions in middle-income countries.
The positive or negative effects of foreign direct investments depends on the level of income in the country. High income level country are associated with positive effects of FDI on the level of emissions instead low-income country have the opposite effect.

Overall, these studies try to understand the complex relationship between FDI inflows, carbon emissions, economic development, and regulatory quality. These studies help us to observe what the effects of FDI could be on the environment and what results could bring more regulation in support of sustainable investments.

In decision-making regarding the environment, a precautionary approach is necessary due to uncertainties and potential irreversible consequences. Without clear limits, even economically efficient resource use can lead to over exploitation and environmental pollution [7].

5.1 Pollution Haven Hypothesis

The Pollution Haven Hypothesis is an economic theory which supports that more stringent environmental regulations in developed countries may lead to the relocation of industries to developing countries in which there are less strict environmental standards.
According to this hypothesis, industries move their operations to countries with weaker regulations, thereby creating pollution havens.

The assumption on which the pollution haven hypothesis is based is that an higher environmental regulation can increase the overall cost of production for companies. Some of these costs can be the installation of pollution control technologies or costs of compliance with emissions standards. Companies try to avoid these costs by moving production to other countries.

In the past, when firms were considering moving abroad, the main aspects to consider were production costs, market access, and taxation. Now one is added which is compliance with environmental regulations. Evidence suggests that in addition the host countries may purposely undervalue their environment in order to attract new investment with international investors that sometimes encouraging such behavior.

The current thinking of companies is to make more profit in the immediate future even at the cost of using natural resources inefficiently or increasing pollution.
To try to achieve sustainable processes for the environment, this trend must be stopped. But institutional responses will always lag behind economic pressures, especially in highly competitive global markets.
Economic pressure is most exerted by developed countries on developing countries. This means that developed countries are one of the reasons for more pollution [6].

Instead of doing this developed countries must try to :

- Reduce unsustainable consumption levels;
- Provide more resources for the environmental governance in less regulated countries;
- Make sure their companies work responsibly abroad.

Currently, no country effectively internalizes the environmental costs of economic activity. One of the reasons why no new rules are established for the amount of pollution is precisely due to competition for FDI.
Countries that need more foreign investment for their growth do not want to put in strict regulations so that investors are incentivized to move to those regions. Addressing this challenge requires more coordination among countries at various institutional levels to raise environmental standards.

In the absence of consumer, shareholder, and community pressure, research indicates that FDI does not necessarily adhere to higher environmental standards compared to domestic firms.

Economic growth driven by liberalization can exacerbate existing market and policy failures related to the environment. The current use of resources and the current levels of pollution are not sustainable for the environment and are not leading toward a more sustainable path. What is needed is to understand whether policies aimed at FDI should be a component of steering the world towards a more sustainable growth trajectory [4].

6 Ghana

Ghana is democratic country. After it gains the independence in 1957 from the British experienced a series of coups. This result in a military governments for about 20 years.

The real changes in the country begin in the 1992 with the establishment of the constitution. From that Ghana transitioned to a system of general elections, granting to all citizens the right to vote.

As for the geographical position, Ghana is located in the western part of Africa. The countries with which it borders are Nigeria, Burkina Faso, Cote d'Ivoire and Togo.

Thanks to a stable government and an efficient use of the resources present on the territory between 2006 and 2009 Ghana has undergone an important economic growth.
Historically, the country's economy heavily relied on the agricultural sector, particularly cocoa production, as a major revenue source for the government. But in recent years the situation has changed, now the service sector is the most important, contribute for approximately 59,4% to the gross domestic product.
The second most important is the industrial sector, about 25,3% and then there is the agricultural sector, 19,7% [9].

6.1 Investment Atmosphere in Ghana

Ghana's goal is to become an entry point to all of West Africa. This can be done because of the strategic position of the country. The government is also bringing measures to increase the attractiveness of the country for new investments. New investments mean new job opportunities.

In this regard, the government has included rules to ensure that local inhabitants can have access to these opportunities.

Companies can hire both domestic and foreign skilled and unskilled labor to be employed, although there are specific quotas for hiring local workers in certain fields. In cases where specialized expertise is required, the laws permit the recruitment of expatriates without restrictions.

To attract new investors and ensure that the total risk of new investments is at a minimum, the government has taken some actions. The country has joined various organizations that provide assurance to investors, such as its membership in the Multilateral Investment Guarantee Agency (MIGA), a unit under the World Bank that offers investment protection against non-commercial risks in developing economies.
Another action taken is the establishment of the Ghana Investment Promotion Centre. This institution seeks to regulate and stimulate investment.
They also offer benefits to investors that can be like customs import duty exemptions for specific commodities and machinery imported for investment activities, including industrial plants and agricultural products [9].

6.2 Foreign Direct Investments in Ghana

As explained in the previous sections there are different interpretations on the effects of foreign direct investments on the economy and environment of a country. Some studies claim that FDI have a positive effect and that are able to overcome challenges in rapid economic reform by privatizing state-owned assets to foreign investors. This positive influence can led to more efficient use of resources, technology transfer and more ease access to global market.

There are also other perspectives that argue that FDI effect is negative. The possible implications can be the promotion of low-wage manufacturing and a dependence of foreign economic actors. All this creates some doubts about the positive effects on the growth of lower-middle-income countries like Ghana.

All we can say is that if foreign investments contribute to the growth of a country and they allow for more domestic investments then they can be positive.

Following financial and political transformation developing countries have seen a notable increase in foreign direct investments. In addition, these countries have taken steps to attract as much investment as possible. Some countries relaxed restrictions on foreign investments, others implemented financial reforms and also they offered tax incentives and subsidies.

Also Ghana takes some actions in this direction. The first measures taken were the Ghana Investment Act in 1994 and in the following year the Free Zones Act which provide tax incentives and investor protection policies to create a conducive environment for foreign investors[8]. These initiatives and policies have contributed to increased FDI and economic growth in Ghana. In addition, the Ghanaian government has introduced new laws to improve investment conditions and the business environment.

All this actions helped Ghana to be recognized as one of the top ten reformers globally for two consecutive years by the World Bank's Doing Business team.

Ghana's share of FDI quadrupled from 2005 to reach $636 million in 2006. Furthermore, in 2008, Ghana garnered increased global attention by hosting the Africa Cup, the UNCTAD XII (United Nations Conference on Trade and Development), and WAIPA (World Association of Investment Promotion Agencies) meetings. These events coincided with strong GDP growth and significant increases in FDI inflows to Ghana[8].

6.2.1 Determinants of Foreign Direct Investments

Over an extended period, foreign direct investment (FDI) generates various external benefits that extend beyond individual companies' income. One benefits as said in the previous section is the possible technology transfer, using these technology can improve production and distribution.
Industrial upgrading, work experience for the labor force, and the introduction of modern management and accounting methods are others possible impacts of FDI.

For example in the services sector FDI exploit a host country's competitiveness by increasing capital productivity and attracting new capital at favorable terms.

In some circumstances there may be a strong relationship between foreign investment and the country's growth. Studies show that one of these circumstances is the presence of a certain level of human capital in the host country.
Economic growth is mainly supported by the transfer of new technologies rather than capital increase.

There are some features in the host country that can increase FDI and others that reduce the investments.

Positive features can be:

- Natural resource endowments;
- Large markets;
- Good infrastructure;
- Efficient legal framework.

Between the negative features there can be:

- Macroeconomic instability;
- Corruption;
- Political instability;
- Investment restrictions.

In developing countries like Ghana, FDI play a crucial role in the economic growth and development. Compared to other forms of capital flows, FDI is considered more stable and has a substantial impact on growth. By facilitating access to foreign markets FDI promotes the integration of the host country into the global economy [8].

6.2.2 Trends of Foreign Direct Investments

The government's efforts to create a business-friendly environment have been effective.
looking at the data of the last 25 years in Ghana there has been a substantial increase in foreign investment.
The first FDI reach a very high amount is in 2011 with an estimated 3,2 billion dollars. In the following year, 2012, investments reached their highest level since 1990.
Before the establishment of the constitution and mainly in the year between 1990 and 1992 the volumes and values of FDI were very low[9].
The reason for this was the internal instability of the military government. FDI rises from $22.5 million in 1992 to $125million in 1993 after the formulation of the 1992 constitution representing 555.5% rate of change. After that there was some instability in the inflow of FDI between 1993 and 1997 but the overall investments at the end of the period increased.

Further help in the growth of investments came in 2013 with the entry into force of the GIPC Act.
this act shaped the Ghana Investment Promotion Centre to energize and advance FDI in the country.

The FDI inflow into the country has grown yearly at an estimated rate of 42%. The total investments in 2006 were 636 million dollars, at the end of 2010 the total value was 2527,4 billion dollars.
But the largest expansion in investments took place between 2010 and 2013, from 2527,4 to 6821 million dollars[9].

Ghana is currently considered one of the African countries that has received the most foreign direct investment in recent years. Also the outflow of investments in the west African region has increased over the past years and Ghana is one of the largest contributors.

In the next figure there are the level of FDI inflows in the country between 2006 and 2016.

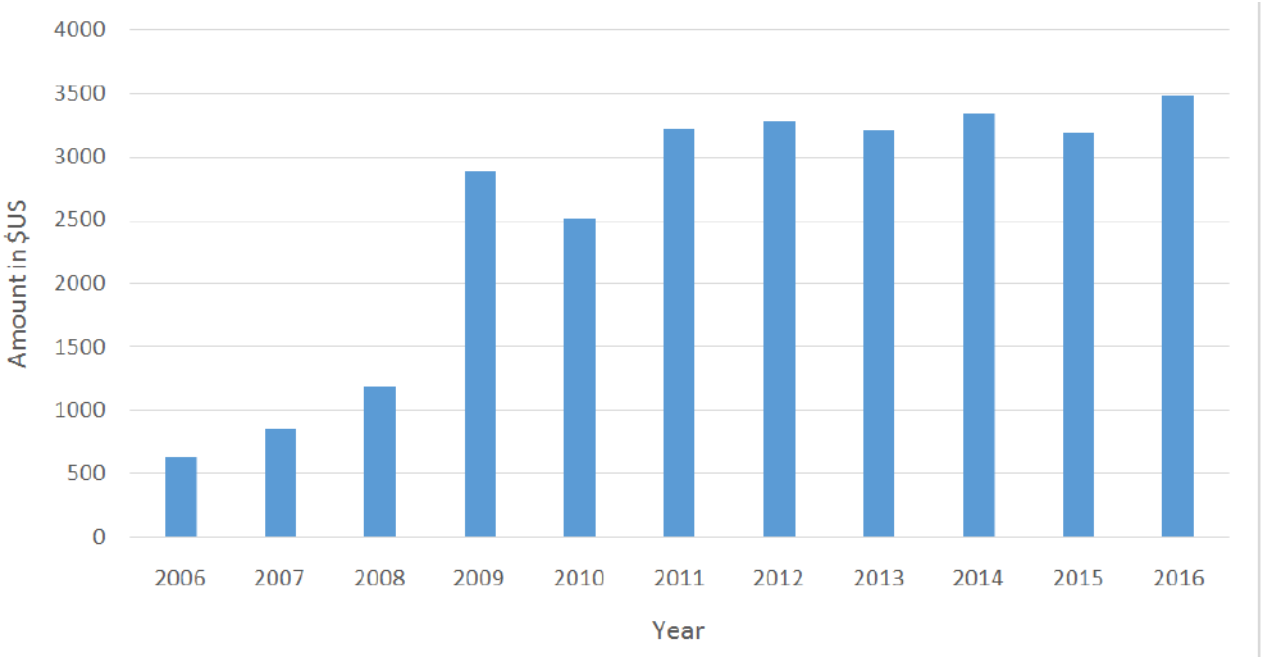


Figure 5: FDI inflow in Ghana from 2006 to 2016 [9]

We can see from the figure below the relationship between FDI and GDP in Ghana. After the low inflows in the 1980's, FDI inflow increased dramatically in the early 1990's and declined after 1994. Between 1997 and 2000 there was a growth but then the ratio declined again at a value lower than 2% From 2006 onwards saw a significance increase in the FDI inflows to Ghana to date.

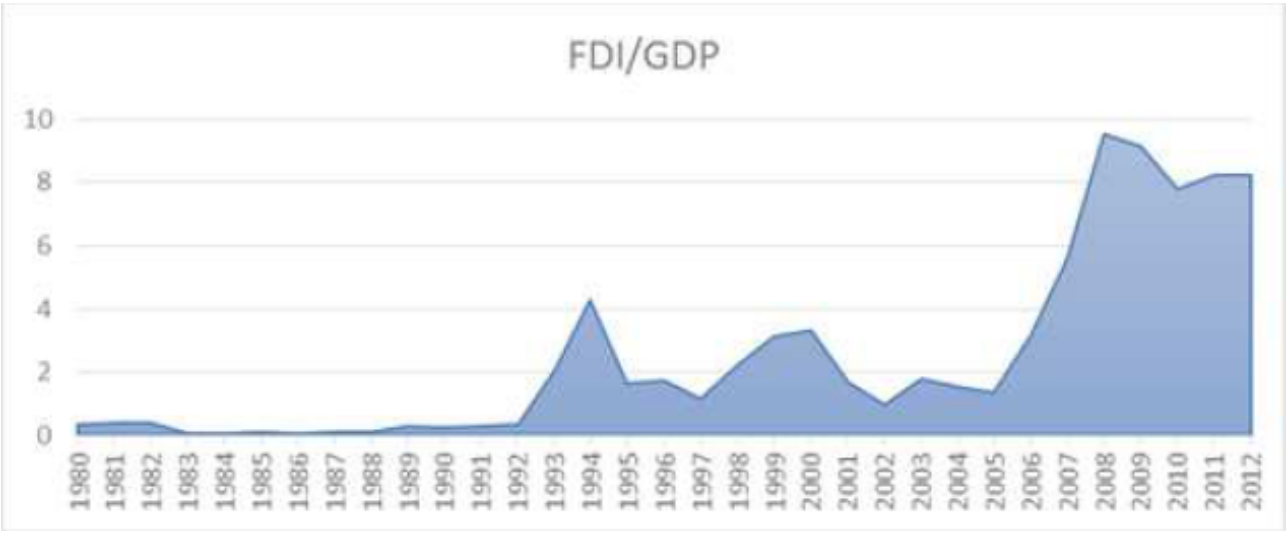


Figure 6: Trend of FDI to GDP ratio [8]

6.2.3 Regional distribution of Foreign Direct Investments

The geographical landmark of Ghana is made up of ten (10) regions. The distribution of investments among these regions is not homogeneous. The distribution of registered projects are usually based on economic zones and the market size of various regions.

The table below shows the number of projects registered in the country in the years between 1994 and 2013.

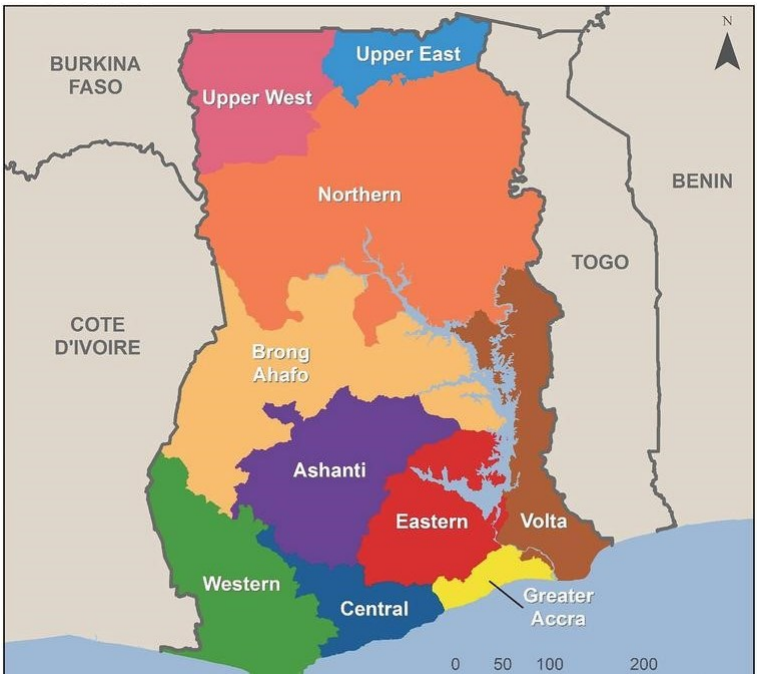


Figure 7: Regions of Ghana

Region	No. of Projects	Total Estimated Cost (US$M)
Ashanti	271	3,195.62
Brong Ahafo	40	354.21
Central	108	420.11
Eastern	105	241.45
Greater Accra	3879	16,890.77
Northern	43	357.33
Upper East	8	3.79
Upper West	4	1.97
Volta	56	98.17
Western	200	7,503.65
Total	4,714	29,067.07

Figure 8: Distribution of projects between 1994 and 2013 [9]

As we can seen the Greater Accra Region received the highest number of registered projects. After that Ashanti and Western are the most sought regions while in the northern regions there are very few projects. The Upper West region received the least value and number of registered projects.
This distribution is mainly due to the strategic position of the southern regions bordering the Atlantic Ocean.

The figure below indicates the percentage of the total estimated value of registered projects from 1994 to 2013. The last figure above clearly shows that also with regard to the value of the projects

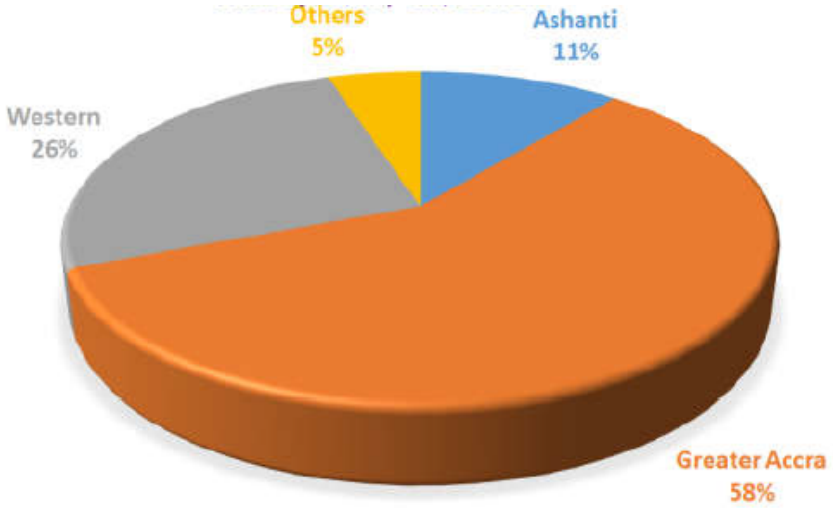


Figure 9: Regional distributed projects from 1994 to 2013 [9]

Greater Accra region wins over the other regions. Greater Accra region accounted for more than half of the total value of all projects.
The top three regions accounted for 95% of the total estimated cost of the registered projects.

In the table below are reported data on the number of projects and cost of projects divided by sector referring to more recent years.

GIPC annual registered companies in terms of number of projects:

SECTOR	2014	2015	2016	2017	2018	2019	2020	2021
Agriculture	7	3	4	1	6	2	1	3
Building & Const.	8	19	18	14	15	3	5	11
Export Trade	12	6	2	5	6	7	15	12
General Trade	29	21	22	32	32	27	11	36
Liaison	28	22	24	34	17	4	1	1
Manufacturing	57	41	39	52	50	59	42	50
Mining	0	0	0	0	0	1	3	0
Service	39	55	68	54	42	44	51	80
Oil & Gas	0	0	0	0	0	0	0	1
Tourism	4	3	2	0	0	0	0	0
Total	184	170	179	192	168	147	129	194

Figure 10: Number of project per sector from 2014 to 2021

GIPC annual registered companies in terms of FDI (US$M)

SECTOR	2014	2015	2016	2017	2018	2019	2020	2021
Agriculture	22,75	12,52	6,47	6,91	8,58	1,31	1	17,42
Building & Const.	11,96	306,69	207,47	51,51	1.115,58	100,32	43,65	55,46
Export Trade	14,29	22,51	1	2,7	2,23	5,02	16,82	67,72
General Trade	96,82	110,62	48,65	55,73	129,4	78,87	250,42	69,51
Liaison	257,87	9,33	32,26	523,14	153,54	3,46	0,5	1,34
Manufacturing	1.377,08	153,83	326,97	2.702,81	625,03	103,28	1.191,73	131,41
Mining	0	0	0	0	0	175,25	424,32	0
Service	1.604,32	1.112,87	1.616,79	271,48	1.291,89	619,02	240,4	616,7
Oil & Gas	0	0	0	0	0	0	0	21,5
Tourism	2,06	600,92	0,9	0	0	0	0	0
Total	3387,15	2329,29	2240,51	3.614,28	3.326,25	1.086,53	2.168,84	981,08

Figure 11: Amount invested per sector from 2014 to 2021

From the last table in the previous page we can see how the sectors: manufacturing, general trade, export trade and services are the most relevant in recent years with a greater number of projects, instead the tourism and Oil and Gas sectors record the lowest number of projects by foreign companies.

We can see by looking at both tables that there is a positive correlation between the number of projects and the dollar investment spending.
As for the amount of foreign direct investments, therefore, we find greater values in the services and manufacturing sectors while in tourism and in the oil and gas sectors there are the lowest values.

Foreign Direct Investments should bring with it new job opportunities in the host country. The following table shows the data regarding the estimates of jobs created with investments in the period between 1994 and 2021. The table divides the possible new jobs for Ghanaians and foreigners.

Economic Sector	Total Estimated Employment	Ghanaian	Non-Ghanaian
Agriculture	231.287	228.852	2.435
Building and Construction	130.416	112.053	18.363
Export Trade	8.141	7.145	996
General Trade	38.191	33.328	4.863
Liaison	11.003	8.960	2.043
Manufacturing	128.407	118.971	9.436
Mining	2.159	2.144	15
Oil and Gas	2	1	1
Services	203.362	178.632	24.730
Tourism	15.491	13.795	1.696
Total	**768.459**	**703.881**	**64.578**

Figure 12: Expected number of jobs creation

We can see that the jobs created by foreign direct investment are mostly occupied by local citizens. Most of the new jobs created during the period are still in the service and manufacturing sectors, but also in agriculture and building and construction there are a lot of opportunities.

6.3 Last Available data on Foreign Direct Investments: 2021

In the year 2021, a total of 271 projects were created in Ghana. The total invested for these projects is about 1.49 billion dollars divided between foreign investments and local investments.

Foreign direct investments cover the largest percentage invested with a value of 1.3 billion dollars while the local component is about 192.66 million dollars. Compared to the values of foreign direct investments in previous years, the value of 2021 shows a decrease of 51% compared to the value of 2020 but an increase of 17.11% compared to 1.1 billion in 2019.

One of the effects that these investments will produce are a total of 15,775 jobs when operating at full capacity. Out of these jobs, 14,340 (90.90%) will be for Ghanaians, while the remaining 1,435 will be for non-Ghanaians[16].

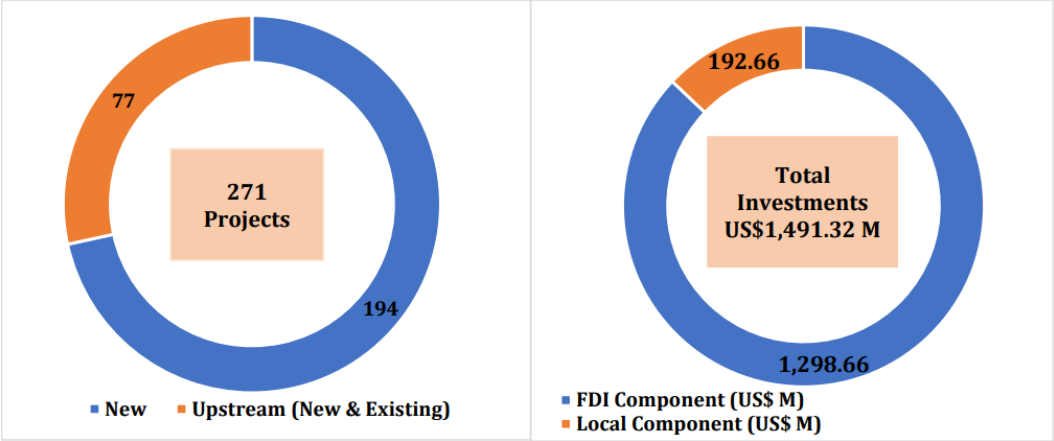


Figure 13: Number of FDI project and amount invested - 2021 [16]

6.3.1 Sectoral distribution

Among the 271 registered projects, 194 were newly registered projects, and 77 were upstream projects. In the figure below we can see the division of projects by sector. It is immediately noticeable that the service sector is the one where more projects are born and developed.

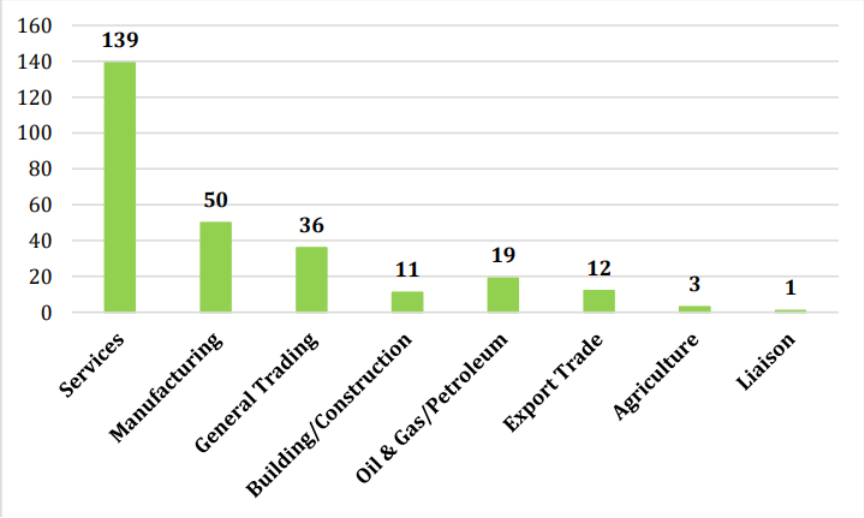


Figure 14: Number of project per sector [16]

Instead, in the following figure we can see the amount of dollar investments per sector. Also in this case the service sector prevails over the others with a value of 689.91 million dollars. After services there are oil and gas sector with US$265.87 million, and the manufacturing sector with US$131.41 million.

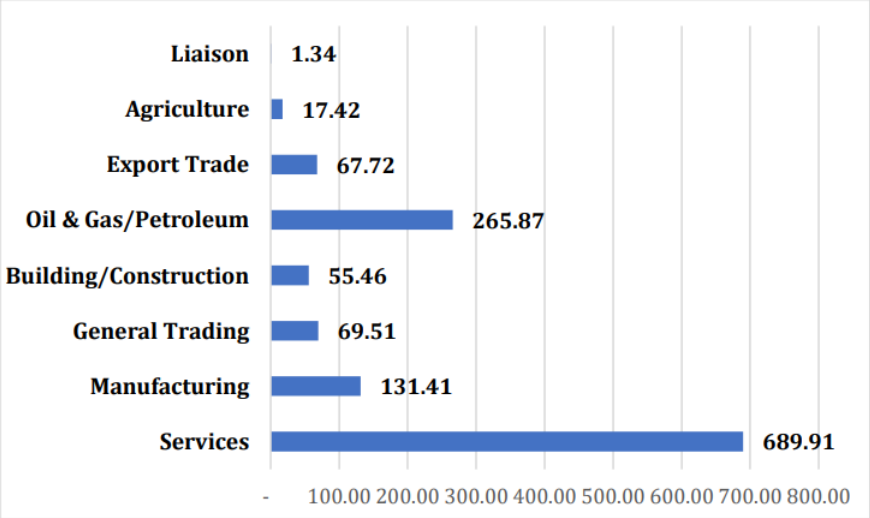


Figure 15: Amount invested per sector [16]

6.3.2 Regional distribution

The division of these projects in the various regions of Ghana is not homogeneous, as can be understood from the figure. The Greater Accra region is the one where the most projects are located, 214 corresponding to 78.97% of the total, in 2021. The Western and Ashanti regions followed, with 29 and 13 projects. The Eastern and Central regions had 6 and 5 projects, respectively, while the Bono, Northern, Upper East, and Upper West regions each had one project [16].

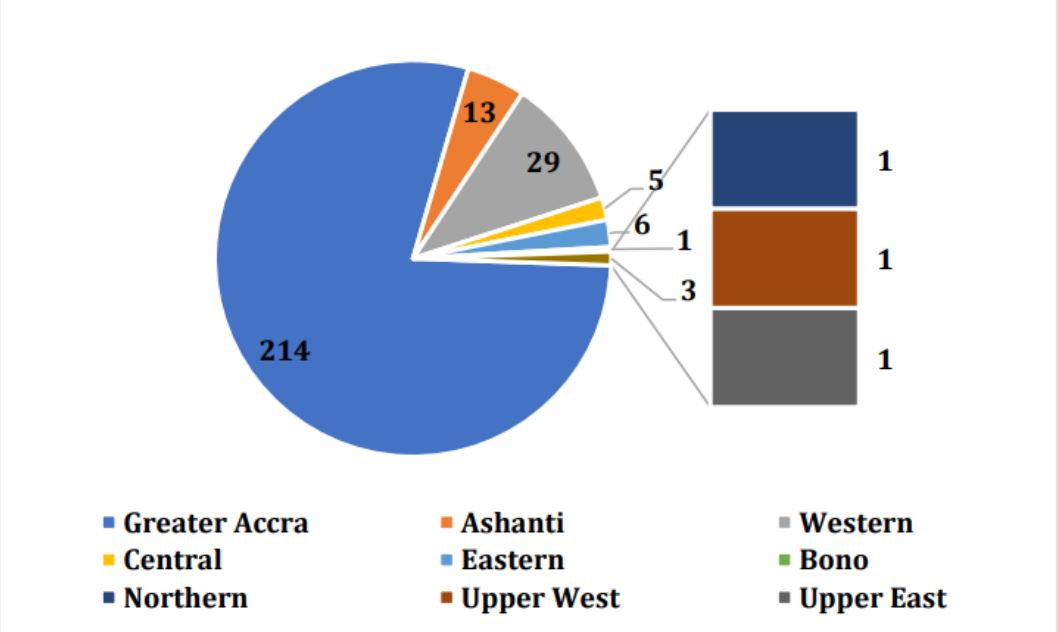


Figure 16: Regional distribution of projects [16]

6.4 Emissions in Ghana

Each country pursues its own economic growth. The positive effects of economic development are many but among the most important we can find:

- Increasing per-capita national incomes;
- Reducing poverty;
- Improving food security;
- Enhancing national nutrition quality.

However, economic growth can lead to negative consequences in the country such as destroying natural resources. Unfortunately, many economies have followed this path. They transformed renewable resources into non-renewable ones in their pursuit of economic growth. Phenomena such as industrialization, globalization and market integration have often led to negative externalities. By negative externalities we mean the negative effects that some decisions can bring to the whole society and some of these effects are: increased greenhouse gas emissions and production of non-degradable waste materials.

As far as Ghana is concerned, the most important sector in the years between 2010 and 2019 was agriculture. In the last decade agriculture has employed about 42% of the population contributing 20% to the country's GDP. The country's major export commodities are primarily based on natural resources including: cocoa, gold and from 2011 onwards also crude oil. The latter has contributed most to the country's economic growth[18].

Growth in greenhouse gas emissions has gone hand in hand with economic growth. Several reasons have contributed to this increase, we can list a few:

- Road transport;
- Thermal electricity generation;
- Biomass utilization;
- Deforestation;
- Population growth;
- Solid waste disposal.

Road transport represents over 95% of all transportation services in Ghana but most important vehicles on the road emit high amounts of exhaust emissions and this contributes highly to the increase in the level of CO2 in the air.

Carbon dioxide remains the dominant GHG in Ghana, accounting for about 66% of the total net emissions levels in 2016.

The figure shown on the following page shows the forecast of trends in greenhouse gas emissions in Ghana up to 2030. To obtain this graph some assumptions have been made:

- Average population growth rate of 2,4% per annum;
- Average GDP growth rate of 7%.

The country's emissions are expected to rise from 42.2 MtCO2e in 2016 to 48 MtCO2e in 2020, 59.1 MtCO2e in 2025, and further to 73.3 MtCO2e in 2030 if no deliberate actions are taken to curb these emissions [18].

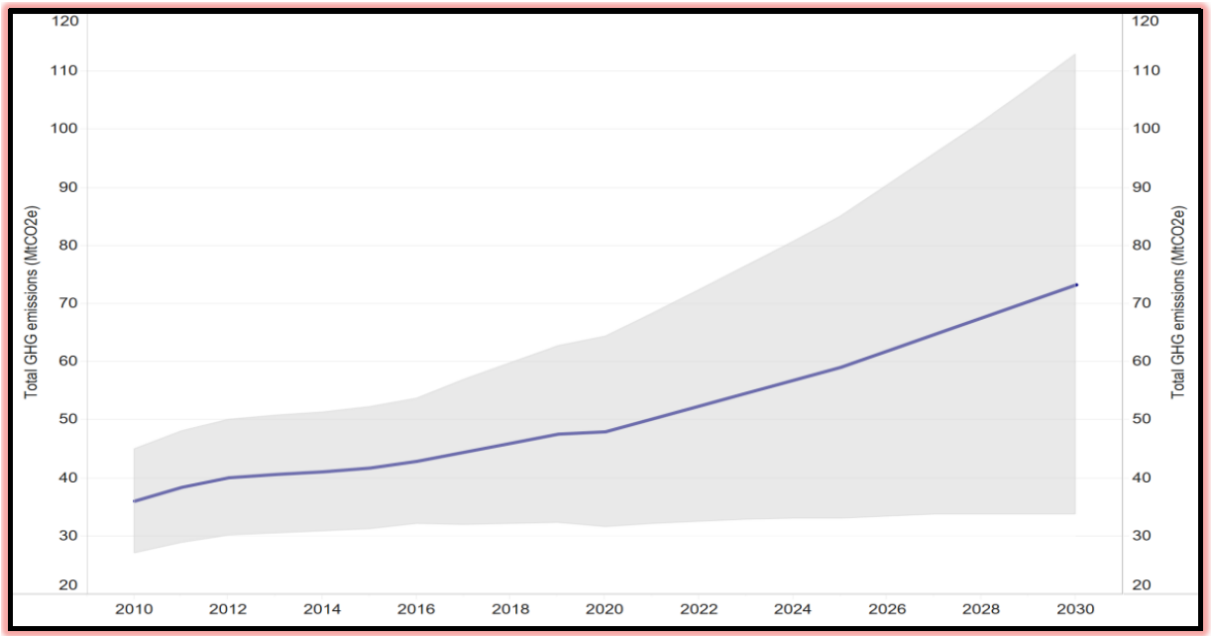


Figure 17: Expected trend of CO2 emissions in the next years [18]

In recent years, the negative effects of uncontrolled economic growth have been brought to the fore nationally and internationally. The objective is the promotion of policies for sustainable development that safeguards the environment and the natural resources. The fight against climate change ,which is caused in part by global warming and air pollution, has become a global challenge and CO2 emissions are widely recognized as a major contributor to these problems.

A study conducted in 2013 showed that CO2 emissions contribute considerably to the amount of greenhouse gases emitted globally. The report further emphasized that 76.7% of GHG emissions originate from CO2 emissions[10].

Developing countries such as Ghana play an important role in this scenario. In these countries they often observe significant increases in greenhouse gas emissions and this is mainly due to the fact that efforts to accelerate economic growth and increase income levels often prioritize economic considerations over environmental concerns.

At a time when climate change has been brought to the forefront internationally, both developed and developing countries have taken actions to try to reduce these effects by creating collaborations between nations and international agreements that seek to regulate emission levels. Two of the most important international agreements are the Kyoto Protocol, adopted in 1997 under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement (2015), which aim to reduce GHG concentrations in the atmosphere and mitigate the pace of climate change.

Ghana is one of the countries that have signed these international climate treaties and is therefore a country's goal to reduce greenhouse gas emissions. To demonstrate commitment to this cause in 2012 the Environmental Protection Agency (EPA), on behalf of the government, developed a national climate change policy with the aim of reducing climate change through sustainable investments across all sectors of the economy.

Despite efforts to try to reduce emissions of polluting gases, emissions have increased. from 2000 to 2010 CO2 emissions increased from 12.2 to 23.9Mt. The main reason is that in Ghana, petroleum and other fossil fuels are the primary sources of energy in the transport industry and electric power generation[10].

In the following two figures it is possible to observe the various sources of energy used in Ghana in the different years. The thing that can be seen from both figures is how over the years the consumption of fossil fuels has increased considerably. From figure 1 we can observe that fossil fuel consumption, which accounted for 22% of total energy consumption in 1971, significantly rose to 52% in 2014 and from figure 2 we understand that fossil fuels is the source of energy that increased most. The conclusion is that fossil fuel consumption has taken the lead in Ghana's energy mix, while the consumption of alternative and nuclear energy as well as combustible renewables and waste has declined. In the last

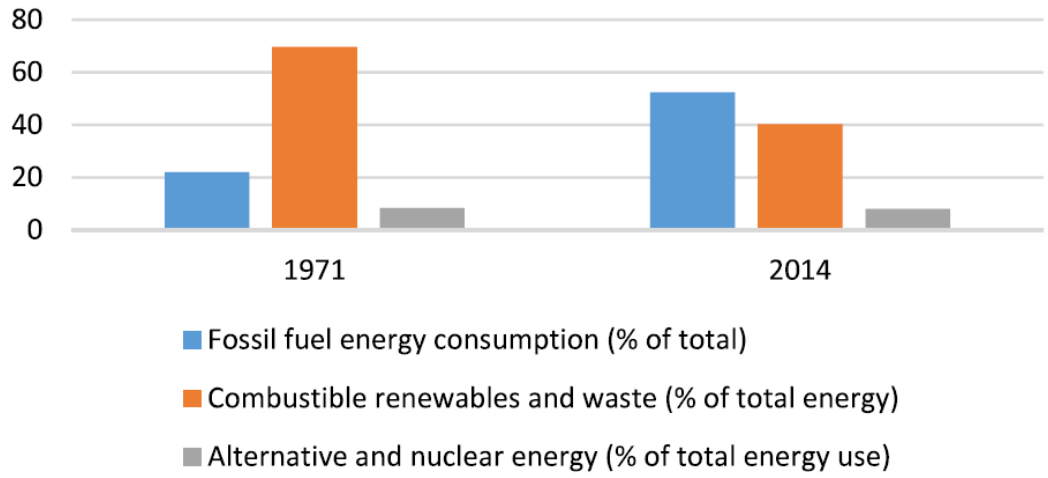


Figure 18: Energy sources in Ghana [10]

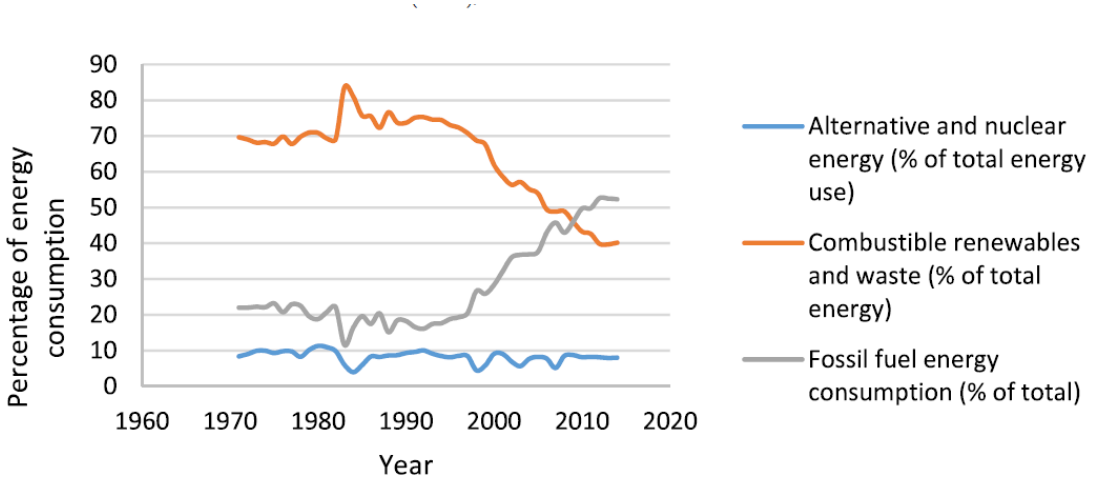


Figure 19: Trends in the use of energy sources [10]

three decades in Ghana economic growth has been one of the best among the states of Sub-Saharan Africa, this growth is mainly due to the growth of the industrial sector that in 2017 contributed to 23.68% of the country's GDP.

The growth of the industrial sector means an increased need for energy to power machinery. this energy in Ghana is derived from a greater use of fossil fuels. It is precisely this increase that has been and still is the main reason for the increase in emissions, especially CO2 emissions, in the country. Emissions increased from 3,817.35 kt in 1990 to 14,466.32 kt in 2014[10].

Grossman and Krueger in a study conducted in 1995 proposed the Environmental Kuznets Curve (EKC) hypothesis. This hypothesis tries to explain the relationship between income growth and environmental degradation with an inverted U-shape curve. The theory suggests that in the beginning phase of economic growth of a country the benefits of increasing output outweigh the increased demands for environmental quality resulting from rising income. This could include practices such as deforestation, pollution, and inefficient resource use. However, when a certain level of income and economic growth is reached the trend reverse. In other words, environmental quality starts to improve despite ongoing economic growth.

This seems to happen in most developing countries, such as Ghana. In these countries, economic growth is often put at the forefront, and to improve the competitiveness of local companies, governments are reluctant to impose restrictions on emissions or environmental quality. This leads to higher levels of emissions and degradation of the environment.

The two concepts of the Environmental Kuznets Curve and the Pollution Haven Hypothesis sustain the assertion that increased output, driven by the needs of a growing population and the high consumption of fossil fuels, lead to higher emissions of greenhouse gases, especially CO2, and general environmental degradation in developing countries like Ghana, where environmental regulations may not be rigorously enforced [10].

The figure below shows the CO2 emissions data from 2000 to 2016. You can always see in the table the percentage changes in emission levels in the various years and the level of emissions per capita. There are also data regarding the population of Ghana. Analyzing this column we can see an increase in population in each year of the period considered

Year	Fossil CO2 Emissions (tons)	CO2 emisions change	CO2 emissions per capita	Population	Pop. change	Share of World's CO2 emissions
2016	**14,469,986**	**3.54%**	**0.51**	**28,481,945**	2.27 %	**0.04%**
2015	**13,974,820**	**2.08%**	**0.50**	**27,849,205**	2.29 %	**0.04%**
2014	**13,689,986**	**-3.37%**	**0.50**	**27,224,473**	2.32 %	**0.04%**
2013	**14,167,117**	**6.97%**	**0.53**	**26,607,645**	2.35 %	**0.04%**
2012	**13,244,093**	**6.40%**	**0.51**	**25,996,450**	2.40 %	**0.04%**
2011	**12,447,255**	**10.17%**	**0.49**	**25,387,712**	2.45 %	**0.03%**
2010	**11,298,231**	**15.30%**	**0.46**	**24,779,619**	2.52 %	**0.03%**
2009	**9,798,895**	**21.31%**	**0.41**	**24,170,940**	2.58 %	**0.03%**
2008	**8,077,878**	**-9.77%**	**0.34**	**23,563,825**	2.61 %	**0.02%**
2007	**8,952,822**	**4.02%**	**0.39**	**22,963,946**	2.61 %	**0.03%**
2006	**8,606,896**	**19.75%**	**0.38**	**22,379,055**	2.59 %	**0.02%**
2005	**7,187,096**	**7.40%**	**0.33**	**21,814,642**	2.55 %	**0.02%**
2004	**6,691,921**	**-6.08%**	**0.31**	**21,272,323**	2.52 %	**0.02%**
2003	**7,125,276**	**-8.40%**	**0.34**	**20,750,299**	2.49 %	**0.02%**
2002	**7,778,834**	**20.59%**	**0.38**	**20,246,381**	2.48 %	**0.02%**
2001	**6,450,714**	**5.94%**	**0.33**	**19,756,928**	2.48 %	**0.02%**
2000	**6,089,280**	**-10.96%**	**0.32**	**19,278,856**	2.48 %	**0.02%**

Figure 20: CO2 emissions from 2000 to 2016 [12]

Instead in the following figure emissions levels are reported over a longer period of time in order to understand the general trend in recent decades and an increase in CO2 levels is observed.

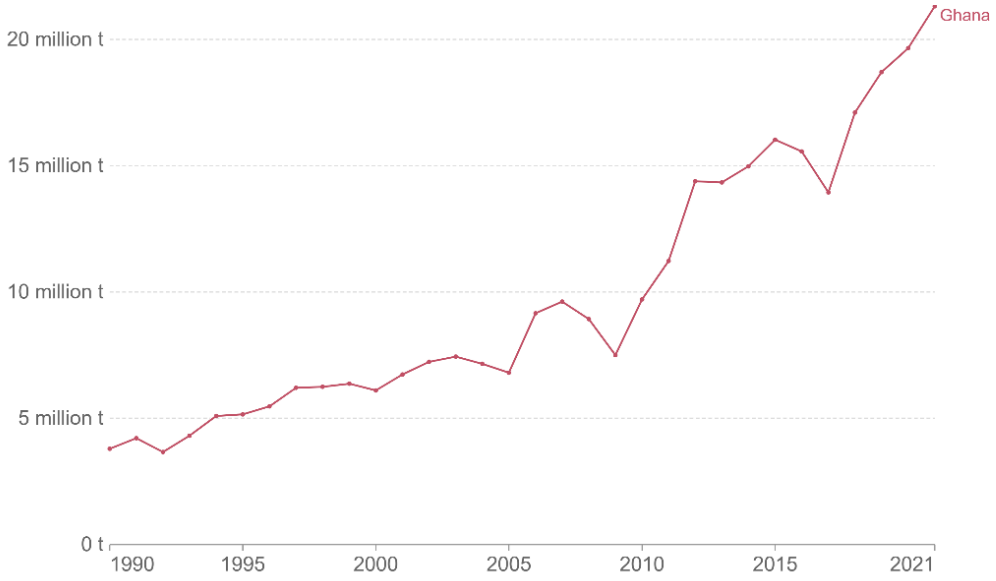


Figure 21: Trend of CO2 emissions [11]

In the latter image the emission levels divided by sector in the period between 2000 and 2018. The residential and transport sectors contribute the most to total emissions of the country.

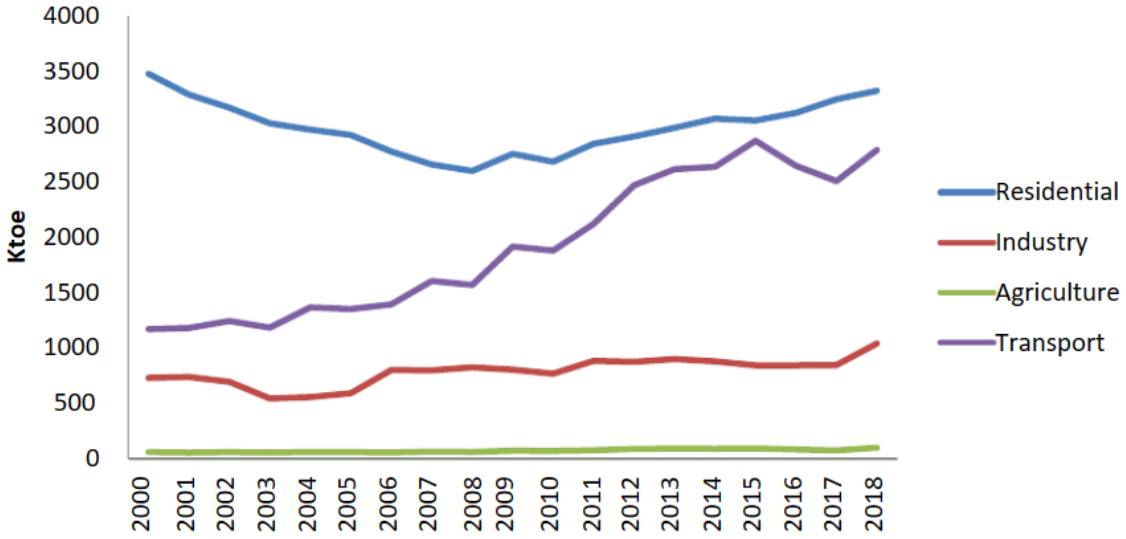


Figure 22: Energy consumption by sectors [13]

6.5 Where to improve

there are many ways in which Ghana can improve its economic activities so as not to worsen the climatic conditions following a low carbon development pathway.
Here are some of them:

- For the agriculture sector, promoting climate-smart agriculture practices, and supporting the adaptation of coastal communities to climate change impacts;
- Construction of new and sustainable infrastructure systems and develop new efficient strategies for waste management.
- Realizing forest resources as assets for climate resilience, end deforestation and instead promote forest conservation as a means of absorbing carbon;
- Promoting the use of clean energy: scaling up the use of renewable energy sources and improving regional energy markets to reduce reliance on fossil fuels and mitigate greenhouse gas emissions;
- As far as the transport sector is concerned, try to modernize it by improving the quality of the vehicles, develop a better public transportation infrastructure and services to reduce the emissions from the transport sector..

These are some areas in which Ghana could invest to try to improve climatic conditions but not only, investments in these areas would stimulate the growth of the country and also fosters sustainable and inclusive growth across various sectors of the economy [14].

7 ArcGis

ArcGis is a set of geographic software, they can be used for the management of geographic data but also for the modification or analysis of this data.
The company that developed these software is ESRI (Environmental Systems Research Institute), founded in 1969.
GIS integrates many different subjects using geography as its common framework. Esri is the global leader in the development of GIS, location intelligence, and mapping and ArcGis is today the leading GIS software in the market.

Specifically ArcGis contains within it:

- ArcMap;
- ArcCatalog;
- ArcGis Pro;
- ArcScene;
- ArcGlobe.

ArcGIS Pro is a full-featured professional desktop GIS application from Esri. With ArcGIS Pro, you can explore, visualize, and analyze data; create 2D maps and 3D scenes.
It enables users to work with various types of geographic information, such as maps, satellite imagery, terrain data, and geospatial databases.
The main advantages of ArcGis Pro over its predecessors are 64-bit processing, integrated 3D, ribbon-based interface and a project-centric approach, making it easy to manage multiple projects [17].

The software supports numerous data formats, allowing users to work with various data types, such as shapefiles, geodatabases, CAD files, raster data, and more.
The software can read graphical images such as (.jpg,.TIF etc), each graphical images contains information which is stored in the attribute table but to access attribute table first the images have to be converted into a raster layer.

The work was done using ArcGis Pro. The goal was to obtain a map that would allow us to visualize where companies of foreign origin are located in the territory of Ghana and at the same time visualize the levels of emissions on the territory.

The following pages illustrate the various steps followed to achieve the goal.

7.1 Step1 - Map of Ghana

The first step was to select the territory of our interest: Ghana. This was done within the ArcGis Pro software by creating a shapefile.

A shapefile is a vector data storage format that stores the location, shape, and attributes of geographic features. It has one feature class and is saved as a group of linked files.

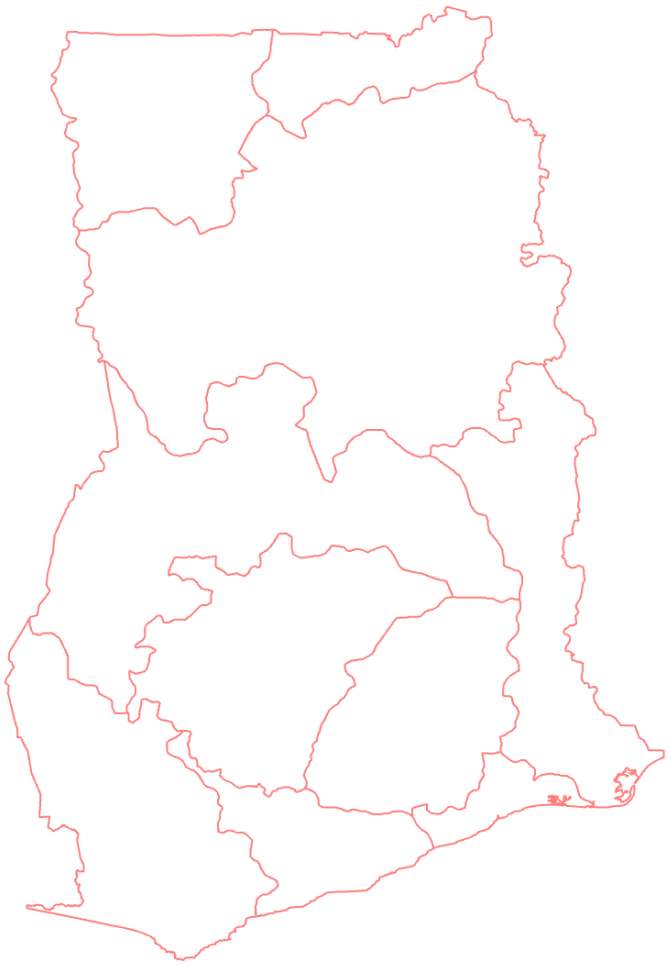


Figure 23: Map of Ghana

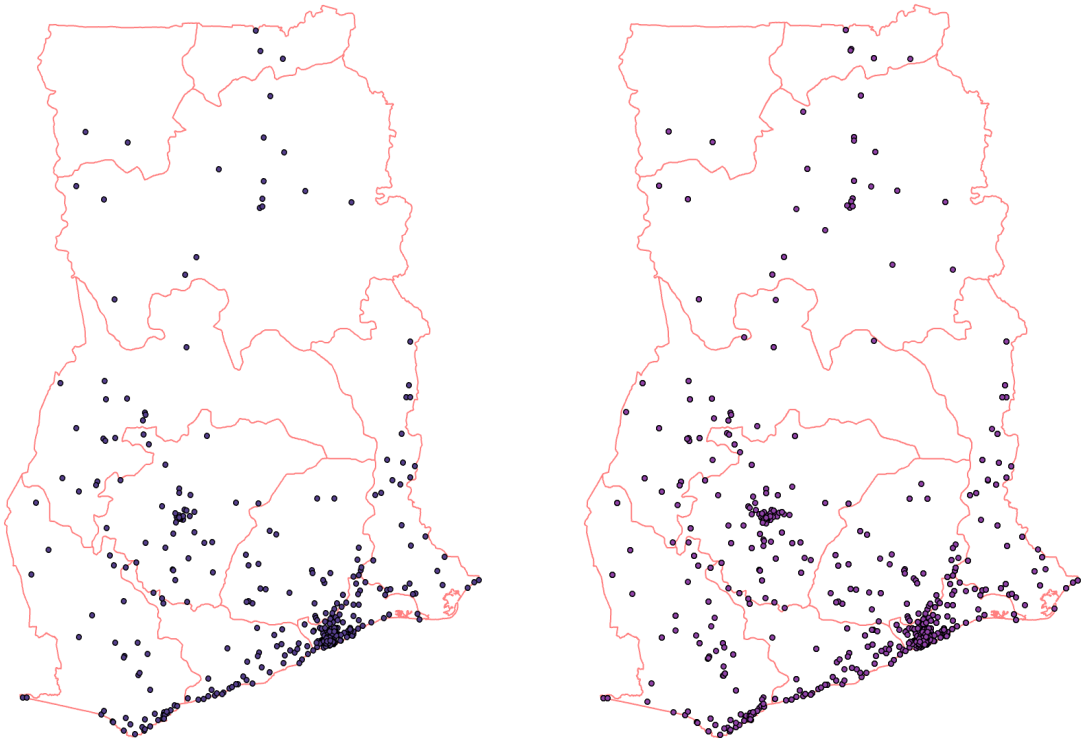
7.2 Step2 - Firms Localization

The second step is to locate foreign companies in the territory. In this ArcGis was very useful thanks to geolocation.

To geocode a table of addresses is necessary a table that stores the addresses you want to geocode and an address locator or a composite address locator. This tool matches the stored addresses against the locator and saves the result for each input record in a new point feature class.

I used as input table the table containing all the data relating to the companies in which there is a column indicating the address of each and as address locator the ArcGis World Geocoding Service.

The results are shown in the following figures. The figure on the left shows the foreign companies present in the area for the first period of time of our interest, 2000-2010. In the figure on the right, instead, the companies in the second period of time, 2010-2020.



(a) Firms in 2000-2010

(b) Firms in 2010-2020

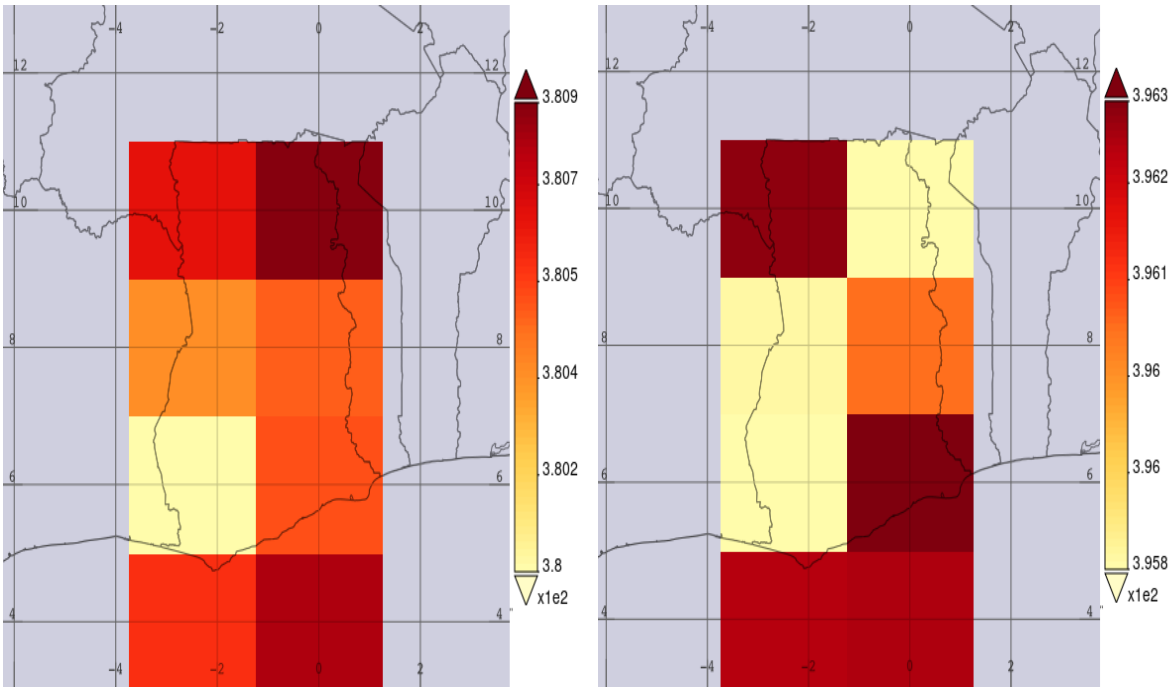
7.3 Step3 - Find Emissions Data

As far as emissions are concerned, I have been working on both carbon dioxide levels in the atmosphere and carbon monoxide levels.

The emissions data were extrapolated from databases available on the NASA website.
On the NASA website you can choose the specific region of interest and also a specific period of time.
The link to the website: https://giovanni.gsfc.nasa.gov/giovanni/.

The following images represent the emission levels always divided into the two periods of time considered. The representation changes between CO2 and CO, this is due to the fact that the CO data within the database has a unit of measurement of parts per billion while for CO2 data of parts per million.

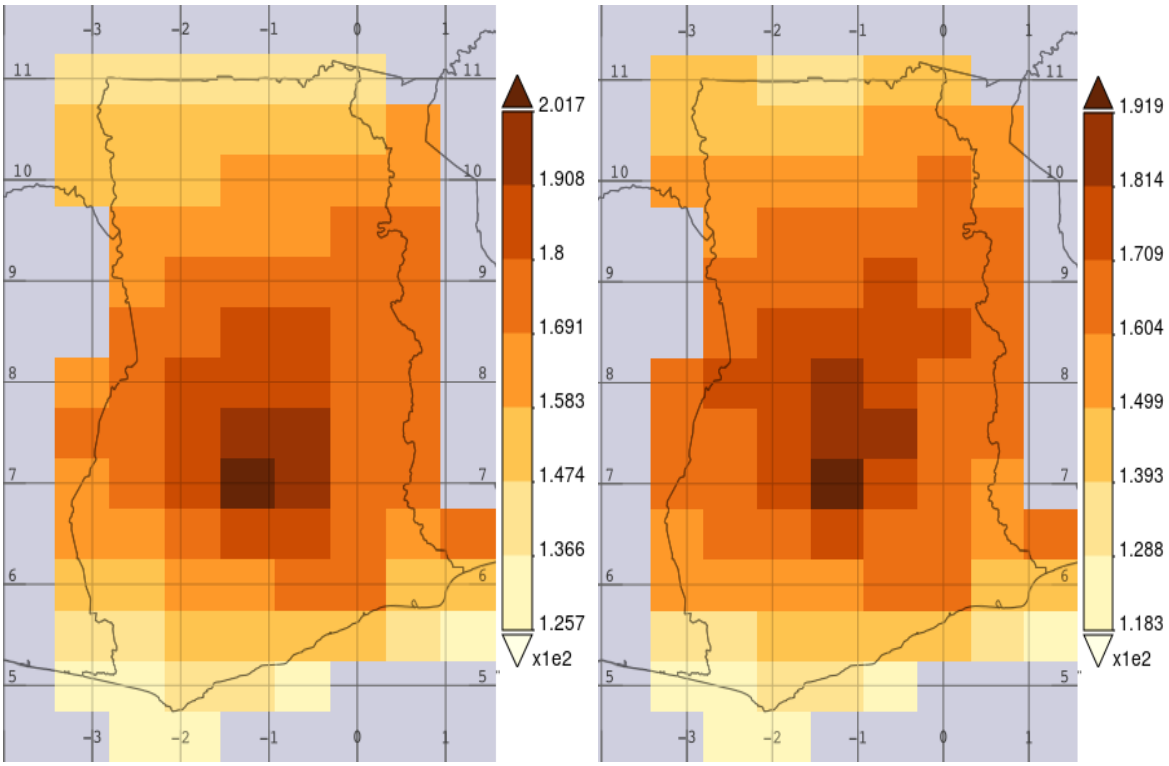
7.3.1 CO2 Data



(a) CO2 Emissions 2000-2010

(b) CO2 Emissions 2010-2020

7.3.2 CO Data



(a) CO Emissions 2000-2010

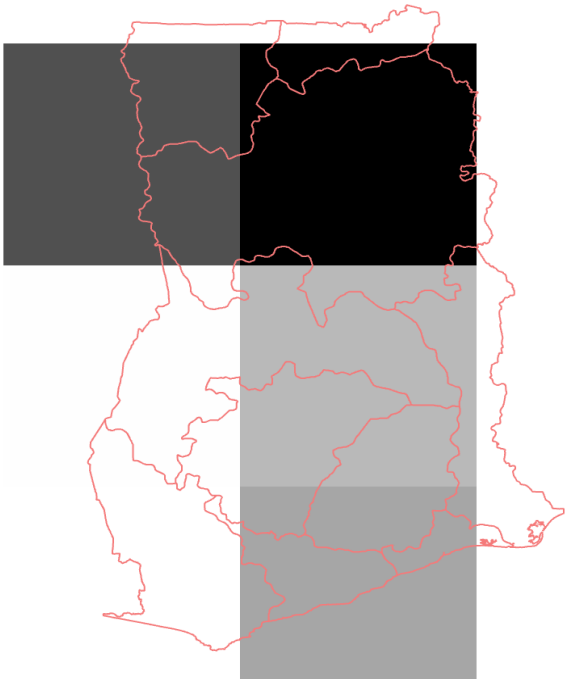
(b) CO Emissions 2010-2020

7.4 Step4 - Emissions Data in ArcGis

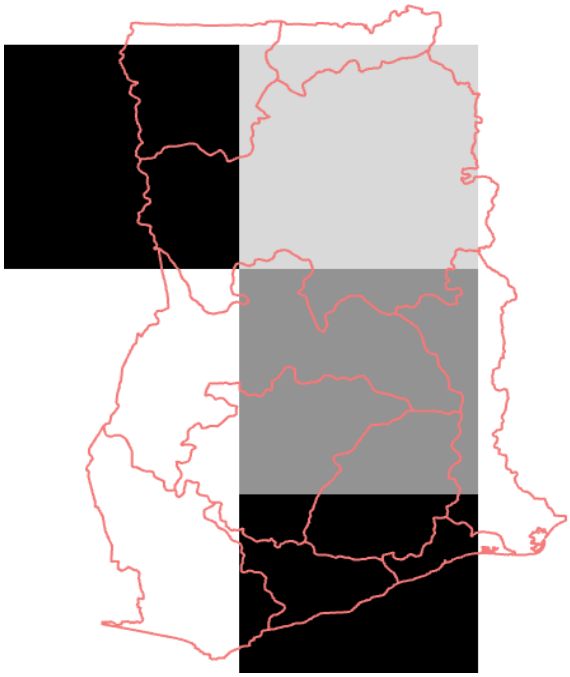
From the NASA's website I downloaded the emissions data in GeoTIFF format.
A GeoTIFF file is a GeoTIFF Raster Image. This format is a metadata format, which provides geographic information to associate with the image data.
Thanks to that the GeoTIFF format can be easily inserted on ArcGis through the "Insert data to the map" command.

The results are shown below.

7.4.1 CO2 Data

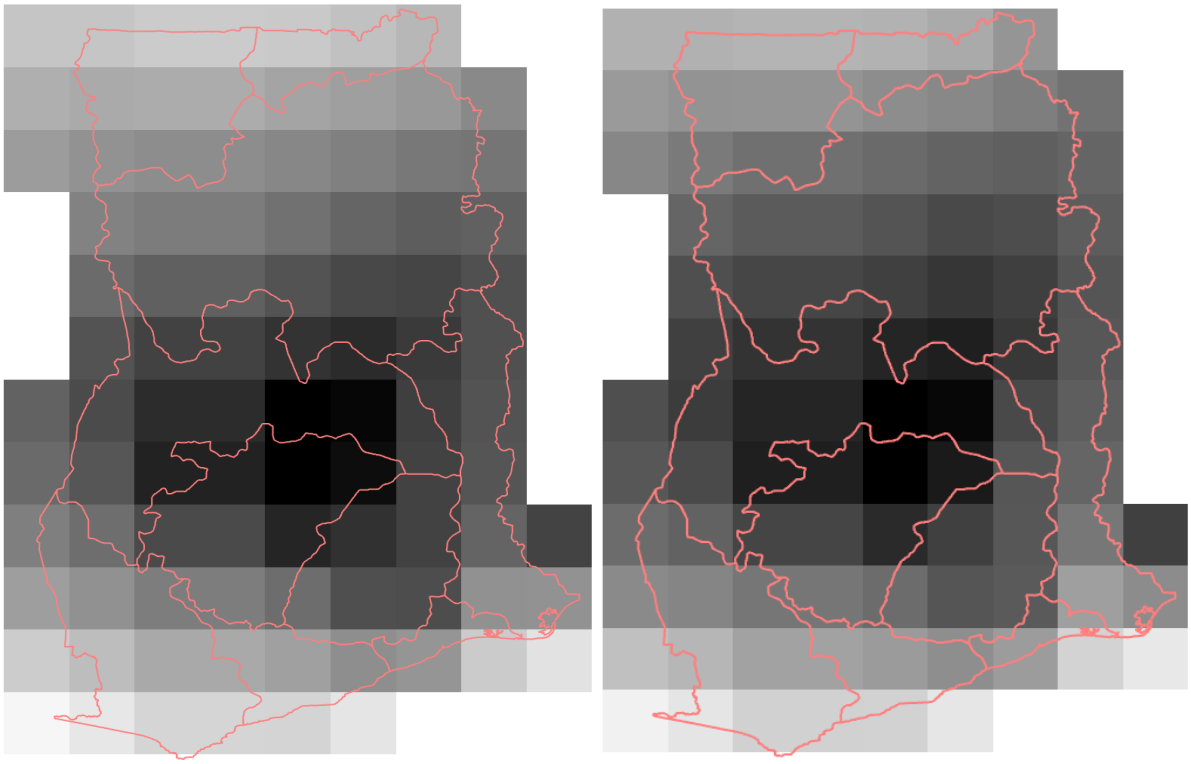


(a) CO2 Emissions 2000-2010-ArcGis



(b) CO2 Emissions 2010-2020-ArcGis

7.4.2 CO Data



(a) CO Emissions 2000-2010-ArcGis

(b) CO Emissions 2010-2020-ArcGis

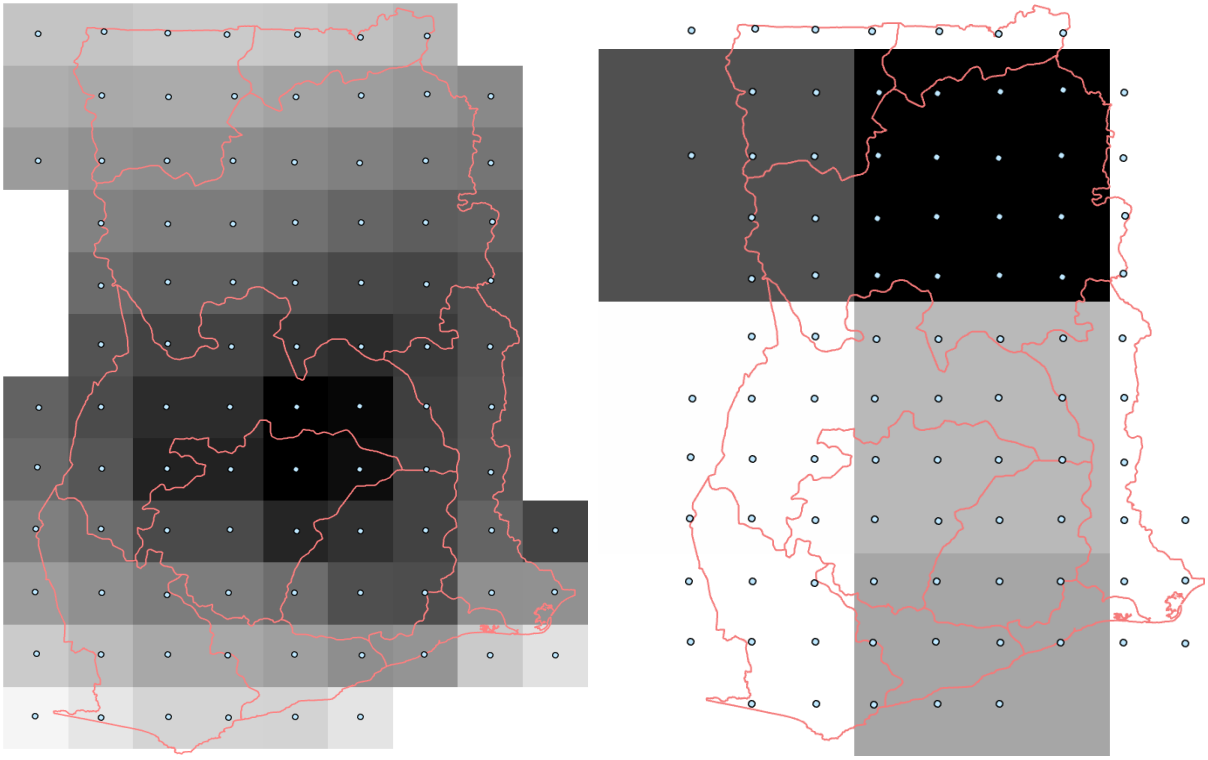
7.5 Step5 - Insert observation points

Through the creation of a feature class I inserted observation points on the map.
Feature classes are homogeneous collections of common features, each having the same spatial representation—such as points, lines, or polygons—and a common set of attribute columns. The most commonly used feature classes are points, lines, polygons.

When creating a feature class, you'll be asked to set the name of the feature class, the type of features to define the type of feature class and also the appropriate coordinate system.

To insert these points I took as a reference the level of division of the territory shown by the CO emissions database. This reference is perfectly correlated with the CO emission levels as for each cell I will have an observation point with different CO values for each. As for CO2 having a database in parts per million we will have more points where the level of emissions will be the same.

The results are shown in the figure below.



(a) CO Observation points

(b) CO2 Observation points

7.6 Step6 - Construction of the database

The last step is to build the database within the previously created feature class. This database must contain for each observation point the emission level for the cell considered and the number of firms present in the same cell. It must contain this data for each of the two time periods considered.

To do this I used the command Extract Multi values to point in the section Extraction of the Spatial analysis toll inside the toolboxes unit.
This command extracts the cell values of a raster based on a set of point features and records the values in the attribute table of an output feature class, in our case the output is the feature class of the observation points.
Output field names are created from the name of the input raster by default. Otherwise you can specify a unique name for each field to store raster values.

An example of the attribute table constructed is shown below.

CAMPIONI-CO

Field: Add Calculate Selection: Select By Attributes Zoom To Switch Clear Del

	OBJECTID *	Shape *	X	Y	AZIENDE/2000-2010	AZIENDE/2010-2020	CO/2000-2010	CO/2010-2020
1	1	Point	-1,126375	5,600969	0	0	152,7912	146,7268
2	2	Point	-1,115259	5,059148	39	49	138,7278	132,2129
3	3	Point	-0,577218	5,06176	1	4	134,1821	126,6628
4	4	Point	-3,241622	9,858543	0	0	153,9165	151,621
5	5	Point	1,029695	5,591442	0	0	135,0373	126,2609
6	6	Point	0,494788	5,593114	8	9	141,2591	131,7378
7	7	Point	-0,051819	5,596457	2919	4677	155,5855	146,5234
8	8	Point	-0,046804	6,129692	51	86	174,7422	163,7028
9	9	Point	0,503146	6,131363	10	18	156,8024	145,4924
10	10	Point	1,026351	6,136378	6	10	156,4896	150,2791
11	11	Point	1,029695	6,667941	0	1	177,3657	170,6093
12	12	Point	0,503146	6,667941	6	10	168,4976	155,9661
13	13	Point	-0,04179	6,671284	4	6	177,644	164,5105
14	14	Point	-0,57983	6,665434	5	5	182,2006	170,5492
15	15	Point	-0,57983	6,130005	10	16	174,2766	164,9279
16	16	Point	-0,566771	5,594577	86	129	157,4169	149,864
17	17	Point	-1,123094	6,130005	10	14	166,095	158,8047
18	18	Point	-1,104811	6,662822	3	3	185,5199	176,4484

Figure 30: Example of Attribute Table for CO

8 Regression Analysis

In order to understand what type of relationship binds two variables you can use regression analysis. Regression analysis is a set of statistical methods used for the estimation of relationships between a dependent variable and one or more independent variables.
The main objective of this analysis is to understand how changes in the independent variables are associated with changes in the dependent variable.

As shown in the figure below, there are three different types of regression analysis.

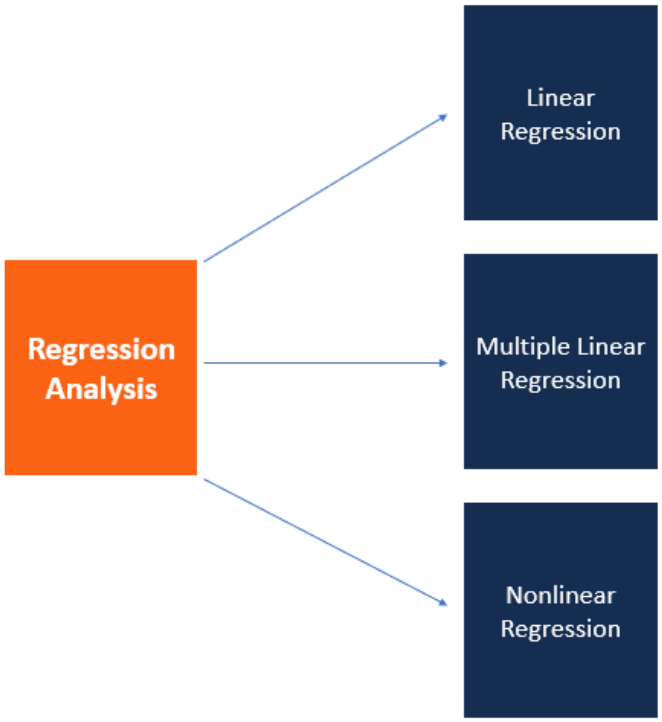


Figure 31: Types of Regression Analysis [20]

- Linear Regression: in this type of analysis the model try to assess the relationship between a dependent variable and an independent variable. In this case there is only one independent variable. The equation shown below represent the equation for a linear regression model:

$$Y = a + bX + \epsilon$$

  Where

  - Y is the dependent variable;
  - X is the independent variable;
  - a is the intercept;
  - b is the slope;
  - ϵ is the residual

- Multiple Linear Regression: in this second type of regression the only difference with respect to the previous one is that more than one independent variable are used. The equation is:

$$Y = a + bX_1 + cX_2 + dX_3 + \epsilon$$

  In this case a,b and c are the slope.

- Nonlinear Regression: the last type of model is used when independent and dependent variable show a nonlinear relationship. This type of regression is more complicated with respect to the previous models.

Another important concept to highlight is the difference between the dependent variable and the independent variables.

- Dependent variable: this is the variable whose course and changes are measured and observed in the study. The variable is expected to vary as the independent variables vary.
- Independent variable: are the variables that influence the dependent variable. They are variables managed by those who carry out the study.

Regression analysis is widely used in various fields, including economics, social sciences, engineering, finance, and many others, to understand relationships between variables [20].
In this work the dependent variable is the variation in the level of emissions in the territory of Ghana while the independent variable is the variation in the number of foreign firms in the same territory.
I also try to understand the effects of the different sectors of the firms and of time on the level of emissions.

To do this I used the linear and multiple linear regression models.

8.1 Model

For the emission assessment I developed different models for CO2 and CO. Below are the equations and explanations of the variables used.

8.1.1 Variable

Before illustrating the various models it is important to understand what is the meaning of the variables I used to perform the regression analysis.

For models that describe CO2 levels, the variables are:

- co2: with this variable I went to indicate the values of CO2, the values indicate the level of CO2 on the territory in parts per million, saved on STATA as double;
- naziende: is an integer variable that indicates the number of companies in the area for each observation point;
- x: The longitude of the territory, a double variable;
- y: also of double type the y variable indicates the latitude, the two variables are important because they allow us to understand if the position of the territory affects the emission levels;
- time: time is a variable that takes only two values and allows us to divide the collected data into the two periods of time considered;
- post: even post takes only two values and it is useful for us to understand if the period of time in which the data was collected affects the emission levels;
- diffCO2: diffCO2 is a double variable that I used to store changes in CO2 levels between the two time periods;
- diffAZ: diffAZ instead indicates the variation, always between the two periods of time, in the number of companies.

As far as CO is concerned, the first two models use the same variables described above but of course as a dependent variable instead of CO2 levels there will be CO levels.

For the last two models I inserted new variables that would divide the total of companies by sector in order to perform a more detailed analysis. In this case the variables are:

- Agr = Number of firms in the Agriculture sector;
- Constr = Number of firms in the Construction sector;
- Exp = Number of firms in the Export sector;
- GenTra = Number of firms in the General Trading sector;
- Lia = Number of firms in the Liason sector;
- Man = Number of firms in the Manufacturing sector;
- Ser = Number of firms in the Service sector;
- Touri = Number of firms in the Tourism sector;

The variables used for the last regression analysis, such as diffAGR, diffCON etc., indicate the changes in the number of companies between the two time periods for each sector indicated above.

8.1.2 CO2

For first thing I took CO2 and analyze the links between the emissions levels and foreign companies included in the territory of Ghana in the two periods of time between 2000 and 2010 and between 2010 and 2020.

I carried out the CO2 analysis despite the fact that the level of aggregation of emissions data was too high to have significant results on the effects of foreign direct investments on the level of CO2 in the territory.
Here are the two models developed:

First model: in this first case I take the level of CO2 as dependent variable while the independent variables are : x, y, the number of firms and also the variable post

The equation relative to this model is:

$$CO2 = \beta_0 + \beta_1 x + \beta_2 y + \beta_3 naziende + \beta_4 post \tag{1}$$

Second model: in this model I take the variation of the level of CO2 in the two time period considered as dependent variable while the independent variable is the variation in the number of firms in Ghana, always between the two time period considered.

The equation that describes this model is:

$$\Delta(CO2) = \beta_0 + \beta_1 \Delta(Firms) \tag{2}$$

8.1.3 CO

Also for the CO I analysed the links between the levels of carbon monoxide in the atmosphere and the foreign companies included in the territory of Ghana, always in the two periods of time between 2000 and 2010 and between 2010 and 2020.

For the carbon monoxide I also conducted a regression analysis taking as an independent variable the various sectors of the companies to understand which of these influences the most the level of emission.
Below the different models:

First model: here I take the level of CO as dependent variable while the independent variables are : x and y, number of firms and post, as in the first regression relative to CO2.

The equation in this case is:

$$CO = \beta_0 + \beta_1 x + \beta_2 y + \beta_3 naziende + \beta_4 post \tag{3}$$

Second model: in this second case I take the variation of the level of CO in the two time period considered as dependent variable while the independent variable is the variation in the number of firms in Ghana, always between the two time period considered.

The equation for this model:

$$\Delta(CO) = \beta_0 + \beta_1 \Delta(Firms) \tag{4}$$

Third model: in this regression analysis I take the level of CO as dependent variable while the independent variables are all sectors in which companies can be grouped and classified.

The equation:

$$CO = \beta_0 + \beta_1 post + \beta_2 naziende \beta_3 Agr + \beta_4 Constr + \beta_5 Exp + \beta_6 GenTra + \beta_7 Lia + \beta_8 Man + \beta_9 Ser + \beta_{10} Touri \tag{5}$$

Fourth model: for the last regression analysis I take the variation, between the two time period, in the level of CO as dependent variable while the independent variables are the difference in the number of firms for each sectors.

Last equation:

$$\begin{aligned} CO = \beta_0 + \beta_1 \Delta(naziende) + \beta_2 \Delta(Agr) + \beta_3 \Delta(Const) + \beta_4 \Delta(Exp) + \beta_5 \Delta(GenTra) \\ + \beta_6 \Delta(Lia) + \beta_7 \Delta(Man) + \beta_8 \Delta(Ser) + \beta_9 \Delta(Touri) \end{aligned} \tag{6}$$

8.2 STATA

To understand the relationships between our dependent and independent variables I used STATA. STATA is a statistical software developed by StataCorp. This software contains several features such as: data manipulation, visualization, statistics, and automated reporting.

Here are some commands used within the software:

- Import: import excel reads worksheets from Microsoft Excel (.xls and .xlsx) files, I used this command to import the table containing the data.
- Summarize: summarize calculates and displays a variety of univariate summary statistics
- Generate: this command creates a new variable
- Describe: this command outputs basic information about the dataset, including the number of observations and variables, variables in the dataset, their type, value label, and variable label
- Drop: drop eliminates variables or observations from the data in memory
- Label: to assign a descriptive label to the variables explaining their meaning
- Rename: with rename is possible to change the name of the variables
- Replace= replace can be used to change just one value,
- Regress: to perform the regression analysis specifying the dependent variable first and then the independent variables

8.2.1 CO2

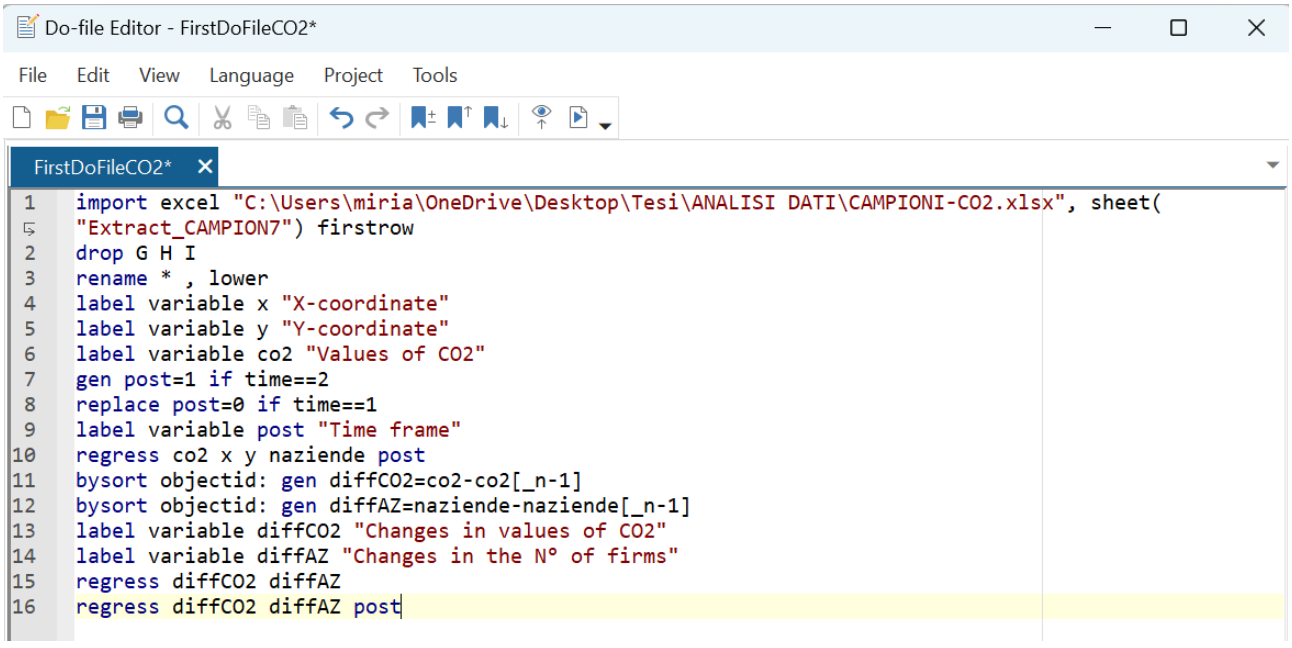


Figure 32: Do-File for CO2 regression analysis

8.2.2 CO

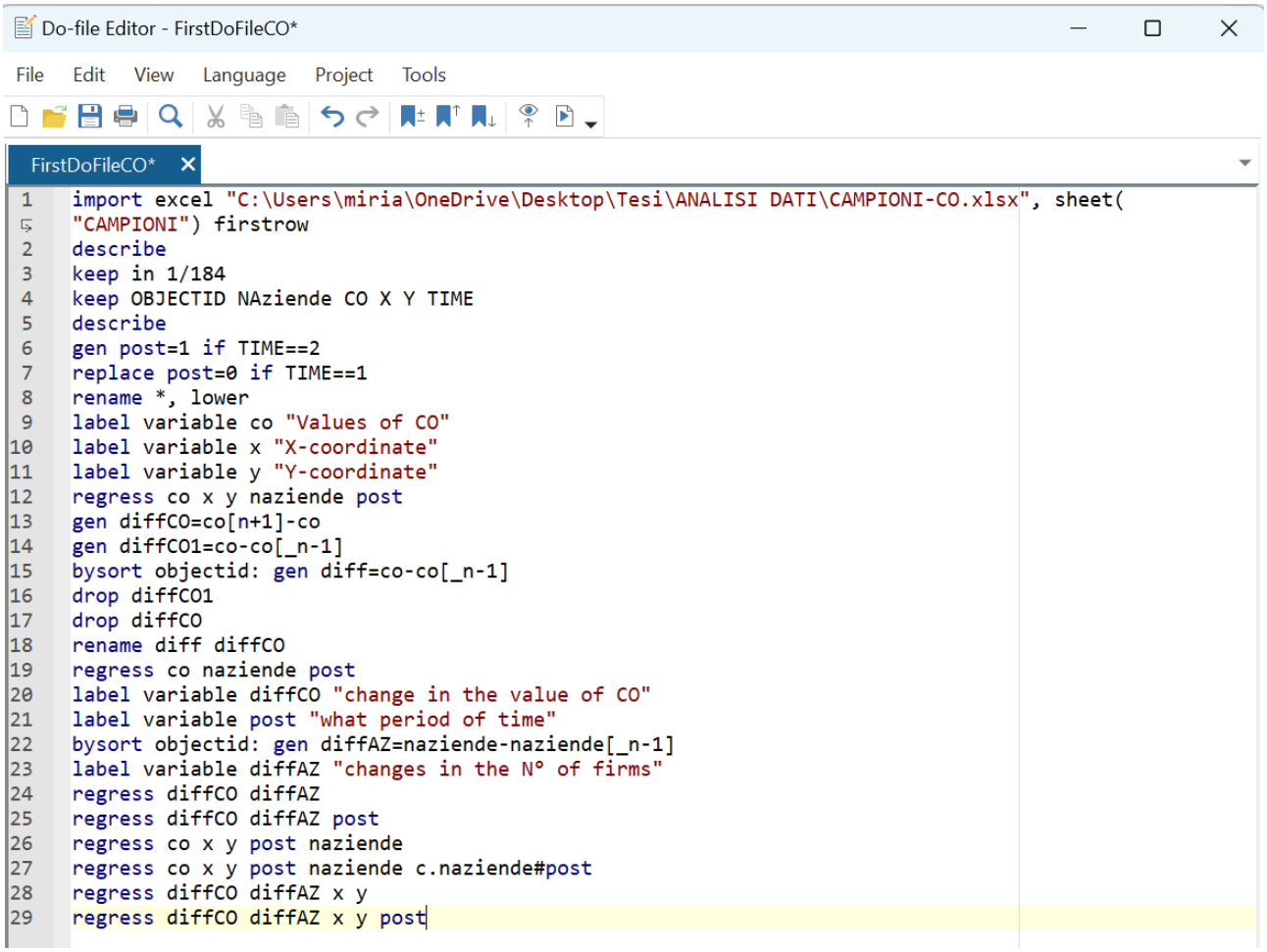


Figure 33: Do-file for CO regression analysis

8.2.3 CO-Sectors

Do-file Editor - SETTORICOdofile

File Edit View Language Project Tools

SETTORICOdofile

```
1  import excel "C:\Users\miria\OneDrive\Desktop\Tesi\ANALISI DATI\CAMPIONI-CO.xlsx", sheet(
   "CAMPIONI") firstrow
2  rename NAziendeAGR AGR
3  rename NAziendeCONSTR CONSTR, NAziendeEXP EXP, NAziendeGENTRA GENTRA
4  rename NAziendeEXP EXP
5  rename  NAziendeGENTRA GENTRA
6  rename NAziendeLIA LIA
7  rename NAziendeMAN MAN
8  rename NAziendeSER SER
9  rename NAziendeTOURI TOURI
10 gen post=1 if TIME==2
11 replace post=0 if TIME==1
12 rename *, lower
13 regress co post agr constr exp gentra lia man ser touri
14 bysort objectid: gen diff=co-co[_n-1]
15 rename diff diffCO
16 bysort objectid: gen diffAGR=agr-agr[_n-1]
17 bysort objectid: gen diffCON=constr-constr[_n-1]
18 bysort objectid: gen diffEXP=exp-exp[_n-1]
19 bysort objectid: gen diffGENTRA=gentra-gentra[_n-1]
20 bysort objectid: gen diffLIA=lia-lia[_n-1]
21 bysort objectid: gen diffMAN=man-man[_n-1]
22 bysort objectid: gen diffSER=ser-ser[_n-1]
23 bysort objectid: gen diffTOUR=touri-touri[_n-1]
24 regress diffCO diffAGR diffCON diffEXP diffGENTRA diffLIA diffMAN diffSER diffTOUR
```

Figure 34: Do-file for CO regression analysis - Firms sectors

8.3 Regression results - Overview

The table below represents the structure of the results of regression analysis on STATA.
In this example the dependent variable is CO while the three independent variable are x,y and post.

First the results of linear regression are presented in three different tables:

- Anova Table: this is the first table in the upper left that includes SS, df and MS;
- Model Fit: this is the table at the top-right, the table summarizes the overall fit of the model. It answers the question "how well does the model use the predictors to model the target variable?";
- Parameter Estimation: this table shows the parameters estimated by the model and their respective statistical significance.

Analysis of the component of the three tables:

SS : the meaning of SS is "Sum of Squares" and is used to represent the variation of the target variable and to understand the difference of the observations from the mean of the variable. The total SS is the total variation of the target variable around its mean.

$$SStotal = \sum (y_i - \bar{y})^2 \tag{7}$$

df : is the degree of freedom associated with a variance. Degree of freedom is the number of independent values that can vary. For the model degree of freedom are considered the number of independent variable in the model. Instead to calculate the degree of freedom for the residual the formula is:

$$Degreeof freedom = n - m - 1 \tag{8}$$

Where:

- n: number of observations;
- m: number of independent variables.

For the total degree of freedom the formula is:

$$Degreeof freedom = n - 1 \tag{9}$$

MS : MS stands for Mean Square and it is the mean of the sum of squares.

Number of Observations : is simply the number of observations used in the regression.

F(n,m) : The F(n,m) is a F-statistics. It is calculated as the ratio of the mean sum of squares (MS) of the model to that of the residual. It measures how the ratio of the explainable mean variance to the unexplainable mean variance is statistically greater than 1. The n and m represents the model's and residual degrees of freedom respectively.

Prob ¿ F : this value represents the probability of obtaining the estimated F-statistics or greater (the p-value). If we take the typical significance level of 0,05, a value lesser than that means that statistically we can reject the null hypothesis of all coefficients equal to zero and this means that the predictors of our model reliably predicts the target variable. For a value higher than 0,05 we cannot reject the null hypothesis.

R-Squared : the value is calculated as:

$$R - Squared = \left(\frac{SSmodel}{SStotal} \right) \tag{10}$$

The R-Squared value represents the goodness of fit. It is numerically the fraction of the variation in the dependent variable that can be explained by the independent variables.

Adj R-Squared Adj R-squared tells us how much of the variation of the dependent variable is determined by the addition of the independent variables. Adj R-squared is the R-squared controlled for by the number of predictors. It is given by:

$$AdjR - Squared = 1 - \left(\frac{SSresidual/(n-m-1)}{SStotal/(n-1)} \right) \tag{11}$$

Root MSE : this value is simply the standard deviation of the residuals (error term).
The formula is :

$$RootMSE = \sqrt{\left(\frac{\epsilon^2}{n} \right)} \tag{12}$$

Coef. : these values represent the coefficients and the last value the constant in the equation that links the dependent variable to the independent variables.

Std. Err. : the standard errors are errors linked to the measurements of the coefficients. They are useful to calculate the p-value.

t : in addition to the estimated coefficients, Stata conducts a hypothesis test using the t-test to find how each estimated coefficient is significantly different from zero.

$P > |t|$: With the values in this column we are going to test the null hypothesis of the statistical test. The null hypothesis for each independent variable is that they have no relationship with the dependent variable hence, they have an estimated parameter of zero.
If p-value is less than a chosen significance level (usually 5%) I reject the null hypothesis. I cannot say that the coefficient is equal to 0 statistically. If there is a p-value higher than 0,05 I cannot reject the null hypothesis.

95% Conf. Interval : the last two columns represents a 95% confidence interval for the value of the coefficient. It is a range of values in which the coefficient falls [15].

8.4 CO2 - Results

8.4.1 Regression - 1

```
. regress co2 x y naziende post
```

Source	SS	df	MS	Number of obs	=	184
				F(4, 179)	=	86662.01
Model	9632.1338	4	2408.03345	Prob > F	=	0.0000
Residual	4.97378221	179	.027786493	R-squared	=	0.9995
				Adj R-squared	=	0.9995
Total	9637.10758	183	52.6617901	Root MSE	=	.16669

co2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
x	.0468638	.0100922	4.64	0.000	.0269488	.0667789
y	.0458846	.0068899	6.66	0.000	.0322888	.0594804
naziende	.0000482	.0000309	1.56	0.120	-.0000128	.0001092
post	14.46787	.0245891	588.39	0.000	14.41935	14.51639
_cons	380.2182	.0590883	6434.75	0.000	380.1016	380.3348

Figure 35: Results CO2 regression 1

Overall Model fit

The number of observations used to carry out this analysis are 184. F(4.179), which I remember being the ratio of Mean Square Model to Mean Square Residual, has a value of 86662,01. The p-value associated with this F value is very small (0.0000). The p-value, compared to our alpha level (0.05), is smaller so we can conclude that the independent variables reliably predict the dependent variable. From the results first we can see the value of R-squared that in this case is 99,95%. This indicates that 99,95% of the variation in the dependent variable is due to the independent variables.
The Adj R-Squared in this case is equal to the R-squared.

Coefficients

If we go to increase the x coordinate and considering all the other constant variables it can be observed that the CO2 increases by 0,0468638, on average.

As for the y-coordinate, CO2 increases on average by 0.0458846, always considering the other variables constant.

By increasing the number of firms the level of CO2 increases by a small amount: 0,0000482.

Finally the increase in post (the data from the next period, 2010-2020) the level of the dependent variable increase of 14,46787, on average.

t-distribution and P-test

Let's now analyze the results of the statistical test in which the null hypothesis is that all the coefficients of the equation are equal to zero.

$$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0 \tag{13}$$

We choose 5% as significance level.

Let's analyze the column with

$$P > |t|$$

If this probability is less than the chosen significance level then we reject the null hypothesis. We cannot say that the coefficient is statistically equal to zero.
On the contrary, if the value in the column is greater than the significance level then we cannot reject the null hypothesis that the coefficient is zero, the effect of the independent variable under consideration on the dependent variable is not statistically significant

If the null hypothesis for the first coefficient is true (β_1=0), the chances of us getting a sample extreme as we did (β_1=0,0468638) would be $P > |t| = 0\%$ for x, which means that we can reject the null hypothesis of coefficient equal to zero. The coefficient has a significant effect on the dependent variable.

Considering the null hypothesis for second coefficient (β_2=0), the chances of us getting a sample extreme as we did (β_2=0,0458846) would be $P > |t| = 0\%$ for y, which means that we can reject the null hypothesis has before. CO2 is significantly affected by the y coordinate

If the null hypothesis for the third coefficient is true (β_3=0), the chances of us getting a sample extreme as we did (β_3=0,0000482) would be $P > |t| = 12\%$, in this case the value is higher than the chosen significance level so we cannot reject the null hypothesis. The coefficient of the variable doesn't have significant effect on the level of CO2.

For the last coefficient if the null hypothesis is true (β_4=0), the chances of us getting a sample extreme as we did (β_4=14,46787) would be $P > |t| = 0\%$, so lower than 5%. We can reject the null hypothesis, the coefficient is different from zero and is statistically significant.

Overall Conclusion

What this first regression analysis makes us understand is that the level of CO2 in the atmosphere is positively influenced by the latitude and longitude of the point considered and also by the period of time in which the measurement was made. The latter means that CO2 values have increased over time.
The variables for which the coefficients are nonzero are: x, y and post.
Another important consideration is that the variable indicating the number of companies on the territory does not significantly affect our dependent variable, its coefficient is zero. So in general, foreign direct investment does not significantly affect carbon dioxide levels.
This allows us to understand that there are other factors in the area that contribute to the increase in carbon dioxide emissions.

8.4.2 Regression - 2

```
. regress diffCO2 diffAZ
```

Source	SS	df	MS	Number of obs	=	92
				F(1, 90)	=	1.20
Model	.078129769	1	.078129769	Prob > F	=	0.2769
Residual	5.87613521	90	.065290391	R-squared	=	0.0131
				Adj R-squared	=	0.0022
Total	5.95426498	91	.065431483	Root MSE	=	.25552

diffCO2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
diffAZ	.0001602	.0001464	1.09	0.277	-.0001307	.0004511
_cons	14.46514	.0268783	538.17	0.000	14.41174	14.51853

Figure 36: Results CO2 regression 2

Overall Model fit

The number of observations used to carry out this analysis are 92, half of before because in this case I evaluated the difference in CO2 values and number of companies between two time periods for each point.
F(1,90) has a value of 1,20. The p-value associated with this F value is higher than before (0,2769). The p-value, compared to our alpha level is higher so we can conclude that the independent variable do not show a statistically significant relationship with the dependent variable.
From the results first we can see the value of R-squared that in this case is 1,31%. This indicates that only 1,31% of the variation in the dependent variable is due to the independent variables.
The Adj R-Squared in this case is equal to 0,0022.

Coefficients

If we go to increase the only independent variable it can be observed that the variation in the level of CO2 increases by 0,0001602, on average.

t-distribution and P-test

Let's now analyze the results of the statistical test, the null hypothesis is the same as before, the coefficient of the equation is equal to zero, we do not consider the constant.

$$H_0 : \beta_1 = 0 \tag{14}$$

We choose as before a 5% significance level.

Let's analyze the column with

$$P > |t|$$

If this probability is less than the chosen significance level then we reject the null hypothesis. We cannot say that the coefficient is statistically equal to zero.
On the contrary, if the value in the column is greater than the significance level then we cannot reject

the null hypothesis that the coefficient is zero, the effect of the independent variable under consideration on the dependent variable is not statistically significant

If the null hypothesis for the coefficient is true (β_1=0), the chances of us getting a sample extreme as we did (β_1=0,0001602) would be $P > |t| = 27,7\%$ for the variation in number of firms, which means that we cannot reject the null hypothesis of coefficient equal to zero. The coefficient doesn't have significant effect on the dependent variable.

Overall Conclusion

In this second analysis I took into account the variation in the number of companies as an independent variable while the dependent variable is the variation in the level of CO2 between the two periods considered. The purpose of this regression is to understand whether the variation in the level of emissions is related to the increase in the number of foreign companies on the territory.
The results show us that the variations do not depend on the increased number of companies, the coefficient of the variable is zero.
It should also be noted that in this model the R-Squared is very low. This shows us how our independent variable can explain a very small percentage, 1.31%, of the dependent variable.

8.5 CO - Results

8.5.1 Regression - 1

```
. regress co x y naziende post
```

Source	SS	df	MS	Number of obs	=	184
				F(4, 179)	=	2.98
Model	2775.41479	4	693.853698	Prob > F	=	0.0205
Residual	41669.74	179	232.791844	R-squared	=	0.0624
				Adj R-squared	=	0.0415
Total	44445.1548	183	242.869698	Root MSE	=	15.258

co	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
x	2.160258	.9236523	2.34	0.020	.33761	3.982906
y	.5234011	.6277074	0.83	0.405	-.7152573	1.76206
naziende	-.0031253	.0028303	-1.10	0.271	-.0087103	.0024597
post	-4.777656	2.250666	-2.12	0.035	-9.218907	-.3364047
_cons	162.1384	5.38925	30.09	0.000	151.5038	172.7731

Figure 37: Results CO regression 1

Overall Model fit

The number of observations used to carry out this analysis are 184.
F(4,179) has a value of 2,98. The p-value associated with this F value is lower than our alpha level (0,0205). We can conclude that the independent variables show a statistically significant relationship with the dependent variable.
From the results first we can see the value of R-squared that in this case is 6,24%. This indicates that only 6,24% of the variation in the dependent variable is due to the independent variables.
The Adj R-Squared in this case is equal to 0,0415.

Coefficients

If we go to increase the x coordinate and considering all the other variables constant it can be observed that the CO increases by 2,160258, on average.

As for the y-coordinate, CO increases on average by 0.5234011, always considering the other variables constant.

By increasing the number of firms the level of CO in this case decreases by a small amount of: -0,0031253.

Finally the increase in post (the data from the next period, 2010-2020) leads to a decrease in the level of CO of -4,777656, on average.

t-distribution and P-test

Let's now analyze the results of the statistical test in which the null hypothesis is that all the coefficients of the equation are equal to zero.

$$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0 \tag{15}$$

We choose 5% as significance level.

Let's analyze the column with

$$P > |t|$$

If this probability is less than the chosen significance level then we reject the null hypothesis. We cannot say that the coefficient is statistically equal to zero.
On the contrary, if the value in the column is greater than the significance level then we cannot reject the null hypothesis that the coefficient is zero, the effect of the independent variable under consideration on the dependent variable is not statistically significant

If the null hypothesis for the first coefficient is true (β_1=0), the chances of us getting a sample extreme as we did (β_1=2,160258) would be $P > |t| = 2\%$ for x, which means that we can reject the null hypothesis of coefficient equal to zero. The coefficient has a significant effect on the dependent variable.

Considering the null hypothesis for second coefficient (β_2=0), the chances of us getting a sample extreme as we did (β_2=0,5234011) would be $P > |t| = 40,5\%$ for y, which means that in this case we cannot reject the null hypothesis of coefficient β_2 equal to zero. CO is not significantly affected by the y coordinate

If the null hypothesis for the third coefficient is true (β_3=0), the chances of us getting a sample extreme as we did (β_3=-0,0031253) would be $P > |t| = 27,1\%$, in this case the value is higher than the chosen significance level so we cannot reject the null hypothesis. The coefficient of the variable doesn't have significant effect on the level of CO.

For the last coefficient if the null hypothesis is true (β_4=0), the chances of us getting a sample extreme as we did (β_4=-4,777656) would be $P > |t| = 3,5\%$, so lower than 5%. We can reject the null hypothesis, the coefficient is different from zero and is statistically significant.

Overall Conclusion

The results show us that the only variables that affect CO levels are x and post. The variable x indicates longitude of the point taken in consideration. The variable post instead indicates the period of time in which the measurement was made.
The dependent variable is positively influenced by longitude.
As far as post is concerned, the influence exerted on emission levels is different from CO2. In this case the coefficient of the variable is negative and therefore a measurement of CO taken in a subsequent period of time is lower than the first.
Here, too, foreign direct investment does not significantly change carbon monoxide levels.

8.5.2 Regression - 2

```
. regress diffCO diffAZ
```

Source	SS	df	MS	Number of obs	=	92
				F(1, 90)	=	1.50
Model	21.2625507	1	21.2625507	Prob > F	=	0.2238
Residual	1275.61048	90	14.1734498	R-squared	=	0.0164
				Adj R-squared	=	0.0055
Total	1296.87304	91	14.251352	Root MSE	=	3.7648

diffCO	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
diffAZ	-.002635	.0021514	-1.22	0.224	-.0069091	.001639
_cons	-4.789662	.3960239	-12.09	0.000	-5.576433	-4.002892

Figure 38: Results CO regression 2

Overall Model fit

The number of observations used to carry out this analysis are 92,half of the preceding regression as in the second analysis of CO2.
F(1,90) has a value of 1,50. The p-value associated with this F value is higher than before (0,2238). The p-value, compared to our alpha level is higher so we can conclude that the independent variable do not reliably predict the dependent variable.
In this case only 1,64% of the variation in the dependent variable is due to the independent variables. The Adj R-Squared in this case is equal to 0,0055.

Coefficients

If we go to increase the only independent variable it is observed that the level of CO decreases by -0,002635

t-distribution and P-test

Let's now analyze the results of the statistical test, the null hypothesis is the same as before, the coefficient of the equation is equal to zero, we do not consider the constant.

$$H_0 : \beta_1 = 0 \tag{16}$$

We choose as before a 5% significance level.

Let's analyze the column with

$$P > |t|$$

If this probability is less than the chosen significance level then we reject the null hypothesis. We cannot say that the coefficient is statistically equal to zero.
On the contrary, if the value in the column is greater than the significance level then we cannot reject the null hypothesis that the coefficient is zero, the effect of the independent variable under consideration on the dependent variable is not statistically significant

If the null hypothesis for the coefficient is true (β_1=0), the chances of us getting a sample extreme as

we did (β_1=-0,002635) would be $P > |t| = 22,4\%$ for the variation in number of firms, which means that we cannot reject the null hypothesis of coefficient equal to zero. The coefficient doesn't have significant effect on the dependent variable.

Overall Conclusion

Also for this case the overall conclusion is that the variation of CO does not depend on the variation in the number of firms present in the territory.
Therefore, an increase in FDI with a consequent increase in industrial plants does not entail significant changes in the dependent variable.
Only 1.64% of the variation of the independent variable is due to the variation in the number of firms.

8.5.3 Regression - 3

```
. regress co post agr constr exp gentra lia man ser touri
```

Source	SS	df	MS		
Model	6344.56397	9	704.951552	Number of obs	= 184
Residual	38100.5908	174	218.968913	F(9, 174)	= 3.22
				Prob > F	= 0.0012
Total	44445.1548	183	242.869698	R-squared	= 0.1428
				Adj R-squared	= 0.0984
				Root MSE	= 14.798

co	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
post	-4.936116	2.208187	-2.24	0.027	-9.294396	-.577835
agr	.7228493	.5034458	1.44	0.153	-.2707973	1.716496
constr	-1.534573	1.23706	-1.24	0.216	-3.976147	.9070005
exp	1.337263	.8328819	1.61	0.110	-.3065886	2.981115
gentra	.609369	.5751919	1.06	0.291	-.5258822	1.74462
lia	.9002853	1.918062	0.47	0.639	-2.885377	4.685948
man	.5191042	.3960183	1.31	0.192	-.2625138	1.300722
ser	-.4754022	.4566433	-1.04	0.299	-1.376675	.4258708
touri	-1.310829	.5032852	-2.60	0.010	-2.304159	-.3174996
_cons	163.6014	1.640873	99.70	0.000	160.3628	166.84

Figure 39: Results CO regression 3 - Sectors

Overall Model fit

The number of observations used to carry out this analysis are 184.
F(9,174) has a value of 3,22. The p-value associated with this F value is lower than our alpha level because in this analysis is 0,0012. We can conclude that the independent variables show a statistically significant relationship with the dependent variable.
The R-squared of this regression is 6,24%. Only 6,24% of the variation in the dependent variable is due to the independent variables.
The Adj R-Squared in this case is much lower than R-squared and equal to 0,0984.

Coefficients

The post coefficient is negative and this indicates that CO levels in the second period are lower than the previous ones

If we go to increase the Agriculture and considering all the other constant variables it can be observed that the CO increases by 0,7228493, on average.

As for the Construction coefficient, CO decreases on average by -1,534573, always considering the other variables constant.

Increasing the export activities the level of CO increases by 1,337263.

The increase in General Trading lead to an increase in the level of the dependent variable of 0,609369, on average.

An increase in the Liason activities entail, considering all the other variables constant, an increase in CO of 0,9002853, on average.

Manufacturing activities lead to an increase in the level of CO by a factor of: 0,5191042.

Instead, always considering all the other constant variables, services and tourism decrease CO by -0,4754022 and -1,310829 respectively.

t-distribution and P-test

Let's now analyze the results of the statistical test in which the null hypothesis is that all the coefficients of the equation are equal to zero.

$$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = 0 \tag{17}$$

We choose 5% as significance level.

Let's analyze the column with

$$P > |t|$$

If this probability is less than the chosen significance level then we reject the null hypothesis. We cannot say that the coefficient is statistically equal to zero.
On the contrary, if the value in the column is greater than the significance level then we cannot reject the null hypothesis that the coefficient is zero, the effect of the independent variable under consideration on the dependent variable is not statistically significant

If the null hypothesis for the first coefficient is true (β_1=0), the chances of us getting a sample extreme as we did (β_1=-4,936116) would be $P > |t| = 2,7\%$, in this case the value is lower than the chosen significance level so we can reject the null hypothesis. The coefficient of the variable have a significant effect on the level of CO.

If the null hypothesis for the second coefficient is true (β_2=0), the chances of us getting a sample extreme as we did (β_2=0,7228493) would be $P > |t| = 15,3\%$ for Agriculture, which means that we cannot reject the null hypothesis of coefficient equal to zero. The coefficient doesn't have a significant effect on the dependent variable.

Considering the null hypothesis for third coefficient (β_3=0), the chances of us getting a sample extreme as we did (β_3=-1,534573) would be $P > |t| = 21,6\%$ for Construction, which means that we cannot reject the null hypothesis has before. CO is not significantly affected.

If the null hypothesis for the export coefficient is true (β_4=0), the chances of us getting a sample extreme as we did (β_4=1,337263) would be $P > |t| = 11\%$,also in this case the value is higher than the chosen significance level so we cannot reject the null hypothesis. The coefficient of the variable doesn't have significant effect on the level of CO.

For General Trading coefficient if the null hypothesis is true (β_5=0), the chances of us getting a sample extreme as we did (β_5=0,609369) would be $P > |t| = 29,1\%$, so higher than 5%. We cannot reject the null hypothesis, the coefficient can be zero and is not statistically significant.

If the null hypothesis for the sixth coefficient is true (β_6=0), the chances of us getting a sample extreme as we did (β_6=0,9002853) would be $P > |t| = 63,9\%$ for Liason, this means that we cannot reject the null hypothesis. The coefficient is not statistically significant.

Considering the null hypothesis: (β_7=0), the chances of us getting a sample extreme as we did (β_7=0,5191042) would be $P > |t| = 19,2\%$ for Manufacturing, also for this sector we cannot reject the null hypothesis. CO is not significantly affected.

If the null hypothesis (β_8=0) is true, the chances of us getting a sample extreme as we did (β_8=-0,4754022) would be $P > |t| = 29,9\%$. The value is higher than the chosen significance level so we cannot reject the null hypothesis. The coefficient of the variable is not statistically significant.

For the last sector, Tourism, if the null hypothesis is true (β_9=0), the chances of us getting a sample extreme as we did (β_9=-1,310829) would be $P > |t| = 1\%$, so lower than 5%. We can reject the null hypothesis, the coefficient cannot be zero and is statistically significant.

Overall Conclusion

In this analysis I went into more detail by dividing the number of companies in the area by sector. The aim of this work is to observe whether segmentation into sectors can offer us more information on the correlation with CO emission levels.
The first observation concerns the post variable which, as in the case without the division into sectors, is statistically significant and negatively affects CO levels over time, as explained in regression number 1.
The second observation concerns the sector variables and it can be noted that only the independent variable relating to the tourism sector has a statistically significant influence on the independent variable. Here, too, the influence is negative, so an increase in the number of companies involved in tourism leads to a decrease in the value of CO in the atmosphere.
Compared to regression number 1, the value of R-squared has grown so it seems that the inclusion of these new regressors can explain a higher percentage of the dependent variable but despite this there is no evidence that the level of CO is influenced by foreign direct investments and the increase in the Adj R-squared is not so high with respect to the first regression on CO.

8.5.4 Regression - 4

```
. regress diffCO diffAGR diffCON diffEXP diffGENTRA diffLIA diffMAN diffSER diffTOUR
```

Source	SS	df	MS		
Model	100.256998	8	12.5321247	Number of obs	= 92
Residual	1196.61604	83	14.4170607	F(8, 83)	= 0.87
				Prob > F	= 0.5458
Total	1296.87304	91	14.251352	R-squared	= 0.0773
				Adj R-squared	= -0.0116
				Root MSE	= 3.797

diffCO	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
diffAGR	-.5047995	.4028279	-1.25	0.214	-1.306008	.296409
diffCON	-.5225102	.7544398	-0.69	0.491	-2.023061	.9780401
diffEXP	.8360792	.9015675	0.93	0.356	-.9571023	2.629261
diffGENTRA	.0394703	.3009512	0.13	0.896	-.5591096	.6380502
diffLIA	.3920008	.5786979	0.68	0.500	-.759006	1.543008
diffMAN	-.2011456	.1812358	-1.11	0.270	-.5616163	.1593252
diffSER	.0653349	.2360828	0.28	0.783	-.4042243	.5348941
diffTOUR	-.1084834	.794341	-0.14	0.892	-1.688396	1.471429
_cons	-4.542592	.4319951	-10.52	0.000	-5.401813	-3.683371

Figure 40: Results CO regression 4 - Sectors

Overall Model fit

Also in this last regression the number of observation are 92,half of the preceding.
F(8,83) has a value of 0,87. The p-value associated with this F value is higher than before (0,5458). The p-value, compared to our alpha level is higher so we can conclude that the independent variable do not reliably predict the dependent variable.
The R-squared value is 7,73%.
The Adj R-Squared in this case is negative and equal to -0,0116.

Coefficients

If we go to increase the difference in Agriculture's firms and considering all the other constant variables it can be observed that the variation in CO decreases by -0,5047995, on average.

As for the Construction coefficient,the variation in the level of CO decreases on average by -0,5225102, always considering the other variables constant.

Increasing the export activities in the second time period causes a variation in the level of CO of 0,8360792.

The increase in General Trading firms lead to an increase of the dependent variable of 0,0394703, on average.

An increase in the Liason activities entail, considering all the other variables constant, an increase in the variation of CO of 0,3920008, on average.

Manufacturing activities lead to a decrease in the level of CO by a factor of: -0,2011456.
Instead, always considering all the other constant variables, an increase in the services activities lead

to an increase of the dependent variable of 0,0653349. Instead the tourism leads to a decrease of CO of -0,1084834.

t-distribution and P-test

Let's now analyze the results of the statistical test in which the null hypothesis is that all the coefficients of the equation are equal to zero.

$$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = 0 \tag{18}$$

We choose 5% as significance level.

Let's analyze the column with

$$P > |t|$$

If this probability is less than the chosen significance level then we reject the null hypothesis. We cannot say that the coefficient is statistically equal to zero.
On the contrary, if the value in the column is greater than the significance level then we cannot reject the null hypothesis that the coefficient is zero, the effect of the independent variable under consideration on the dependent variable is not statistically significant

If the null hypothesis for the first coefficient is true (β_1=0), the chances of us getting a sample extreme as we did (β_1=-0,5047995) would be $P > |t| = 21,4\%$ for Agriculture, which means that we cannot reject the null hypothesis of coefficient equal to zero. The coefficient doesn't have a significant effect on the dependent variable.

Considering the null hypothesis for second coefficient (β_2=0), the chances of us getting a sample extreme as we did (β_2=-0,5225102) would be $P > |t| = 49,1\%$ for Construction, which means that we cannot reject the null hypothesis has before. The variation of CO is not significantly affected.

If the null hypothesis for the third coefficient is true (β_3=0), the chances of us getting a sample extreme as we did (β_3=0,8360792) would be $P > |t| = 35,6\%$,also in this case the value is higher than the chosen significance level so we cannot reject the null hypothesis. The coefficient of the variable doesn't have significant effect on the level of CO.

For General Trading coefficient if the null hypothesis is true (β_4=0), the chances of us getting a sample extreme as we did (β_4=0,0394703) would be $P > |t| = 89,6\%$, so higher than 5%. We cannot reject the null hypothesis, the coefficient can be zero and is not statistically significant.

If the null hypothesis for the first coefficient is true (β_5=0), the chances of us getting a sample extreme as we did (β_5=0,3920008) would be $P > |t| = 50\%$ for Liason, this means that we cannot reject the null hypothesis. The coefficient is not statistically significant.

Considering the null hypothesis: (β_6=0), the chances of us getting a sample extreme as we did (β_6=-0,2011456) would be $P > |t| = 27\%$ for Manufacturing, also for this sector we cannot reject the null hypothesis.The variation in CO is not significantly affected.

If the null hypothesis: (β_7=0) is true , the chances of us getting a sample extreme as we did (β_7=0,0653349) would be $P > |t| = 78,3\%$. The value is higher than the chosen significance level so we cannot reject the null hypothesis. The coefficient of the variable is not statistically significant.

For the last sector, Tourism, if the null hypothesis is true (β_8=0), the chances of us getting a sample extreme as we did (β_8=-0,1084834) would be $P > |t| = 89,2\%$, so higher than 5%. We cannot reject the null hypothesis, the coefficient can be zero and is not statistically significant.

Overall Conclusion

In the latter case I went to insert as further regressors the variation over time in the number of companies for each sector.
Looking at the results of the regression we understand that no variable is statistically significant.
So changes in CO levels over time are not significantly affected by the change in the number of companies.
Also here compared to regression number 2 the value of R-squared has increased but even in this more detailed case we have some evidence of correlation between emissions and number of companies. The Adj R-squared in this case has a value that is lower with respect to regression 2 and is negative.

9 Conclusion

Foreign direct investments can have significant economic importance for the host country, It attracts new possible investors, allows an increase in jobs and a generalized increase in the wealth of the country.

As far as the environment is concerned, the effects of foreign direct investment are not always positive. Some countries deliberately do not include regulations regarding emission levels and environmental protection to attract more investors.

In the specific case of this study we analyzed how Ghana attracts more and more foreign investors as can be seen from the increase in the number of foreign companies located on the territory, especially in the southern part of the country.

But how is the environment affected by these investments?
Through the regression analysis we went to study the change in the levels of carbon monoxide and carbon dioxide emissions in relation to the change in the number of foreign companies on the territory. As far as carbon dioxide is concerned, we have found that it is not significantly influenced by the number of companies in the area.
Instead, as we can see in figure 36 the variable that influences the level of CO2 is post. This variable takes into account the period in which the data were collected, first period 2000-2010, second period 2011-2020. So the CO2 levels in the second period considered are higher. We also observed that there is no correlation between the change in CO2 levels and the variation in the number of companies between the first and second period of time.

For carbon monoxide we can draw the same conclusions as before. The only variable that influences CO significantly is post with the difference that in this case the influence is negative. CO values decrease between the first and second period of time. The conclusion of the analysis on the sectors of the companies present in the territory was that no sector significantly affects the level of CO in the atmosphere.

From our study we can conclude that in Ghana foreign direct investments have no significant environmental effects. Nothing seen in this work supports the pollution haven hypothesis.
However as our world continues to deal with the challenges of a globalized economy and environmental degradation, it is imperative to approach FDI with a clear understanding of its potential impacts.

While FDI can contribute to environmental improvements through the transfer of cleaner technologies, enhanced resource efficiency, and increased environmental awareness, it can also exert adverse pressures on the environment. Issues such as increased resource consumption, pollution, habitat degradation, and even displacement of local communities highlight the potential negative externalities of FDI.

In order to promote responsible environmental practices within various industries, it is imperative for governments both in home and host country to work together. This collaboration aims to eliminate counterproductive and wasteful competition that revolves around reducing environmental benchmarks. This objective calls for a comprehensive global structure for investment connections. This structure involves reaching consensus on established guidelines for overseeing the environmental aspects of Foreign Direct Investment (FDI).
It also encompasses defining the boundaries of impartial treatment at the national level, placing constraints on financial incentives associated with FDI, and amplifying international support for fostering and upholding the capacity for regulatory measures. The attainment of ecological stability relies on being part of a more extensive framework of economic administration. This framework should uphold and enhance fundamental human and labor rights, as well as facilitate sound market management.

In conclusion, in Ghana emissions are not affected by the change in the number of companies on the territory, the effects of foreign direct investments are not significant in terms of pollution. However, these investments must always be evaluated in detail to understand all possible environmental consequences with the aim of promoting the exchange of cleaner technologies.

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