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What Accounts for the Growth of CO2 Emissions in the Philippines? The Role of the Three Major Industries – Agriculture, Hunting, Forestry and Fishing, Industry, and Service Sector

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***Abstract*: This paper investigates the relationship between the GDP of the Three-Major Industries - Agriculture, Hunting, Forestry and Fishing (AHFF), Industry, and Service sector and the Carbon Dioxide (CO2) emissions of the Philippines from 1988-2020, applying the Multiple Linear Regression model. The study looks into the aggregation of the gross value added of the resident producer units in the country and not in the disaggregation of industries by sub-sectors. Empirical results from the model show that the GDP of the Industry sector is positively significant to CO2 emissions and disprove the hypothesis that there is no relationship between the variables. While the GDP of AHFF and the Service sector show a positive insignificant relationship to CO2 emissions, highlighting that it still contributes to greenhouse gas emissions but not to the same degree as the industry sector due to variations in production processes and energy requirements. In the same paper, carbon reduction proposals related to industry incentivization, and subsidization are recommended for addressing the increasing levels of Carbon Dioxide in the country and assisting the industries transition to a more greener production practices that satisfies the parameters of sustainability.**

***Keywords*: Carbon Dioxide (CO2) emissions, GDP by Three-Major Industries (Agriculture, Hunting, Forestry and Fishing (AHFF), Industry, and Service Sector), Incentivization, Subsidization.**

1. Introduction

The industrial revolution ushered lasting transformations not only in business and economics but also in the basic structure of the society (Wilkinson, 2020). It shifted small-scale farming into mass production of goods through the help of machineries. The advent of industrial development revamped the patterns of human settlement, labor, and family life and since then, development has been taking place in various forms. As industrialization materializes, environmental externalities transpire due to the actions taken by economic agents during the production and consumption of commodities and services. A previous study (Mahmood, et al., 2019) demonstrated that an economy's fundamental structure has a significant impact on how well it performs environmentally. Thus, it exclusively says that as an economy strives to grow and develop, it needs further improvement in the processes it involves, therefore needing an extreme amount of resources that unveils the picture of environmental breakdown.

Consequently, it epitomizes the most pressing concern of today's generation, that is the climate crisis. Whereas its manifestations include long-term shifts in temperatures and weather patterns, rising sea levels, forest burning, and stronger natural disasters. These repercussions are attributable to the rising anthropological activities in different parts of the world as brought about by the rapid industrialization among industries. In fact, as industrialization happens, extreme amounts of carbon dioxide and other greenhouse gasses are released into the atmosphere by various human activities, which has contributed to the warming of the earth's climate. Natural sources and processes, such as decomposition of organic matter, ocean release, respiration, volcanic eruptions and changes in the sun's energy are also accounted for by the rapid increase in carbon dioxide.

In accordance with the United States Environmental Protection Agency (2020), Carbon Dioxide (CO2) is the significant greenhouse gas generated by human activity. It naturally occurs in the atmosphere as a byproduct of the carbon cycle on Earth (the process by which carbon is naturally transferred between the oceans, atmosphere, soil, plants, and animals). Both through increasing the amount of CO2 in the atmosphere and by affecting the ability of natural sinks, including forests and soils, to absorb and store CO2, human activities are altering the carbon cycle. Despite the fact that a variety of natural sources produce CO2, it is human-caused emissions that are to blame for the atmosphere's growth since the industrial revolution.

One of the renowned cases that exhibit how human activities contributed to Carbon Dioxide emission took place in 2013, when typhoon Haiyan, otherwise known as super typhoon Yolanda, hit multiple regions in the Philippines that resulted in immense devastation of lives and properties. It was recorded as

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one of the most powerful tropical cyclones ever in modern history. Such occurrences are a great example of how industrial development affects the severity of a natural disaster. The amount of Carbon Dioxide emitted in the atmosphere by the Three-Major Industries in the Philippines, namely: (1) Agriculture, Hunting, Forestry, and Fishing; (2) Industry; (3) Service sector, contributed to the exacerbation of that typhoon. Furthermore, such an incident is most likely to happen again and could take into more serious forms of natural disturbances if little importance is given to the reduction and mitigation of greenhouse gasses by industries.

2. Literature Review

A. Agriculture, Hunting, Forestry and Fishing and CO2 Emissions

Lin, Boqiang and Xu, Bin (2018) studied the carbon emissions in China's agriculture sector among 30 provinces between 2001 to 2015. The provinces are broken down to 6 quantile grades, and the STIRPAT model and quantile analysis are used to look at the factors that influence CO2 emissions at low, medium, and high emission levels. The results showed that the impact of urbanization in the provinces in the higher 90th quantile is stronger than in the provinces in other quantiles due to variances in the degree of agriculture production and accumulation of human capital (Lin & Xu, 2018). Thus, in the provinces in the higher 90th quantile, financial capability had the greatest impact on CO2 emissions. However, compared to other quantile provinces, the 90th quantile provinces experience less of an influence from industrialization. Therefore, when considering the mitigation and reduction of carbon emissions in China's agriculture sector, it is advised to take into account the varied effects of the driving forces.

Similarly, Dong et al., (2020) extended the above analysis by integrating the STIRPAT decomposition model to their study. The study covers the six major industrial sectors in China namely Agriculture, Industry, Construction, Transportation, Retail, Accommodation and other industries from 2000 to 2017. These industries are the research objects of the study. Tapio decoupling method and the grey relation analysis are employed to further discuss the relationship among the variables. The study showed that since 2000, the value-added proportion to agriculture, manufacturing, and transportation are indirectly correlated with carbon emissions, while those of construction, retail, and accommodation, and other industries are directly correlated with the country's CO2 emissions.

In Chinese provinces from1997 to 2014, Luo et al. (2017) looked at the disengaging of carbon dioxide (CO2) emissions from agricultural economic growth. Furthermore, the paper examines the degree of regional and temporal variation in Carbon emissions in China's agricultural sector. It contrasts the decoupling of China's carbon emissions from the agricultural sector with the value of agricultural output over different geographical areas and time periods. The study's findings showed that cow rearing, rice cultivation during the season, and fertilizer use were the categories of agrarian manufacturing operations that produced the most carbon emissions. Additionally, it showed that between 1997 and 2014, East China accounted for the majority of the times when CO2 emissions strongly decoupled.

Samargandi, Nahla (2017) In the example of Saudi Arabia, the environmental Kuznets curve (EKC) hypothesis was evaluated by taking into account a number of distinct channels, including (1) production volume, (2) sector GDP value addition, and (3) technical innovation. The EKC hypothesis was refuted by the study using the autoregressive distributed lags (ARDL) methodology. The findings also indicated a linear connection between economic growth and Carbon emissions. However, it also puts forth the notion that Saudi Arabia's value-added growth in the service and industrial sectors is what is driving the country's faster rate of increase in CO2 emissions, while Saudi Arabia's value-added growth in the agricultural sector is only marginally and indirectly related to Carbon emissions. Alternately, technological progress has a negligible impact on the nation's CO2 emissions. Therefore, to reduce CO2 emissions without harming the nation's economic growth, significant technological advancement in the production process must be prioritized. Mahmood et al(2019) investigation of nearly the same analysis examined the environmental kuznets curve (EKC) hypothesis together with energy use and the revenue contribution from agriculture. The study examined how these factors affected Saudi Arabia's CO2 emissions. The EKC hypothesis is supported by the findings, which showed that the country's Gross Domestic Product per capita and Carbon emissions shared an inverted U-shaped relationship as well as the impact of agriculture to GDP and CO2 emissions.

Uniformly, the study of Alam, Janifar (2014) employed the same EKC hypothesis between the trends of CO2 emissions with GDP per capita of Bangladesh from 1972 to 2010. However, the U-shaped pattern does not hold true as what has been revealed in the study of Samargandi, Nahla (2017) and Mahmood et al., (2019). However, it observed a faster structural shift from agriculture to non-agriculture and the emergence of services that have a significant role in the rising trend of carbon emissions in the country.

According to a prior study (Lin et al., 2015), the industrial value-added and carbon dioxide emissions have an inverse and substantial relationship, indicating that there is no indication that industrialization has increased carbon emissions in Nigeria from the year 1980 and 2011. While population and GDP per capita have a favorable and considerable impact on CO2 emissions. Last but not least, industrialization's increased energy and carbon intensity has a 10% level positive but marginally significant influence on carbon dioxide emissions.

Balsalobre-Lorente et al., (2019) stated that according to empirical evidence, agriculture has a detrimental environmental impact in all of the BRICS countries. The study uses Dynamic Ordinary Least Squares (DOLS) and the Fully Modified Ordinary Least Square (FMOLS) for long run regression to investigate the impact of specific independent factors that influence carbon emissions in BRICS. This study supports the negative environmental impact of agriculture. Carbon emissions are also influenced by electricity usage and trade openness. However, using a mobile device minimizes pollution.

The relationship between power usage and agricultural operations has an additional detrimental effect on the ecosystem, according to this study. Consequently, this study suggests adopting cleaner energy methods and facilitating high-tech and clean foreign investment.

Due to Ethiopia's economy's substantial reliance on agriculture, the effects of climate change are compounded there. A recursive dynamic computable general equilibrium model was used by (Eshete et al., 2020) to investigate how CO2 emissions affect agricultural productivity and household welfare. CO2 emissions are detrimental to both home and agricultural productivity. Real agricultural GDP in the 2020s is anticipated to be 4.5 percent lower than the baseline under a no-CRGE scenario. Particularly CO2 emissions lower the productivity of both traded and non-traded crops, but not of cattle. All types of households are harmed by emissions, although rural, low-income households are especially at risk.

According to Parajuli et al. (2019), utilizing international panel data between 1990 to 2014 for 86 distinct countries, the researchers assess the influence of agricultural land and forests on carbon dioxide emissions using the Environmental Kuznets Curve methodology (EKC). The interactive panel data approach results that trees are a key factor in lowering carbon emissions worldwide, although the impacts differ per area. Keeping everything else fixed, they anticipate a 0.11 percent reduction in CO2 emissions for every 1 percent increase in forest area worldwide. The agriculture sector, on the other hand, has been identified as a real CO2 emitter. The work adds to the empirical evidence supporting forests' responsibilities in controlling atmospheric CO2, emphasizing the significance of forests in worldwide climate change strategies.

In 86 countries around the world, the hypothetical relationship between carbon emissions, agricultural area, energy consumption, and forests area is being studied using the EKC framework. Our results validate the EKC hypothesis on CO2 emissions by demonstrating the illustration of an inverted U-curve relationship between Carbon emissions and worldwide economic development, though the outcomes are distinct by region. Energy use and agricultural land area are positively correlated with CO2 emissions, showing that both industries are responsible for some of the atmospheric CO2 emissions.

The proportion of land and water resources influence agricultural carbon dioxide emissions differently in different Chinese regions. In general, provinces with a higher Matching Degree of Water and Land Resources (MDWL) than those with a lower MDWL had a far stronger inhibitory effect. The Logarithmic Mean Divisia Index (LMDI) model was used by (Zhao et al., 2017) to analyze the connection between the use of land and water resources and cultivational carbon emissions and to propose policy recommendations for the succeeding low-carbon growth of agriculture in China. The report recommends that in order to boost agricultural energy efficiency and encourage reduction of carbon emission, land consolidation, substantial processes, retrenchment of water irrigation, and crops should rotate through fallow fields.

The nation may achieve sustainable agricultural development by comprehending the connection between carbon emissions, economic expansion, and how the agricultural sector saves energy. In order to investigate the connection between carbon dioxide emissions, consumption of energy, and economical growth in the agriculture branch, Zhanga et al. (2019) used the autoregressive distributed lag (ARDL) model. Both immediately and later on, the amount of energy used in agriculture has a detrimental impact on agricultural carbon dioxide emissions. The analysis found that there is a causal relationship going in both directions, from farm power use to cultivational agriculture economic growth and its carbon emission, in both the short term and long term.

Forests, according to Routa et al., (2011) function as carbon dioxide (CO2) sources and sinks that affect atmospheric CO2 levels and the earth's climate. This emphasizes how important it is to understand how management and the dynamics of the forest ecosystem interact to affect the carbon balance in forests. This is especially true when evaluating the function of forest biomass in energy generation as a substitute for fossil fuels.

Energy generated from forest biomass contributes to the global carbon cycle. Because the burning of biomass emits the same amount of CO2 that was gathered during its growth, this energy is termed carbon neutral. This is accurate in the long run, but at different phases of the energy biomass supply, CO2 and other greenhouse gasses (GHG) are released. The production and management of biomass, in addition to the operation of bioenergy plants and the shipping of feedstock and biofuels, all require the use of fossil fuels. However, management and harvesting practices change the amount of carbon that forest ecosystems store.

Withey et al., (2019) explained that many recent reports claim that bioenergy causes global warming because of the length of time it takes to regenerate a forest after a forest is taken down and when emissions are at their peak. As a result, The GWP of bioenergy, or GWPbio, has been studied in a number of recent studies. Bioenergy may be an effective substitute for fossil fuels in the fight against climate change if the magnitude of GWPbio is less than that of fossil fuels (normalized to one). A positive GWPbio, on the other hand, implies the presence of climate change rather than zero or negative emissions from bioenergy. Negative GWPbio values would suggest that bioenergy, like BECCS, can support IPCC policy objectives by reducing emissions.

With regards to the CO2 emissions coming from Fishing sector, according to Krista Greer (2011) in order to understand how to reduce and/or control the impacts of climate change, it is important to first investigate the variables that contribute to GHG emissions. GHG emissions, mostly from fuel burning, have been identified as the primary driver of climate change. As a result, there has lately been a lot of research on which industrial sectors are major contributors and how their carbon emissions might be decreased. Fishing is now an industry that has been largely disregarded, despite being one of the most energy-intensive food production methods in the world, relying virtually entirely on fossil fuels. The contribution of fisheries to global GHG emissions has largely gone unstudied, although preliminary estimates imply that industrial fishing contributes around 1% of world GHG emissions.

GHG emissions from marine boats are connected with fuel consumption, and fuel consumption may be estimated using fishing effort. The fishing effort was computed by multiplying nominal fishing power, estimated from length, by the number of fishing vessels, days spent fishing, and a technical coefficient to calculate effective effort: the energy wasted over a given unit of time (kWdays-1). Similarly, estimating CO2 emissions may be done by first estimating the fuel burned per vessel in a particular fleet; this value can then be multiplied by an emissions factor to provide the effective CO2 emissions from a certain fleet.

H1: There is no relationship between the GDP of AHFF and CO2 emission.

B. Industry sector and CO2 Emissions

Shahzad et al., (2021) studied the dynamic connections in the Philippines between the use of coal energy, geothermal energy, industrial value added, and carbon emissions. Shahzad et al(2021) .'s focus was to close the gap between total renewable energy and economic growth as well as the absence of research on how geothermal energy affects economic and environmental indicators. The f-bounds test, ARDL, and pairwise granger causality test were all used in the study. Results confirmed the feedback hypothesis that there exists a bidirectional connection among production of energy and total income. It has been discovered that industry value added drives coal use and vice versa. While coal and geothermal energy show a paradoxical positive and negative impact on carbon pollution over the short and long terms. These conclusions highlight the value of incorporating geothermal energies into the country's electricity supply chain given that the country's electricity structure is predominantly controlled by fossil fuels.

There are indications that a test of carbon trading strategy has a considerable positive impact on the pilot programs' target industries' ability to compete globally in the low-carbon economy. The difference in difference in difference model (DDD) and a number of dependable tests were used by (Qi et al., 2021) to demonstrate how a policy in carbon trading enhances low carbon industry aggression by accelerating advancement in technology to cut carbon emission. In addition, an examination of the phenotypic variation in attributes and methods for allocating carbon allowances across pilots reveals that the influence of policy in carbon trading on industry low-carbon global aggression is largely mirrored in industry sectors with comparably low carbon dioxide emissions, state-owned capital, and significant exports.

An et al. (2021) used the DEA-GS (co integration analysis and grid search) concept to influence the creation of the carbon policy of China from a cost perspective and comprehend the characteristics of carbon reduction in the manufacturing sector. Each sub-impact sector's number of reduction activities and enterprises is different. Manufacturing enterprises' emission reduction behaviors are largely concentrated in urbanized areas or in the vicinity of big cities, as assessed by carbon pricing. Areas with significant emission reductions, on the other hand, are more dispersed. The study suggests that it is crucial to fully recognize the unique characteristics of each sub-emission sector's reduction when developing carbon regulations for China's manufacturing sector. Furthermore, China's manufacturing sector's carbon strategy needs to go beyond simply developing regions.

The manufacturing industry has been considered as one of the largest producers of carbon emissions and understanding the factors that influence Carbon emissions is critical for successful environmental policy. Studies of the effects of foreign direct investment (FDI), economic development, and intensity of energy on the manufacturing carbon emissions of China use the fixed effect panel quantile regression model (Ma et al., 2020). The study reveals that the manufacturing sector of China has a lot of room to cut emissions. Economic expansion has a favorable impression on manufacturing industry carbon dioxide emissions, with a greater benefit in high-carbon-emitting regions. The reduction of energy intensity has no effect on carbon dioxide emissions reduction. The stronger influence of energy intensity on carbon emissions from manufacturing in higher-emission regions indicates that there is a rebound in energy effects in the manufacturing industry in China.

As people become more conscious of the importance of sustainability, the concrete sector has been pushed to lower its carbon footprint. The production of Portland cement, the main binder in concrete, as well as the transportation of materials account for nearly all of the carbon dioxide emissions from the industry sector. The emissions from the concrete industry are also influenced by other ingredients, including aggregates, admixtures, and construction techniques. Additionally, because the manufacturing of concrete has increased, the natural reserves of these resources are under a great deal of stress. The concrete industry is a big user of natural resources. However, the industry has taken some encouraging initiatives in the past ten years to improve its sustainability and reach net-zero emissions by 2050. These initiatives cover everything from the utilization of alternative resources, such as waste products, to process optimization for the manufacture of concrete and the utilization of alternative energy sources. Innovations in the concrete sector that reduce carbon dioxide emissions will not only improve the sustainability of our environment but also create new opportunities for supplying the raw materials needed to produce concrete in the future. Additionally, incorporating various initiatives to lessen carbon emissions linked to the concrete production would lead to a comparable drop in the price of concrete (Adesina, 2020).

As expressed by Nidheesh & Kumar (2019), Fuel combustion and clinker formation in the cement industry produce carbon dioxide emissions, therefore, could be diminished by encouraging cross with raw materials that have been decarbonated in place of carbonate stone. Further reducing carbon dioxide emissions can be accomplished through enhancing efficiency of energy, process technology, and putting carbon capture technologies into use. The greater energy requirements for clinker manufacturing can be reduced by using mixed cements. The requirement for energy in the cement industry is significantly reduced through the introduction of waste heat recycling systems, highly efficient calciners and precalciners, highly efficient clinker coolers, high efficiency separators, high performance dryers, and other energy-saving equipment.

The use of a sustainable strategy in steel production reduces waste and emissions. Nearly all of the carbon emissions from the steel sector are caused by iron production in blast furnaces. Around nine hundred ninety-seven kg of carbon dioxide are released every bulk of steel in the steel sector, which makes up around 4–5% of international carbon emissions. The main source of Carbon emissions comes from the blast furnaces used to make iron. The use of advanced technologies, like the development of enhanced steel instead of conventional steel, the use of biomass, such as charcoal, rather than coke and coal in blast furnaces for the production of steel, and the adsorptive developed water gas shift technology are just a few examples of methods to cut carbon dioxide emissions. Carbon sequestration, conversely, can help to lower emissions. By switching out old blast furnaces for direct reduction/electric arc furnaces and utilizing waste heat recovery techniques, energy consumption during production can be reduced partially. In addition to being used as raw materials for soil improvement, steel byproducts can also be used to make cement, steel, electrode preparation, glass, ceramics, fertilizer, cosmetics, and other products.

The study of Miller et al., (2018) is a proposal to the UNEP series on eco-efficient cements, which tests how material-based solutions can reduce Carbon emissions from the production of cement while taking into account factors that could affect uptake. Urbanization around the world has led to an escalation in demand for cement and items made from it. The Carbon emissions from its fabrication are increasing questions due to its rising usage. However, research has not yet been done on the significance of reduction plans in an international framework that takes material availability and market uptake into account. This study shows that increasing the calcined clay usage and tailored filler with dispersants can help achieve the 2°C scenario goals for 2050. Reaching reduction goals may be made possible through the creation of novel Portland clinker-based cement substitutes, the use of materials activated from alkali, and improved cement effectiveness. Reducing technologies are already available and may be readily implemented.

Numerous studies of the literature stress the significance of manifested energy and resource emissions for zero energy, zero emission structures (Chastas et al., 2018). Thus, he examined 95 case studies of rural buildings' assessments in an attempt to evaluate the scope of incorporated carbon emissions and its relationship to the proportion of incorporated energy and carbon for various degrees of the building's efficient energy. In order to evaluate the variables, the study used the life cycle inventory (LCI) technique. Results demonstrated that structural components had a larger environmental impact than wood structures, whereas concrete structures had a lower GWP impact than steel structures across a wide variety of system limits.

Fugiel & Smolinski (2017) investigated the environmental impact evaluation of the mining and quarrying industries' emissions of air pollutants of the 12 countries in Europe by using the LCA (Life-Cycle Assessment) model. Finland, Bulgaria, Denmark, Germany, Spain, France, Poland, Italy, Great Britain, Norway, Finland, Netherlands, and Czech Republic are among the 12 nations that were taken into account. The combined figure of the quarrying and mining industries' production of these nations accounts for 98.3% of the sector's overall production value in all of Europe. Data for 2012 was analyzed, and the results revealed that the quarrying industries as well as mining in Great Britain and Bulgaria had the greatest and lowest particle and gas emissions, respectively. The greatest environmental indices in Norway, Germany, Poland, Great Britain and Germany were discovered in all of the consequences and harm categories for the two sectors.

The carbon dioxide emissions in the construction sector of China between 1995 and 2011 were empirically researched by Chen et al. (2017). The IO (Input-Output) model is used to carry out this study. The global input-output database served as the source of the data. The investigation' findings showed that from 1995 to 2011, when they reached 3035.9 Mt, carbon dioxide emissions in the construction industry of China climbed by 388.7%. Nevertheless, between 1995 and 2011, the sector's carbon intensity dropped by 46.9%, reaching 0.00198 Mt/million USD.

Hasanbeigi et al., (2016) elaborated that Manufacturing processes that need a lot of energy include the manufacturing of steel and iron. The study's objectives were to create a framework for contrasting the carbon dioxide intensity with regards to energy requirement of the steel creation across nations and at the same time to show how this methodology may be used to examine the steel industries of Mexico, United States. Germany, and China. The approach addresses the establishment of the conversion and industry's factors and borders as well as organizational framework. Manufacturing processes that need a lot of energy include the manufacturing of steel and iron. The study's objectives were to create a framework for comparing the energy-related carbon dioxide (CO2) emissions intensity of steel production across nations and to show how this methodology may be used to examine the steel industries of Mexico, United States, Germany, and China. The approach addresses the establishment of the industry's borders, conversion factors, and organizational framework.

On the other hand, the country of China, has the least production percentage of EAF between the four nations, accounting for 9.8% at 2010's base year. In one situation, the researchers integrated the share of EAF Chinese citizens in the other case studies in the country, resulting in the steel's production contribution to CO2 emissions of 19% in Germany, 92% in the country of Mexico, and 56% in the United States when differentiated to the analyses of base-case for these countries. In the counteracting scenario, they have integrated to the other three nations the national average grid power of China with the carbon dioxide emissions factor from the year 2010 that has the inflated emissions factor among the four. The intensity of CO2 emissions from steel manufacturing have grown by 5% in the country of Germany, while 11% in Mexico, and in the United States by 10% under that scenario.

To combat climate change and achieve sustainable growth, it is necessary to measure the elements that cause CO2 emissions in emerging nations (Sumabat et al., 2016). The Philippines' CO2 emissions are well documented, but there is little analytical research on the factors that cause them. As a result, Sumabat et al. (2016) applied the LMDI (logarithmic-mean-divisia-index) to calculate the factors that changed how much CO2 the Philippines emitted from 1991 to 2014. Results indicated that greater standards of living and economic expansion had a detrimental influence on CO2 emissions. Economic activity as well as energy intensity both contribute to CO2 emissions, although in opposite directions.

Yan & Fang (2015) studied the negative effects that China's manufacturing sector's energy-related carbon dioxide emissions have on both the nation and the rest of the world. The study focused on the historical trends and characteristics of CO2 emissions in the industrial section of China and then used the logarithmic mean divisia index (LMDI) approach to further analyze its affecting elements. By including scenario analyses, it also investigates potential mitigation measures. The findings revealed that (1) although CO2 emissions intensity showed a declining trend from 1993 to 2011, they underwent remarkable but erratic growth over that time. (2) It was discovered that an emissions configuration dominated by electricity was vulnerable to an emissions structure dominated by coal. (3) The top three industries that produced almost 60% of all CO2 emissions were the smelting and pressing of ferrous metals, as well as the production of raw chemicals, chemical products, and non-metallic mineral goods. (4) The economies of scale was the largest cause of CO2 emissions, while energy intensity was the factor that contributed the least. (5) Reducing CO2 emissions in the near future will mostly depend on decreases in energy intensity.

According to Hasanbeigi et al., the creation of steel and iron is one of the most energy-intensive industries in the world (2014). In addition, the creation of steel and iron uses a lot of coal, which results in some of the biggest CO2 emissions of any business. The International Energy Agency (IEA) estimates that the industry of steel and iron is responsible for 27% of all CO2 emissions from the global industrial sector.

Annual global steel demand is predicted to rise from around 1410 million tonnes (Mt) in 2010 to around 2200 Mt in 2050. The majority of this expansion will occur in China, India, and other Asian developing countries. This huge rise in steel use and production will result in a significant expansion in absolute energy demand and carbon dioxide emissions for the sector.

According to projections, the annual global demand for steel will increase from roughly 1410 million tonnes (Mt) in 2010 to roughly 2200 Mt in 2050. China, India, and other developing nations in Asia will account for the majority of this expansion. Absolute energy demand and CO2 emissions for the industry will climb significantly as a result of this enormous increase in steel use and production.

Hanafi & Zurina (2013) stated that the Transportation industry is a main contributor of greenhouse gasses that give direct impact to the environment. Planning for multimodal transportation is crucial because it makes it possible to lessen the environmental impact of transportation by combining at least two modes into one chain of transportation, without changing the goods' container, with the majority of the course being traversed by rail, road, ocean vessels, or in-land waterway, as well as with the relatively short beginning and final travels made possible by the interconnected roadways. In the fresh produce sector, multimodal transportation planning is recommended, with time as another element. The sensitivity analysis result is explained in order to draw academic and practical conclusions for carbon control policy making and logistics network layout.

According to Zhou et al., (2013), CO2 emission intensity in China has increased dramatically since 1995, with coal usage accounting for the most dramatic increase. Because natural gas use has remained steady, carbon dioxide emissions from natural gas have not changed much. Crude oil consumption grew after 2004 but has lately fallen due to price increases. China's CO2 emissions have mostly come from coal consumption, and emissions from coal have been on the rise since 2002, notably between 2007 and the year 2009, the degree of carbon emission has increased from 2007 with 5.25E+12 t and in 2009 with 9.14E+1.

The researchers also found evidence that the little carbon progress and development plan has contributed to the reduction of Carbon Dioxide emissions by causing a decline in the intensity of local infrastructure development's CO2 emissions. The quantity of urbanization and CO2 emissions are significantly positively correlated. China is increasingly urbanizing, which raises energy use and rigidly raises the demand for energy requirements. The steel and cement, both of which can only be manufactured in the United States, are in higher demand because of the construction of a sizable scale of housing projects and other forms of infrastructure. In addition, the employment structure in China mandates the supremacy of an intensive labor sector. Urbanization and energy consumption go hand in hand logically for a nation the size of China. Furthermore, due to the close relationship between urbanization and industrialization, high-energy intensive industries have increased in size quickly, leading to a large surge in the consumption of energy. The Carbon Dioxide emission of China has also been significantly impacted by migration from rural to urban areas.

According to Sesso et. al., (2020) regardless of the country under consideration, the economic activities that need non-renewable fossil fuels (transportation), huge amounts of energy (mine, metallurgy), and by-products of petrochemical origin (rubber and plastic) have the largest percentages of growing emissions. Textiles and apparel, with a 55 percent loss in US sector emissions and a 44 percent drop in the EU, and leather and footwear, with a 72 percent drop in the US and a 42 percent drop in the EU, were the sectors that demonstrated emission reductions in the majority of the nations under review. When all nations were considered, the electricity, gas, and water sectors had the greatest absolute value of emissions per unit of production (million dollars in 2009).

H2: There is no relationship between the GDP of the Industry sector and CO2 emission.

C. Service Sector and CO2 Emissions

Numerous studies have been conducted with regards to the use of energy and CO2 emissions in the industrial areas (Wang et al., 2020). However, research on the environmental difficulties generated by the rise of the service industry have been insufficient. Thus, Wang et al., (2020) looked into the embodied Carbon Dioxide emissions and the efficiency of the service sector in China. The three-stage data envelopment analysis (EDA) model and input-output analysis were used. Findings showed that the service sector emitted a notable level of embodied CO2 emissions. As a result, there is substantial disparity in CO2 emissions efficiency, which is unchanging with the amount of regional economic development.

Reduction of Carbon Dioxide emission in service sector as well as its temporal and spatial distribution, is crucial to encouraging green growth in the service industry; however, research on carbon emission reduction maturity (CERM) as well as with the regional disparity of spatial mechanism is limited. (Wang et al, 2019) addresses this issue by selecting the service industry's starting index CERM derived from the Kaya identity, measuring the China's CERM for the service industry from the year 2006 to the year 2015 integrating the grey relational model, and then examining the structural pattern of its development using the spatial auto-correlation approach. The findings demonstrated that CERM in the service industry in China is spatially aggregated. Neighboring regions of similar maturity impact one another and cause evident geographical spillover effects, resulting in a decrease in spatial disparity.

The influence of ICT to both consumption of energy and CO2 emissions differs across the sectors in the economy. Shabani and Shahnazi (2019) evaluated the short-run and long-run causation among the variables Carbon Dioxide emission, energy consumption, GDP, and Iranian economic sectors ICT from the year 2002 to 2013. The DOLS (Dynamic Ordinary Least Squares) estimator was used to approximate the relationships between the variables stated above in the long-run. The observed data indicated the existence of an environmental Kuznets curve among the sectors studied, as well as ICT's positive influence on the Carbon Dioxide emissions in the industrial sector and its detrimental influence on CO2 emissions in the sectors of services and transportation.

The Carbon Dioxide emissions and the Vehicle Miles Traveled of the two models of delivery—one using auto and unmanned aerial vehicles (UAVs) and the other using trucks were estimated in a prior study (Goodchild & Jordan, 2018). This investigation looked into potential variations in Carbon Dioxide emissions and VMT among the delivery and passenger vehicles. Based on the results, emissions vary considerably and are strongly influenced by the drone's energy needs and by the distance traveled and the recipients it serves. Additionally, it was discovered that the VMT measurements for both models were comparable to previous research contrasting regular passenger travel with truck delivery.

Meng et al., (2017) stated that the System of National Account's conventional sectors do not include tourism, making national-scale carbon dioxide emissions figures difficult to quantify. In other investigations, the bottom-up and top-down measuring methodologies were mostly utilized. The Input-Output (IO) model of the tourism satellite account from the productive yielding industry are combined, with an extremity that takes in the domestically and inbound tourism consumption. The domestic tourism consumption incurred in association with the outbound travel, and domestically incurred tourism in connection to the paid airfares of national carriers to accurately estimate the national Carbon Dioxide emissions of the tourism sector.

According to the research, the overall CO2 emissions of the tourist sector of China were the following figures, 111.49 Mt, 141.88 Mt, 169.76 Mt, and 208.4 Mt in 2002, 2005, 2007, and 2010, accounting for 2.489 percent, 2.425 percent, 2.439 percent, and 2.447 percent of overall CO2 emissions of China. Except for the transportation industry, the indirect carbon emissions from other tourism sectors were 3-4 times higher than their direct CO2 emissions. When differentiated to the production business, the tourist sector produces less pollution and uses less energy.

The Carbon Dioxide emissions from the service section have expanded quickly in response to China's economic development and industrial upgrading. Service sector comprises businesses, such as hotel and catering, retail, wholesale, real-estate and financial. The service sector's CO2 emissions ranked third overall, causing an increase from the figure of 52.5 Mt in 1992 to a high record of 251.3 Mt in 2012. The standard CO2 emissions to added value ratio in the service industry was 67.5 RMB (in tons/millions), which was significantly lower than the counterpart sector which is the industry with a value of 838.7 RMB (in tons/millions). As a result, in order to reduce overall emanation, the national government of China should appropriate policies that will support future expansion of the service sector, including culture, tourism, finance, and education (Zhao et al., 2017).

Piaggio et al. (2015) investigated the emissions of carbon dioxide of Uruguay's service sector division in 2004. Input-output analysis was integrated to determine the link of Carbon Dioxide emissions between the service subsystem and the rest of the economy. As a result of transportation-related industries, the results revealed that direct emissions from services constitute the most significant component. The pollution that the service subsystem gives to the rest of the economy, on the other hand, is enormous and is nearly entirely accounted for by non-transport related industries.

In the study titled "Total-Factor Carbon Emission Performance of the Chinese Transportation Industry: A Bootstrapped Non-radial Malmquist Index Analysis," Zhang et al. (2015) concluded that the transportation industry total-factor CO2 emission performance over the year has decreased significantly by 32.8%. The reduction was associated with the technological reduction in China's transportation sector.

According to Zhang et al. (2015), increasing global trade is a factor in rising CO2 emissions, especially in the short term.

Even worse, exporting production and the resulting carbon leakage from industrialized to low wage developing nations may not only increase CO2 emissions in developing nations but also have a net impact on world emissions. Long-term dynamics indicate that CO2 emissions in many developing nations will initially increase before declining as they reach significantly higher income levels.

The transportation sector eats up a high-level of energy and eventually causes major problems in the environment. Activities related with transportation services are developed in China, including modes of transportation, volumes of freight and passenger turnover, distance traveled, and other life cycle characteristics. Duan et al. (2015) used a simplified life cycle assessment technique to investigate what percentage of carbon emissions created at the national level are attributable to road, air, water, rail, and pipeline transportation services, as well as what important factors influence carbon emissions. The findings reveal that carbon emissions from the transportation service sector have increased quickly in recent decades, roughly correlating to annual turnover increases. The acquired results provide a fundamental foundation for properly dimensioning emissions in the transportation service industry.

Using second-stage panel data techniques, Martinez and Inés (2013) discovered that productivity in labor, energy taxes as well as investments have a positive significant impact towards the Carbon Dioxide emission and energy intensity, inferring that escalating these factors leads to decreased carbon emission intensity and increased energy efficiency. The study emphasizes the need for both formulating and implementing suitable energy-related policies directed to further stimulate and improve energy usage and industrial sectors management of energy to attain the prime goal of developing an economy that is low-carbon emission. The data illustrated that the service firms of Swedish have expanded their energy utilization together with Carbon Dioxide emissions over the studied period, however energy intensity and carbon emissions have declined in recent years. The service industry of Swedish has a lot of space to develop a better energy efficiency to reduce Carbon Dioxide emissions, based on the eco-efficiency models in the Malmquist data envelopment analysis model.

In a prior study, Lin and Xie (2014) investigated China's transportation sector by using the Kaya Identity model and Monte Carlo approach to examine the long-term link between CO2 emissions and influencing variables such energy intensity, Gross Domestic Product, urbanization rate, and carbon intensity. According to the findings, the transportation sector in China will emit 1024.24 mt of carbon dioxide in the year 2020 under the Business as Usual (BAU) scenario, compared to the 304.59 mt and 422.99 mt, respectively, under the restrained and advanced reduction emission scenarios.

From 1996 to 2010, Wang and Zhang (2014) investigated the stochastic, σ and β-convergence of CO2 emissions in six industries in 28 Chinese provinces. They observed that between 1996 and 2010, the std. of CO2 emissions for each sector have declined, meaning that the sectors display σ-convergence. Unit root panel testing demonstrated that stochastic convergence occurred in all sectors. Meanwhile, the β-convergence test results demonstrated that the per capita CO2 emissions have conditional convergence. The main factors that influence the convergence per capita of CO2 emissions in the industry sector are the industrialization processes, GDP per capita, and population density. The convergence of per capita CO2 emissions in the telecommunications, postal, and transportation sector were impacted by the per capita GDP and population density. In addition, trade openness has also affected the convergence of CO2 per capita emissions in the retail, trade, wholesale, and catering sectors. Lastly, the convergence of CO2 emissions per capita in residential consumption, retail and wholesale, as well as trade and catering sectors is affected by the population density.

According to Zhang et al., (2014), a large chunk of consumption-based Carbon Dioxide emissions of the provinces were manufactured by the urban consumption that include economic agents food, livelihoods, clothes, gas, etc. From the year 2002 and 2007, the portion for food remained relatively stable, while the garment and textile consumption share have declined in most Chinese locations. The merged share of CCEU in total for the EHGW sector has increased. For instance, between the years 2002 and 2007, the percentage of general transmissions from clothing have decreased from 19 to 7 percent, while the EHGW percentage has increased by 15% from 7 to 22 percent. The sudden increase was associated with the rapid rise in the demand for energy and water utilizing appliances and the indirect use of EHGW as an input to production of other commodities in the market.

Because of the abrupt rise in consumption of the urban to services such as travel, sports, education, etc., from the year 2002 and 2007, a portion of the Carbon Dioxide emissions based on consumption produced by the service sectors for the general CCEU have exorbitantly increased in most provinces. Therefore, the paper suggests that the government should enact governing rules that will alter the usual capital investments patterns to further decline the trajectory of growth in carbon emissions caused by the usage of capital materials and services.

According to Andreoni and Galmarini (2012), decomposition analysis is used to assess success in decoupling Italian economic development from CO2 emissions. The time period covered is 1998-2006, which is significant since it falls between the passage of the Kyoto Protocol and the October 2008 financial disaster. The service sector was the most important contributor to GDP growth, accounting for more than 63% of the increase. It was the only industry that had a rise in CO2 emissions as a percentage of GDP (6.3%). Carbon dioxide emissions from the services sector increased by nearly 6800 kt from 1998 to 2006. According to the decomposition analysis, economic activity (G impact) and structural changes effect (ES) are significant drivers to the expansion in carbon emissions from the services sector. According to ENEA and ISTAT figures, the service sector accounts for greater than 60% of total Italian Gross Domestic Product.

The global carbon emissions have escalated from 22.5 billion tons in the year 1990 to 31.5 billion tons in 2008, according to Lin & Sun (2010). Since 2006, China has surpassed the US as the largest CO2 emitter, thanks to the country's remarkable growth economically, a heavy energy coal system, and the growth of exports. The GDP of China has increased by 10.1% from 2000 to 2008, and more than half of the country's coal consumption went toward meeting electricity demand. According to some research, exports from developing countries help to sustain the rising consumption of energy-intensive commodities in the developed world. In 2008, goods and services exports made up around one-third of China's GDP. As a result, these developing nations' production-related greenhouse gas emissions rise.

Transportation operations are the ones that produce the largest direct emissions in the industry. Other areas of the economy rely on these operations to a greater extent than they do on their own. As a result, emissions from products sold to other sectors surpass the ultimate demand. However, Alcántara and Padilla (2009) describe how, in the case of other service activities, direct and indirect emissions connected to final demand are significantly more relevant, due to the considerable pull impact of service activities on other economic activities. Retail and wholesale commerce, restaurants and hotels, real estate, rental and commercial enterprises, and government services all want special attention. These services are given less attention in the drafting of laws aimed at reducing emissions, despite the fact that they are mostly responsible for the recent major increase in emissions.

Friedl & Getzner (2003) found that in addition to economic growth, the momentary changes in Gross Domestic Product and weather situations can influence CO2 emissions. Furthermore, it has long been hypothesized that changes in the structural area in a minor open economy like Austria's play a crucial part in determining Carbon Dioxide emissions. The researchers found that growing the service sector generally results in lower CO2 emissions. In addition to "exporting," firms that emit CO2 also reduce CO2 emissions through imports. However, Austria's CO2 emissions are primarily caused by economic growth. Structures can only be changed so that they have less of a tendency to develop; they cannot, on their own, reduce CO2 emissions sufficiently to bring about a mean-reversion process of emissions.

Increased import restrictions or the importance of the service sector as a whole are examples of structural changes that do not have enough of an effect to stabilize or lower CO2 emissions. Policy changes aimed at "policy induced price shocks," such as the ecological tax reform, have appeared to be the most suitable environmental policy mechanism for successfully reducing carbon emissions. Austria will need to make a significant change to its climate policy in order to meet its obligations under the Kyoto Protocol.

H3: There is no relationship between the GDP of the Service sector and CO2 emission.

D. Simulacrum

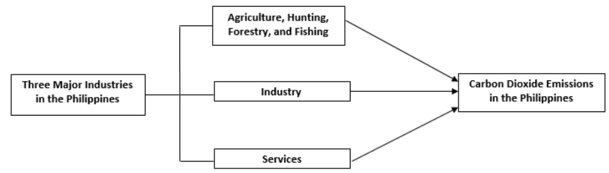

Fig. 1. Simulacrum of AHFF, Industry, and Service sector and Carbon Dioxide (CO2) emissions in the Philippines

3. Methodology

In this chapter, the researchers give the discourse on the data and sources of the study, the research method employed, and the estimation procedure, otherwise known as the statistical treatment, that will be used to conduct an explicit data analysis and interpretations.

A. Data and Sources

This study utilized the Global Carbon Project time-series data set for the annual CO2 Emissions of the Philippines and the time-series data set from the Philippine Statistics Authority (PSA) regarding the GDP of the Three-Major Industries for the period 1946 - 2020. The study looks into the aggregation of the gross value added of the resident producer units and not in the disaggregation of industries by sub-sectors as there is limitation in the availability of data from the Philippine Statistics Authority (PSA). The study has an equivalent number of 75 observations. The dependent variable is the annual carbon dioxide emissions measured in metric tonnes. While the independent variables include the Gross Domestic Product of the Three-Major industries namely, (1) Agriculture, Hunting, Forestry and Fishing, (2) Industry, and (3) Service sector in million Philippine peso at constant 2018 prices. This grants the researchers to consider the relative influence of the GDP by industry on CO2 emissions in the Philippines.

B. Method of the Study

This paper utilizes the Quantitative Research method as the procedure for gathering the date and interpreting it afterwards. It is applied to determine patterns and averages, to make predictions, to verify the causal connections, and to generalize findings for larger groups (Bhandari, 2021). This study will apply a causal-comparative type of research design as it will examine which of the Three-Major Industries has the most contribution to the Carbon-Dioxide Emission in the Philippines. It will also look into whether the independent and dependent variables have a direct or indirect relationship with one another.

The mathematical model that will be applied is the Multiple Linear Regression Model. Multiple Regression is developed primarily for creating regressions on models with a single dependent variable and multiple independent variables (Grant, 2019). It also investigates the relationship between numerous independent variables and one dependent variable (Hayes, 2022). It is in line with the study because there will be three independent variables that will be observed in relation to the one dependent variable. There are two major advantages of utilizing a multiple regression model to analyze data. The first is the capacity to determine the relative effect of one or more predictor variables on the criteria value. The capacity to detect outliers, or abnormalities, is the second benefit. Any drawback of employing a multiple linear regression model, on the other hand, is typically due to the data being utilized. Using inadequate data and incorrectly thinking that a correlation is a causation are two examples of this (Weedmark, 2018). The software that will be used in order to generate the Multiple Regression Model is the GRETL Software. The GRETL is the first full econometric software package which is distributed via the GNU software license (Baiocchi and Distaso, 2003).

C. Estimation Procedure

First, this study will estimate the Goodness-of-fit of the OLS framework, for the researchers to conduct the Multiple Linear Regression Model to imply that there is a correlation between each independent variable and the single dependent variable. By assigning a unique regression coefficient to each independent variable, the researchers may ensure that the more influential independent factors drive the dependent variable. The essence of this is to examine what factors of industrial development contribute to the growth of CO2 emission based on given multiple independent variables (Three-major industries in the Philippines). Also, to determine the strength of each variable's relationship to the Dependent Variable.

Inputting Annual C02 emission as the dependent variable and the three-major industries as the Independent Variable. Rearranging the formula into

$$C02 = B0 + B1AHFF + B2IND + B3SRV + e$$

Whereas

- C02 = The estimated figure value of the dependent variable
- B0 = the constant (y-intercept; the figure value of y if all the parameters are set to 0)
- B1AHFF = The regression coefficient of the Agriculture, Hunting, Forestry and Fishing
- B2IND = The regression coefficient of Industry
- B3SRV = The regression coefficient of Services
- e = model error (asking how much variation there is in our estimate of CO2)

After rearranging the formula of multiple linear regression, using the gretl software, the researchers are bound to find the descriptive statistics and time series plot which summarizes and describes the data set being used. The gretl software will guide the researchers throughout the entire model creation process. Also, there are certain conditions that allow the researchers to identify if the data set being used is useful or needs to be altered for them to come up with a promising OLS model. The correlation matrix would tell the researchers that if all variables output is less than 1, then it indicates that the data set is not highly correlated. In the collinearity diagnostics test, if the condition variables are less than 30, then that indicates that there is no evidence of excessive collinearity.

Finally, various diagnostic tests will be employed to evaluate the fitness of the model. For instance, this study integrates the Augmented Dickey-Fuller Test to determine whether the variables would show an asymptotic p-value of less than (0.05) alpha, if not, then it indicates that the researchers should use the add log or add differences among their variables in the OLS output. Concurrently, the researchers would conduct heteroskedasticity, autocorrelation, normality of residual, ARCH, Chow Breakpoint and Ramsey Reset Tests to determine the degree of goodness of fit of the model.

4. Results and Discussion

This research aimed to determine which Philippine industry sector has the least and greatest contribution to carbon dioxide (CO2) emission. Crafting carbon emission reduction proposals and recommendations geared toward industry incentivization, and subsidization is the target of this paper to enable the industries to transition to greener production practices and apply such recommendations on the ground to generate a favorable influence on the well-being of the environment and society in general. In this paper, time-series variables were utilized: annual Carbon Dioxide emission (in metric tons) from the Global Carbon Project and the GDP of the Three-Major industries in the Philippines namely, Agriculture, Hunting, Forestry, and Fishing (AHFF), Service, and Industry (in million Php) from the Philippine Statistics Authority for the period 1988 - 2020. The year range has been adjusted accordingly to achieve stationarity of the time series data.

The researchers employed a Multiple Linear Regression model in this study with Carbon Emission (CO2) as the dependent variable and AHFF, Service, and Industry sector's GDP as the independent variables. First and second difference is applied among the variables which is represented by the equation below:

$$d\_C02 = B0 + B1d\_AHFF + B2d\_d\_IND + B3d\_d\_SRV + e$$

Table 1
Descriptive Statistics

	d_CO2Emission	d_AHFF	d_d_Industry	d_d_Services
Mean	3.14E+06	28717	-25194	-35862
Median	4.17E+06	28828	19733	21966
Minimum	-1.06E+07	-70343	-1.08E+06	-1.87E+06
Maximum	1.27E+07	90573	3.44E+05	2.49E+05
Std. Dev.	4.76E+06	30044	2.19E+05	3.40E+05
Covariance	1.5184	1.0462	8.7037	9.4724
Skewness	-0.5647	-0.79001	-3.3786	-4.9345
Kurtosis	0.96329	2.0772	14.713	24.261
5% percentage	-7.90E+06	-32484	-4.97E+05	-6.81E+05
95% percentage	1.15E+07	78320	2.49E+05	1.90E+05
IQ range	5.61E+06	35526	92785	97056
Missing Obs.	0	0	0	0

A. Time Series Plot

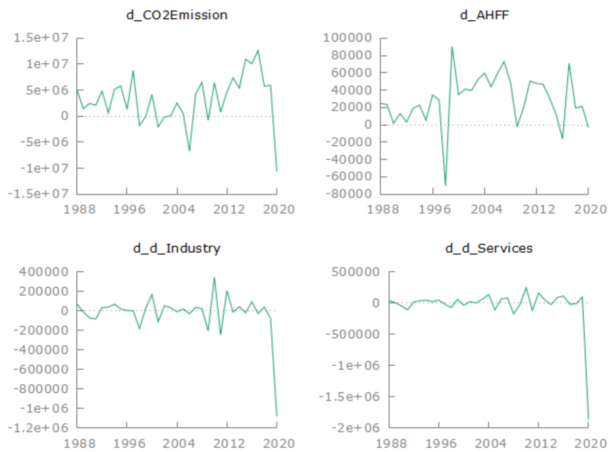

Fig. 2. Time Series Plot of AHFF, Industry, Services, and CO2 Emissions

Figure 2 above shows the Time Series Plot of the dependent variable CO2 emission and the independent variables AHFF, Industry, and Service sector used in the study. The following variables exhibit a fluctuating trend which signals the likelihood that there is less possibility to encounter regression errors in the model (the more fluctuating the trend is, the better). The unanticipated drop in the GDP level of the Three-Major industries for the year 2020 was associated with the reduction in economic activities in all sectors of the economy due to the Covid-19 Pandemic. Therefore, causing the value of CO2 emission in the Philippines to fall off as well due to fewer economic activities brought about by hefty quarantine measures and restrictions.

B. Correlation Matrix

Table 2 shows the correlation matrix of the study which indicates the extent of correlation that exists between the variables. AHFF and CO2 emission has a correlation coefficient of 0.0691 which indicates a weak correlation. Industry and CO2 emission has a correlation coefficient of 0.597 which indicates a moderate correlation. The same findings apply to Services and CO2 emissions with a correlation coefficient value of 0.5363. Consequently, since most values are far off from reference point one (1), then the variables are not highly correlated.

C. Collinearity Test

The values of the collinearity test for the constant and variables included in the study is less than 30, which indicates that there is no evidence of excessive collinearity. The given values further illustrate that the independent variables are not correlated to each other, hence, it does not violate the key point of the multiple linear regression model.

D. Augmented Dickey Fuller Test

The Augmented Dickey-Fuller (ADF) test findings demonstrate varied order of integration, where none of the variables are stationary. When the 1st Difference is applied both the CO2 Emission and AHFF are now at the stationary level. Consequently, when the 2nd Difference is applied both the Industry and Services are now at the stationary level. All values of the unit root tests for the variables are less than 0.05 alpha.

E. Autoregressive Distributed Lag (ARDL)/OLS Based Model

The constant is significant at .01 alpha. If all the independent variables are set to zero (0), then the value of the dependent variable - Carbon Dioxide (CO2) emission will be the constant.

As shown in table 5, the industry sector is positively significant at 0.10 alpha. Therefore, revealing that as the Gross Domestic Product (GDP) of the industry sector is increasing, the level of Carbon Dioxide emissions in the Philippines is increasing as well. The model exhibited a direct causal relationship between the GDP of the industry sector and CO2 emissions. Highlighting in the study that the alternative hypothesis is accepted since the p-value of the industry sector is 0.0749 which is less than .10 alpha. Further signifying that

Table 2
Correlation matrix

d_CO2Emission	d_AHFF	d_d_Industry	d_d_Services	
1	0.0691	0.597	0.5363	**d_CO2Emission**
	1	0.2591	0.2157	**d_AHFF**
		1	0.9088	**d_d_Industry**
			1	**d_d_Services**

Table 3
Collinearity test

lambda	cond	const	d_CO2Emission	d_AHFF	d_d_Industry	d_d_Services
2.379	1.000	0.016	0.053	0.032	0.014	0.015
1.846	1.135	0.056	0.004	0.049	0.019	0.022
0.494	2.195	0.007	0.432	0.440	0.005	0.009
0.198	3.465	0.816	0.421	0.429	0.000	0.101
0.083	5.349	0.106	0.089	0.049	0.962	0.853

Table 4
Augmented Dickey Fuller Test

	Level		1st Difference		2nd Difference		Decision
Variables	Intercept	Trend and Intercept	Intercept	Trend and Intercept	Intercept	Trend and Intercept	
CO2 Emission	0.9806	0.1892	0.007672	0.0006656			1
AHFF	0.9997	0.9714	1.609e-12	2.554e-13			1
Industry	0.9616	0.4623	0.2184	0.2276	0.01094	0.08863	2
Services	0.9997	0.9879	0.9975	0.9972	0.0001	0.0004253	2

there is a positive significant relationship between the industry sector's GDP and CO2 emissions in the Philippines. Besides, the findings of the study are not surprising as the sub-sectors under industry are all energy intensive. A study done by Hanafi & Zurina (2013), Hasanbeigi et al., (2014), and Sesso et al., (2020) revealed and concluded the same findings that the industry sector (primarily manufacturing, mining, and quarrying) is the largest contributor of carbon dioxide emissions and accounts for the biggest chunk of greenhouse gas emissions worldwide by roughly 27%.

In the same model, the GDP of AHFF and Services is positively insignificant since the two independent variables resulted in a p-value that is greater than alpha indicating that both industries are not as much affecting the growth of CO2 emissions in the country. Both sectors are contributing to CO2 emissions at a low level and not to the same degree as the industry sector since they differ in production processes and energy intensity requirements. Therefore, the decision rule is to fail to reject the null hypothesis of both AHFF and Service sector since the p-value of both independent variables are greater than any of the alpha.

F. Durbin Watson P-value

Table 6
Durbin Watson

Durbin-Watson statistic = 1.359981
H1: positive autocorrelation p-value = 0.0333691
H1: negative autocorrelation p-value = 0.966631

The Durbin-Watson statistic has a value of 1.359981 illustrating that it approaches the reference value of 2 which is a good indication of not having an autocorrelation error in the model. Consequently, its p-value for both positive and negative are 0.0333691 and 0.966631which are greater than 0.01 alpha which indicates that we should accept the null hypothesis that there is no presence of autocorrelation error in the model.

G. Heteroskedasticity (White's and Breusch Pagan Test)

The p-value we derived from White's test for heteroskedasticity is 0.394774. The probability is greater than alpha therefore, we accept the null hypothesis that there is no heteroskedasticity error in the model.

The p-value we derived from the Breusch-Pagan test for heteroskedasticity is 0.225406. The probability is greater than alpha therefore, we accept the null hypothesis that there is no heteroskedasticity error in the model.

Table 8
Breusch Pagan Test

Breusch-Pagan test for heteroskedasticity OLS, using observations 1988-2020 (T = 33) Dependent variable: scaled uhat^2				
	coefficient	**std. error**	**t-ratio**	**p-value**
const	0.611137	0.431532	1.416	0.1674
d_AHFF	1.33796e-05	1.04591e-05	1.279	0.2110
d_d_Industry	−3.83806e-06	3.35356e-06	−1.144	0.2618
d_d_Services	2.56696e-06	2.14120e-06	1.199	0.2403
Explained sum of squares = 8.71401				
Test statistic: LM = 4.357003, with p-value = P(Chi-square(3) > 4.357003) = 0.225406				

Table 5
Ordinary Least Squares Model

	Coefficient	**Std. Error**	**t-ratio**	**p-value**	
const	3.89868e+06	1.00366e+06	3.884	0.0005	***
d_AHFF	−14.6951	24.3258	−0.6041	0.5505	
d_d_Industry	14.4097	7.79970	1.847	0.0749	*
d_d_Services	−0.652241	4.97999	−0.1310	0.8967	

Mean dependent var	3137036		S.D. dependent var	4763432
Sum squared resid	4.61e+14		S.E. of regression	3988332
R-squared	0.364683		Adjusted R-squared	0.298960
F(3, 29)	5.548827		P-value(F)	0.003900
Log-likelihood	−546.2561		Akaike criterion	1100.512
Schwarz criterion	1106.498		Hannan-Quinn	1102.526
rho	0.319741		Durbin-Watson	1.359981

Table 7
White's Test

White's test for heteroskedasticity OLS, using observations 1988-2020 (T = 33) Dependent variable: uhat^2				
	coefficient	std. error	t-ratio	p-value
const	3.94744e+012	8.82063e+012	0.4475	0.6587
d_AHFF	1.69644e+08	3.40402e+08	0.4984	0.6230
d_d_Industry	−1.65385e+08	1.25671e+08	−1.316	0.2011
d_d_Services	3.21797e+08	1.62461e+08	1.981	0.0597 *
sq_d_AHFF	4909.16	3908.20	1.256	0.2217
X2_X3	2945.85	3273.54	0.8999	0.3775
X2_X4	−7623.60	4076.12	−1.870	0.0742 *
sq_d_d_Industry	−599.809	472.448	−1.270	0.2169
X3_X4	677.176	925.615	0.7316	0.4718
sq_d_d_Services	−60.5149	402.107	−0.1505	0.8817
Unadjusted R-squared = 0.287071				
Test statistic: TR^2 = 9.473359, with p-value = P(Chi-square(9) > 9.473359) = 0.394774				

Table 9
Serial Correlation Test

Breusch-Godfrey test for first-order autocorrelation
OLS, using observations 1988-2020 (T = 33)
Dependent variable: uhat

	coefficient	std. error	t-ratio	p-value
const	−873540	1.02405e+06	−0.8530	0.4009
d_AHFF	30.7640	26.8234	1.147	0.2611
d_d_Industry	−0.779776	7.34089	−0.1062	0.9162
d_d_Services	0.895795	4.69931	0.1906	0.8502
uhat_1	0.458960	0.209154	2.194	0.0367 **

Unadjusted R-squared = 0.146738
Test statistic: LMF = 4.815226,
with p-value = P(F(1,28) > 4.81523) = 0.0367

Alternative statistic: TR^2 = 4.842339,
with p-value = P(Chi-square(1) > 4.84234) = 0.0278

Ljung-Box Q' = 3.68948,
with p-value = P(Chi-square(1) > 3.68948) = 0.0548

Table 10
Normality of Residual

Frequency distribution for residual, obs 43-75
number of bins = 7, mean = -4.23328e-010, sd = 3.98833e+006

interval	midpt	frequency	rel.	cum.
< -7.685e+006	-9.309e+006	1	3.03%	3.03%
-7.685e+006 - -4.436e+006	-6.060e+006	0	0.00%	3.03%
-4.436e+006 - -1.188e+006	-2.812e+006	13	39.39%	42.42%
-1.188e+006 - 2.061e+006	4.367e+005	12	36.36%	78.79%
2.061e+006 - 5.310e+006	3.685e+006	5	15.15%	93.94%
5.310e+006 - 8.558e+006	6.934e+006	1	3.03%	96.97%
>= 8.558e+006	1.018e+007	1	3.03%	100.00%

Test for null hypothesis of normal distribution:
Chi-square(2) = 4.066 with p-value 0.13094

H. *Serial Correlation Test*

All the p-values derived from the Breusch-Godfrey test for first-order autocorrelation is greater than alpha. Therefore, we accept the null hypothesis that there is no first-order autocorrelation error using the Breusch-Godfrey serial correlation LM test for the model.

I. *Normality of Residual*

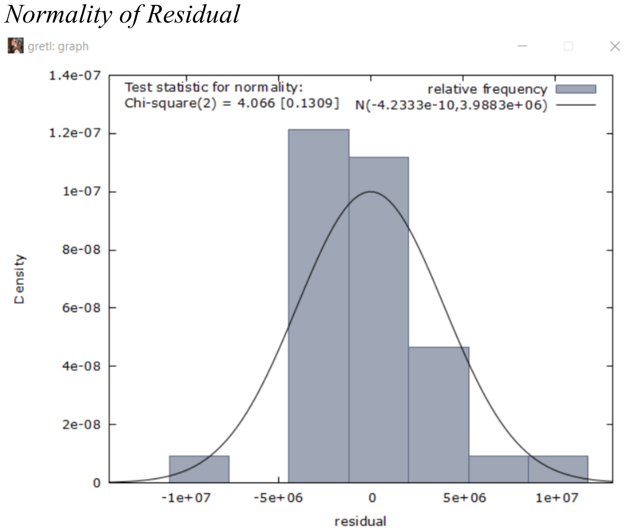

Fig. 3. Normality of Residual

The p-value derived from the Normality of Residual test is 0.13094. The probability is greater than alpha therefore, we accept the null hypothesis that there is no non-normality error in the model. Thus, we achieved the Normality of Residual. According to the study made by Osborne in 2013, the normality of residuals is a continuous variable that appears to impact the credibility of confidence intervals.

J. *ARCH Test*

Table 11
ARCH Test

Test for ARCH of order 1

	coefficient	std. error	t-ratio	p-value
alpha(0)	1.46838e+013	5.08404e+012	2.888	0.0071 ***
alpha(1)	−0.0191181	0.182570	−0.1047	0.9173

Null hypothesis: no ARCH effect is present
Test statistic: LM = 0.0116924
with p-value = P(Chi-square(1) > 0.0116924) = 0.913891

The p-value derived from the Test for ARCH of order 1 is 0.913891. The probability is greater than alpha, therefore we accept the null hypothesis that there is no Autoregressive Conditional Heteroskedasticity of order 1 error in the model. No ARCH effect is present.

K. *Chow Breakpoint Test*

The p-value derived from the Augmented regression for Chow test is 0.4116. The probability is greater than alpha, therefore, we accept the null hypothesis that there is no structural breakpoint in our model.

The structural break at observation 2004 was associated with the Executive Order No. 320 of the former President Gloria Macapagal-Arroyo, designating the Department of Environment and Natural Resources (DENR) as the National Authority for Clean Development Mechanism (CDM). The executive order was inaugurated on 25 June 2004 with the aim of reducing the emission of harmful greenhouse gasses in the

Table 12
Chow Breakpoint Test

Augmented regression for Chow test OLS, using observations 1988-2020 (T = 33) Dependent variable: d_CO2Emission				
	coefficient	std. error	t-ratio	p-value
const	2.94514e+06	1.31240e+06	2.244	0.0339 **
d_AHFF	−27.1150	41.3230	−0.6562	0.5177
d_d_Industry	25.9557	15.1170	1.717	0.0983 *
d_d_Services	−10.5756	26.0701	−0.4057	0.6884
splitdum	2.75113e+06	2.15388e+06	1.277	0.2132
sd_d_AHFF	−4.44178	56.9491	−0.07800	0.9385
sd_d_d_Industry	−14.6355	17.7190	−0.8260	0.4166
sd_d_d_Services	12.5414	26.7112	0.4695	0.6428
Mean dependent var	3137036	S.D. dependent var		4763432
Sum squared resid	3.96e+14	S.E. of regression		3980291
R-squared	0.454519	Adjusted R-squared		0.301784
F(7,25)	2.975872	P-value(F)		0.020541
Log-likelihood	−543.7406	Akaike criterion		1103.481
Schwarz criterion	1115.453	Hannan-Quinn		1107.509
rho	0.196390	Durbin-Watson		1.602012
Chow test for structural break at observation 2004 F(4, 25) = 1.02932 with p-value 0.4116				

atmosphere as included in the United Nations Framework Convention on Climate Changes (UNFCCC) and Kyoto Protocol that has been signed by the Philippines as DENR being the representative agency.

The Kyoto Protocol created the Clean Development Mechanism (CDM), whereby projects that will prevent or absorb greenhouse gasses may be established in developing countries like reforestation, use of renewable energy, etc., with the carbon emission to be prevented or sequestered to be purchased by developed countries in compliance with the provisions of UNFCCC and Kyoto Protocol.

The participation of the Philippines in the CDM will provide numerous benefits in terms of foreign investments in CDM projects, employment, and income opportunities, the establishment of ecologically friendly projects that will contribute to a healthier environment, technology transfer, and income from carbon purchases by the developed countries.

Indicated below are the following powers and functions vested on the National Authority for Clean Development Mechanism:

a) Formulate and develop a national Clean Development Mechanism policy.
b) Develop the criteria, indicators, standards, systems and procedures, and evaluation tools for the review of CDM projects.
c) Undertake the assessment and approval of CDM projects that will be submitted to the UNFCCC and Kyoto Protocol.
d) Monitor the implementation of CDM projects, and
e) Perform other functions that are related to and in pursuance of the development of CDM.

The following powers vested on the National Authority for Clean Development Mechanism, designating DENR as the representative agency, will redound on a much healthier Philippine economy since their will now be a governing body that will do the check and balance with regards to the carbon dioxide emissions of the producer units in the economy particularly with the industry sector which has the highest requirement of energy power. With the establishment of this executive order, an orchestrator from the public sector has been built to ensure that the increasing levels of greenhouse gasses from the country will now be restricted to a minimum. Consequently, the structural breakpoint at 2004 where the GDP of the Industry sector declined was linked to the establishment of this executive order that restricts the producer units to yield economic outputs at maximum and at the expense of the natural environment. For instance, if the industry sector can produce 100 units of bags prior to the establishment of the executive order, then now it can only produce around 70 units of the same commodity since environmental costs linked to production have been internalized and the utilization of natural capital has been set to consume at a manageable level. Nonetheless, this executive order will be more inclusive so long as the implementation on the ground is built from both vertical and horizontal coordination across government agencies and LGUs to various regions where the plants of various industries are situated.

L. Ramsey Reset

Table 13
Ramsey Reset

RESET test for specification (squares and cubes) Test statistic: F = 0.167714, with p-value = P(F(2,27) > 0.167714) = 0.846
RESET test for specification (squares only) Test statistic: F = 0.137708, with p-value = P(F(1,28) > 0.137708) = 0.713
RESET test for specification (cubes only) Test statistic: F = 0.313780, with p-value = P(F(1,28) > 0.31378) = 0.58

The p-value for Ramsey RESET test for specification (squares and cubes) is 0.846. The p-value for the RESET test for specification (squares only) is 0.713. The RESET test for specification (cubes only) is 0.58. All probabilities are greater than alpha therefore, we accept the null hypothesis that there is no specification error in our model. It means that the model is properly specified.

5. Conclusions and Policy Implications

A. Conclusions

Using the time-series data of the Three-Major industries GDP and CO_2 emission from the year 1946 - 2020, the researchers tested the assertion that "there is no existing relationship between the Gross Domestic Product of the Three-Major industries to CO_2 emission" and found statistically using the Multiple Linear Regression model that a positive significant relationship existed between the GDP of Industry sector and CO_2 emission. Statistically, a significant causal-comparative result has been generated from the model indicating that as the Gross Domestic Product of the Industry sector increases, the level of CO_2 emissions in the Philippines increases as well. While AHFF and the Service sector's Gross Domestic Product were less likely to cause changes in the CO_2 emission levels as both independent variables are positively insignificant. The study was able to demonstrate that a positive causal relationship existed between the GDP of the Industry sector and CO_2 emission and not in the AHFF and Service sector of the Philippines.

Included in the Industry sector are the following: (1) Mining and quarrying, (2) Manufacturing, (3) Construction, and (4) Electricity, Gas, and Water Supply (EGWS). These subsector's production processes are all energy-intensive industries; hence, it is not surprising that this sector has been the primary contributor to the growth of CO_2 emissions and other greenhouse gasses in the Philippines. The study looks into the aggregation of the gross value added of the resident producer units and not in the disaggregation of industries by sub-sectors as there is a limitation in the availability of data from the Philippine Statistics Authority (PSA).

B. Policy Implications

Following the results of the statistical tests and analysis, the following policy recommendations are suggested by this paper.

Given the externalities contributed by the producer units from their production processes, it is vital that we encourage them to integrate Green Accounting and by simultaneously disclosing their Sustainability Reporting. Integrating such environmental initiatives would develop positive environmental results in the long-run as internalizing the costs associated with production is now captured. Such encouragement would bring initiative among the differentiated industry sector to become environmentally accountable and ethical producers. With regards to the return of this recommendation, the industry who will successfully participate are expected to generate a good reputation that will yield better investment opportunities in the future. Accounting for the environmental costs might be a value-added burden to some firms, but the benefits it has will yield directly to the welfare of the people in general as taking care of the environment would mean taking care of the people living within it. Moreover, firms are not restricted to use the natural capital as their inputs to production, however, they should take into account that they can only utilize up to a certain point to not cause degradation and depletion to the environment and to allow it to revert from its normal level. By doing so, we are expecting to see a constant rate of degradation and a stable growth in the various industries so long as we bear in mind to take natural resources at a manageable level. Furthermore, we should grow the economy in such a way that we mitigate the damage that we do in the environment.

Providing cross-subsidy to those industries who wanted to transition to greener practices but do not have the capacity to do so given their current financial situation should be considered. The fund that could spearhead this policy could be generated through public-private partnerships (PPPs), NGOs and other streams of public income. Such policy is geared toward sustainability as it aims to transition those old energy-intensive types of machinery and equipment into a more efficient and less energy-intensive one. It is about time that we craft such a policy to shift the old culture of production processes with high contributions to harmful greenhouse gasses into a more sustainable and high-yielding resource. Although, transitioning entails economical costs as being efficient is expensive at the beginning due to resources employed with research and development. Decreasing the transaction costs associated with R & D will encourage more firms to transition to sustainable practices. The return on investment with regards to R&D might take years before it can be reverted back as it will take time to mature and become less costly. Consequently, boosting the industries efficiency both from capital and labor is an avenue to bridge the gap between carbon pollution, biased carbon pricing, and sectoral efficiency.

The Philippines is not yet ready to impose a carbon tax as a move to reduce carbon emissions in various industry sectors. At the same time, it is biased to the targeted industry as carbon emission problems are a shared responsibility among economic agents. It is further reiterated by officials from the Philippine energy sector that imposing a carbon tax will only make the country uncompetitive in attracting investments in power generation. Instead of looking into carbon tax as a solution to cut carbon emissions, developing renewable energy sources such as solar panels, hydropower, geothermal, and other indigenous energy sources is crucial as part of the decarbonization process in the country. With the said policy recommendation, the government can incentivize those industries who will engage in these kinds of energy sources by giving them tax reduction based on their level of participation. Moreover, it will also lessen the amount of greenhouse gasses in the atmosphere, therefore, increasing the number of people who will not get sick due to pollution so long as this initiative will be employed realistically.

Improved vertical and horizontal coordination across government agencies and LGUs should materialize in order to ensure that all environmental and carbon reduction proposals will be carried out on the ground. If cross agency problems are reduced, then we could expect more high-yielding environmental policies that fosters sustainability. In the same manner that cross-reporting between national and local levels in terms of environmental issues and monitoring will now be in sync and could be targeted to resolve the issue immediately, without being inefficient. Nonetheless, achieving common good will only manifest if agencies will come into terms to reconcile their conflicting goals in relation to carbon related issues and the trajectory of growth among industries.

Providing incentives to those industries to encourage consumers to lessen their carbon footprint by the means of taking into account the industry's substitution of materials used in manufacturing and reducing their yield losses. Losses not only affect performance and productivity but as well as the quantity of energy utilized and the carbon footprint. Finding substitute materials for standard goods can cut carbon footprints just as much as switching to a lower-carbon version of the same material used in manufacturing goods. Any design engineer, nevertheless, is aware that changing a product's material is not as straightforward as doing so. The approach to effective material substitution is to select a new material with attributes that are comparable to those of the original, whether those properties are mechanical, and such.

In addition, one way for the government to indirectly incentivize the end consumer is for the companies to implement directly that when they opt to purchase materials that will help in lessening their carbon footprint, they will receive incentives as well. Some examples of incentives are cash rebates, discounts on your next purchase, and free products to boost human behavior into carrying out the goal of minimizing carbon emissions.

This is a real-world illustration of economic incentives for environmental protection. Many users are repelled by the high installation and maintenance expenses of solar panels and batteries. As a result, the United States government offers tax credits to citizens who install solar power systems at their homes. Tax credits return a percentage of income tax to citizens, reducing the total tax amount. As a result, it may act as a significant incentive for prospective consumers to install solar panels. According to Forbes, customers should expect a tax credit rate of 22-26% in 2023. The average discount rate in 2021 was 26%. We can apply this in the Philippine setting wherein the Philippine government will offer tax credits to companies who will employ renewable energy sources such as solar power systems. It will be a win-win situation for the government, the industries, and the consumers because the government will have the opportunity to reach its target to cut greenhouse gas emissions to a 75% reduction by 2030 under its commitment to the Paris Agreement on Climate Change. The industries will have a decrease in their corporate tax and if this happens, the price of the products and services they will offer will lower down making consumers satisfied.

Kyoto protocols involve support for renewable energy, the improvement of energy efficiency and reduction of environmental degradation. The main reason why the Kyoto protocol was created is because developed countries have contributed the most to the buildup of Carbon Emission in the atmosphere which was around 77% of emission between 1750 and 2004. Consequently, the Kyoto Protocol has also been the cause of a lot of controversy and opposition. Countries with the largest contribution on carbon emission tend to ratify this protocol but without binding targets. Instead of mandates each country will set its own targets and come up with an individual plan of action based on its own unique mix of resources and energy needs. They argue that Kyoto protocol goals are not established by science but rather by political negotiation and therefore arbitrary and ineffective in nature. Moreover, without the USA ratifying the protocol or recently emerging economic powerhouses such as China reducing carbon emissions drastically, the targets will likely not be met. Even the permissible degree of global generated by target levels if reached will have far greater environmental impact than was originally envisioned. Therefore, while the Kyoto protocol has good intentions, it is more of a steppingstone and major action against emission and therefore climate change as a whole.

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