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Article

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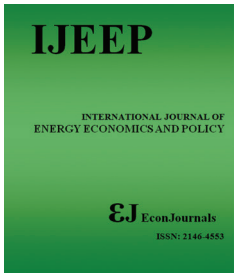

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Determinants of Greenhouse Gas Emissions in the Transportation Sector in Indonesia: Official Statistics and Big Data Approach

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ABSTRACT

The Covid-19 pandemic has affected every aspect, including the greenhouse gas emissions from the transportation industry. The adoption of Lockdown during the Covid-19 outbreak has decreased greenhouse gas emissions in the transportation sector. Studying the variables that affect the transportation sector's greenhouse gas emissions during the COVID-19 pandemic is particularly fascinating. Big data and official statistics were combined to create the data for this study. Official statistics are sourced from Statistics Indonesia (BPS) and the National Development Planning Agency (BAPPPENAS) while big data is sourced from the google mobility index. Based on the results of the generalized linear model with the gamma link, it can be concluded that the growth of GRDP per capita and the mobility of people to workplaces have a negative effect on greenhouse gas emissions in the transportation sector, mobility of the population to groceries and pharmacies has a positive effect on greenhouse gas emissions in the transportation sector, while people's mobility to recreation and retail has no effect on greenhouse gas emissions in the transportation sector. During the Covid-19 pandemic, population mobility to Workplaces which showed reduced work from office (WFO) and increased work from home (WFH) had the greatest influence on reducing greenhouse gas emissions in the transportation sector. Work from home (WFH) can be used as a solution to reduce greenhouse gas emissions in the transportation sector at the beginning of the Covid-19 endemic.

Keywords: Transportation Sector Greenhouse Gas Emissions, Work from Home, Google Mobility Index
JEL Classifications: C55, O18, Q56

1. INTRODUCTION

The Covid-19 pandemic has an impact on all dimensions and human life, as a result of the imposition of mobility restrictions by the government and the fear of being exposed to Covid-19. Air, train, land, water, and other modes of mass transportation, as well as modes of mobility for people and goods, have all been severely restricted. This has had a negative impact on the transportation industry. Global transportation activity has decreased by about 50% below the 2019 average before the Covid-19 pandemic. Commercial flights are almost down by around 75% compared to 2019, the challenge of reduced mobility due to the pandemic has an impact on reducing greenhouse gas emissions in the transportation sector (Abu-Rayash and Dincer, 2020; Soni et al., 2022; Stoll and Mehling, 2020). One of the short-term benefits of the Covid-19 pandemic is improving air quality, reducing carbon dioxide and other greenhouse gas emissions; this can be sustainable as long as all residents are able to change their lifestyle (Chapman and Tsuji, 2020; Forster et al., 2020). The greatest reduction in greenhouse gas emissions during the Covid-19 pandemic was due to the implementation of lockdowns in various countries which caused various means of transportation to temporarily not be used (Camargo-Caicedo et al., 2021).

Based on the 2021 Climate Transparency report, one of the positive impacts during the COVID-19 Pandemic is the reduction of CO_2 emissions by around 6% in all G20 member countries in 2020, but in 2021, these emissions are projected to soar to 4%. The

COVID-19 pandemic has the potential to have long-term effects on energy and the environment on a global scale. Policy responses taking aim at the transportation sector, particularly those based on land transportation, can encourage a transition to sustainable mobility that lowers the risk of long-term environmental damage caused by Covid-19. This includes being able to reduce the volume of private vehicle use or changing behavior.

In 2020 in Indonesia, when the COVID-19 Pandemic occurred, it resulted in a reduction in greenhouse gas emissions of around 29.5%, although the economic recovery after the COVID-19 pandemic outbreak was able to be controlled, there will likely be a rebound in emissions in 2022. The COVID-19 pandemic has had a positive effect on the environment and has been shown to directly reduce the concentration of NO_2, PM2.5, and PM10 in the air during the implementation of the COVID-19 lockdown. Controlling pollution from vehicle traffic and limiting human activities during the COVID-19 pandemic lockdown period has also been shown to be an effective way in improving air quality in an area (Sannigrahi et al., 2021). When lockdown regulations are followed in the city, the COVID-19 pandemic has indirectly improved air quality. Due to fewer individuals leaving their houses during the lockdown period beginning on March 23, 2020, concentrations of NO_2 and PM2.5 pollutants fell by 66% and 19%, respectively (Kazakos et al., 2021). Additionally, there has been an improvement in the air quality in Indonesia, particularly in JABODETABEK, the epicenter of the pandemic that is currently limiting social mobility (Pramana et al., 2020).

The occurrence of greenhouse gas emissions in Indonesia has a negative impact, causing a loss of around $1,426.7 million per year on average (PPP). More than 168,300 individuals died in Indonesia in 2019 from lung cancer, chronic respiratory diseases, heart disease, and stroke as a result of air pollution. The average death rate from greenhouse gas emissions is in the 9th position in the G20 countries (Kazakos et al., 2021).

The transportation sector is one of the largest contributors to energy consumption and greenhouse gas emissions (Wang et al., 2011). In Indonesia, the transportation sector contributes to direct emissions of about 27% of Indonesia's energy-related CO_2 emissions. Emissions from the transportation sector are predicted to increase by around 22.45%. This should be the government's attention, so that undesirable things such as increasing carbon emissions after the COVID-19 pandemic do not increase too significantly (Climate Transparency Report, IESR 2021) (Figure 1).

Appropriate policies regarding sustainable transportation need to be considered, especially in the face of the COVID-19 endemic (Griffiths et al., 2021). Based on this explanation, it is interesting to study what factors affect the greenhouse gas emissions of the transportation sector in Indonesia, so the research question in this study is what variables affect the greenhouse gas emissions of the transportation sector in Indonesia, especially during the COVID-19 pandemic.

This study uses data that is a combination of official statistics, especially those sourced from Statistics Indonesia and BAPPENAS, and will use a Big Data approach, especially regarding the Google Mobility Index. The use of Big Data will be able to provide an overview of a very diverse phenomenon and be able to provide extraordinary input for stakeholders, especially when the provision of data from official statistics is very difficult to obtain due to various policies. Big Data can be used when real-time data is needed (Sebestyén et al., 2021). Then in this study using the Generalized Linear Model, this is because based on the results of the Kolmogorov Smirnov Test and the Cullen and Frey Graph which are shown in Table 1 and Figure 2 below, it can be concluded that greenhouse gas emissions are not normally-distributed but are exponentially distributed, tending to the gamma or beta distribution. If the data is not normally distributed, one of the capitals that are robust against data that is not normally distributed is the Generalized Linear Model, besides that the GLM is also robust to estimate parameters with a relatively very small number of samples (McCullagh and Nelder, 2019).

2. LITERATURE REVIEW

The results of the study by Lyeonov et al. (2019) found that there was a significant relationship between per capita GRDP growth and greenhouse gas emissions and renewable energy. According to Wang et al. (2011), the effect of economic activity per capita and the effect of shifting transportation modes are the main causes of encouraging the growth of CO_2 emissions in the transportation sector. But on the other hand, a decrease in per capita income can increase the use of transportation modes together, and this will lead to a decrease in CO_2 emissions in the transportation sector. Rapid economic development and accelerated urbanization have caused the transportation sector to experience dramatic growth leading to excessive demand for fossil fuel energy and an increase in the greenhouse effect due to the transportation sector (Achour and Belloumi, 2016). The demand for transportation will increase drastically due to population growth, urbanization, globalization, and overall economic development. Increasing transportation will encourage carbon emissions (Khalili et al., 2019).

Greenhouse emissions have decreased substantially due to the reduced burning of gasoline and diesel fuel from the transportation sector during the COVID-19 lockdown (Camargo-Caicedo et al., 2021). During the Covid-19 pandemic, travel to all places such as work, shops, retail, schools, and other places has decreased sharply, this is due to changes in travel behavior during the Covid-19 pandemic which affect greenhouse gasses, especially those from sector emissions transportation (DeWeese et al., 2022). The lockdown process is able to reduce traffic flow in various sectors and offers opportunities to reduce greenhouse gasses and improve air quality (Restrepo, 2021). The means of transportation used for travel or tourism activities produce massive emissions of greenhouse gases (GHG), such as carbon dioxide (CO_2) (Achour and Belloumi, 2016).

3. METHODS

3.1. Generalized Linear Model (GLM)

According to McCullagh and Nelder (2019), GLM is an extension of regression in which the distribution of the response variables

is not normally distributed but may have an exponential family distribution such as Binomial, Poisson, Negative Binomial, Gamma or Inverse Gaussian. GLM does not require classical regression assumptions. In GLM there is a link function so that g(μi)=ηi becomes:

$$g(\mu_i) = g[E(Y_i)] = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_p X_{ip} \quad (1)$$

The random variable Y with probability density function (pdf) and parameter θ is a member of the exponential family, if f can be expressed as:

$$f(y; \theta) = exp\,[a(y)b(\theta) + c(\theta) + d(y)] \quad (2)$$

Based on the results of Cullen and Frey graph, the greenhouse effect in the transportation sector is Beta distributed, in this study because the new GLM facilitates several exponential family distributions, the distribution of the greenhouse effect in the transportation sector will be approximated by a gamma distribution because the beta distribution is a special occurrence of the gamma distribution. Beta distribution is a continuous distribution constructed from two continuous random variables $X_1 \sim GAM(1, \alpha)$ and $X_2 \sim GAM(1\beta)$. Gamma distribution is a Beta distribution with parameters (α, β) (Warella et al., 2021).

3.2. Projected Calculation of Greenhouse Gas Emissions in the Transportation sector by BAPPENAS

In calculating greenhouse gas emissions in the transportation sector, refer to the projection results that have been calculated by BAPPENAS. Projection of greenhouse gas emissions in the transportation sector uses the Long-range Energy Alternatives Planning System (LEAP) approach. LEAP is a comprehensive modeling tool and is an integrated scenario based on energy and the environment. LEAP has a scenario of calculating energy consumption, conversion, and energy produced in an energy system based on several assumptions, namely population, economic development, technology, and prices. In the projection of greenhouse gas emissions in the transportation sector with LEAP, several provinces are the basis for calculating the baseline so that the projection data for the province that becomes the baseline is not released. The provinces are Jambi for the Sumatra Island Baseline, DKI Jakarta as the Java Island baseline, South Kalimantan as the Kalimantan Island baseline, West Papua as the baseline for the Sulawesi, Maluku and Papua regions. North Kalimantan is still part of East Kalimantan, so data on the projected results of greenhouse gas emissions in the transportation sector only covers 29 provinces (BAPPENAS, 2021).

3.3. Data

The data in this study are official statistics sourced from BAPPENAS and Statistics Indonesia and big data sourced from the Google Mobility Index. The details of each data can be seen in Table 2.

Table 1: Kolmogorov Smirnov test results data on the greenhouse effect in the transport sector

Exponential parameter	Mean	6463561.207
Kolmogorov-Smirnov Z		0.889
Significance		0.408

3.4. Data Processing

Data processing using R software with attached syntax and for text mining using Orange Software. The detail of research framework can be shown in Figure 3.

The research framework in this study are:

3.4.1. Hypothesis

The alternative hypotheses used are:

H_1: There is an influence between the growth of GRDP per capita, Google Mobility Index to the groceries and pharmacies, to workplaces and, to recreation and retail to greenhouse gas emissions in the transportation sector.

4. ANALYSIS AND FINDINGS

4.1. Descriptive Statistics

The transport sector greenhouse gas emissions is illustrated in Figure 4. Based on the calculation of projected greenhouse gas emissions in the transportation sector in 29 provinces in Indonesia, which was carried out by BAPPENAS. In 2020, Central Java Province is the province that produces the highest greenhouse gas emissions, which is 30.4 million tons of CO_2 equivalent, while the province that produces the lowest greenhouse gas emissions is East Nusa Tenggara with a contribution of 10,860 tons of CO_2 equivalent.

In 2020, the highest per capita GRDP growth was in Central Sulawesi Province with a per capita GRDP growth of 7.13%, while the one experiencing a contraction in per capita GRDP growth in 2020 was Papua Province, where per capita GRDP growth contracted to −20.13%. The details of the GRPD growth can be seen in Figure 5.

The first Covid-19 case in Indonesia was discovered in March 2020. Therefore, the government had set various policies to reduce the spread of Covid-19, including physical or social distancing, implementing work from home, closing shopping centers and tourist attractions, reducing worker density in the industrial sector, large-scale social restrictions or Pembatasan Sosial Berskala Besar (PSBB) to the Enactment of Micro Community Activity Restrictions or Pemberlakuan Pembatasan Kegiatan Masyarakat (PPKM). With the enactment of this policy, people carry out various activities such as working and studying from home so that people's mobility outside the home is reduced. This can be seen from the value of the Google Mobility Index (GMI) which notes that the mobility of Indonesian people to work, where they sell daily necessities and drug stores or pharmacies, retail and recreational shopping places, parks, and transit areas has decreased.

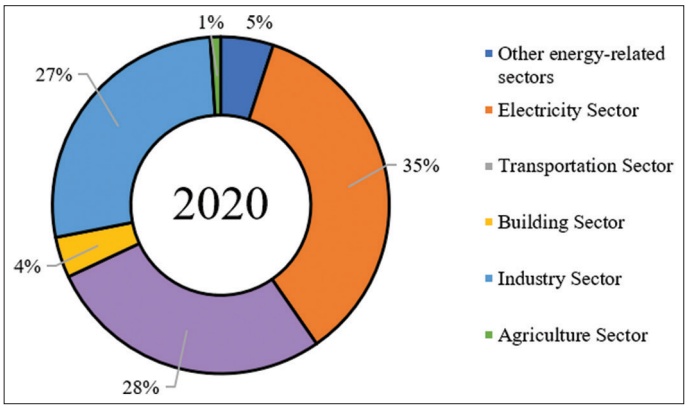
The mobility of the Indonesian people to shopping for daily necessities and drug stores or pharmacies in several provinces in Indonesia is below the baseline line, this indicates reduced or no mobility of the population to shopping for daily necessities and drug stores or pharmacies, this is most likely due to the implementation of PSBB and PPKM. Provinces that show reduced mobility of people to places of daily necessities or pharmacies. are the largest in Bali Province, however, there are still provinces whose residents still move a lot or move to places where daily necessities are sold and to drugstores or pharmacies. The province Based on the population

Table 2: Variables in research

Variable	Description	Source
Transportation Sector Greenhouse Gas Emissions	Projected Greenhouse Emissions in Transportation sector (equivalent to tons of CO_2)	BAPPENAS
GRDP per capita growth	GRDP value per person	Statistics Indonesia
Google Mobility Index to the category of the groceries and pharmacies sector, to the category of the workplace sector, and to the category of the recreation and retail sector.	The total number of individual data whose visits are recorded via Google Maps, after the location history feature is active. Changes in the number and length of visits to places of sale of daily necessities and drug stores or pharmacies, to places of work and to places of recreation and retail	Google Community Mobility Reports

GRDP: Gross regional domestic product

Figure 1: Energy-related CO_2 emissions by sector



Source: IESR climate transparency report, 2021

Figure 2: Cullen and Frey plot

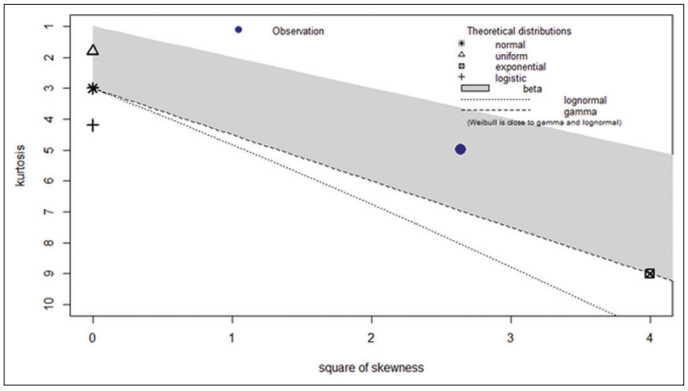
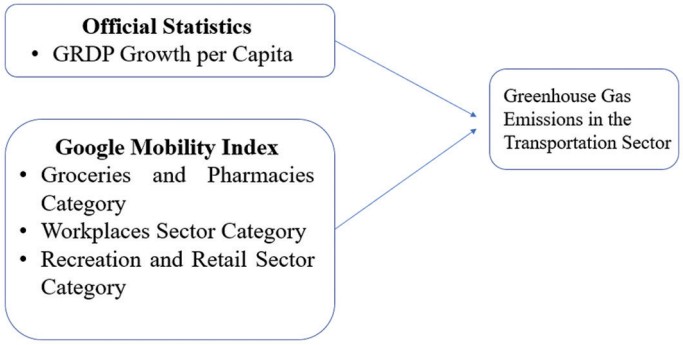


Figure 3: Research framework



mobility to groceries and pharmacies that shown in Figure 6, the province with the most population mobility to shop for daily necessities and drug stores or pharmacies is North Maluku Province.

During the Covid-19 pandemic, the movement or mobility of the population to the workplace has decreased drastically, this is because at the beginning of the Covid-19 pandemic there were not a few workplaces that implemented work-from-home (WFH) apart from the implementation of PSBB and PPKM so there was no mobility. In addition to mobility to work as illustrated in Figure 7, residents to the office or place of work as usual. The province with the movement or mobility to work that has experienced a drastic decline is the Province of Bali. At the beginning of the Covid-19 pandemic, there were still provinces with very high levels of population mobility to the workplace, the province was West Sulawesi, this was indicated by the GMI value to the workplace's category being positive or above the baseline line.

As illustrated in Figure 8, the movement or mobility of the population to the category of recreational or retail places has also decreased drastically, almost all provinces in Indonesia have experienced a decline in population mobility to recreational and retail areas. The province with the smallest decline in mobility to recreation and retail is West Sulawesi Province, while the province with the largest decline in population mobility to recreational areas is Bali, this is indicated by the GMI value to the workplace's category with negative value and the smallest, far below the baseline.

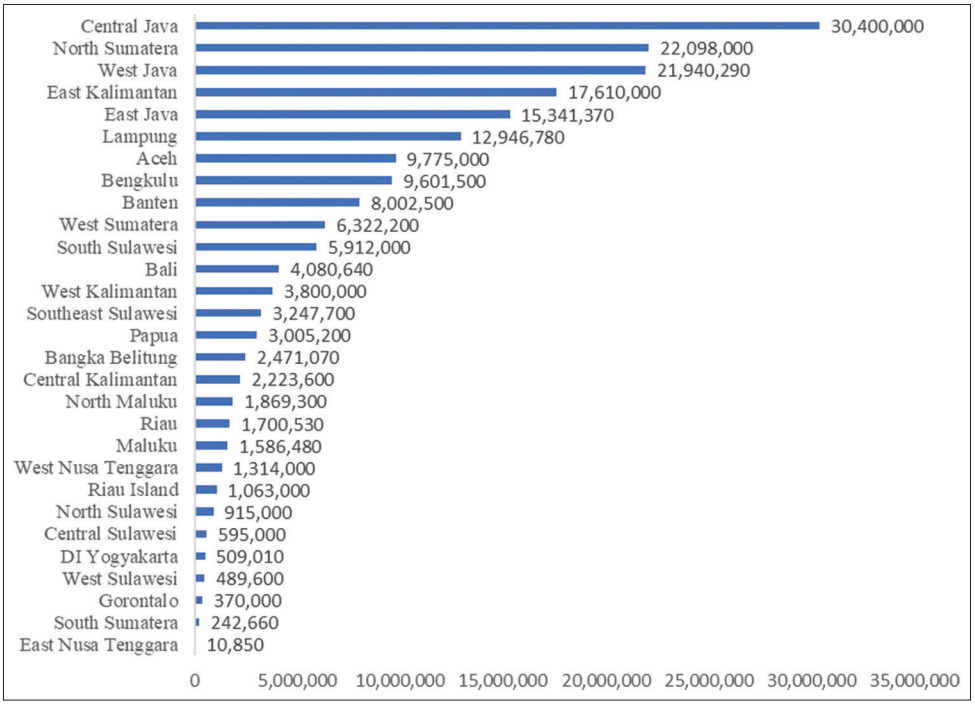
4.2. Generalized Linear Model Analysis

From the previous explanation using the Kolmogorov-Smirnov test and the Cullen and Frey graph, it can be concluded that greenhouse gas emissions in the transportation sector are not normally distributed but are exponentially distributed, tending to have a gamma or beta distribution. Therefore, to analyze the variables that affect greenhouse gas emissions in the transportation sector, the Generalized Linear Model with Gamma link will be used.

The results of the Generalized Linear Model show that the growth of GRDP per capita and people's mobility to workplaces have a significant negative effect on greenhouse gas emissions in the transportation sector. There was a significant positive effect between people's mobility to groceries and pharmacies and greenhouse gas emissions in the transportation sector, while no significant effect was found between people's mobility to recreation and retail and greenhouse gas emissions in the transportation sector.

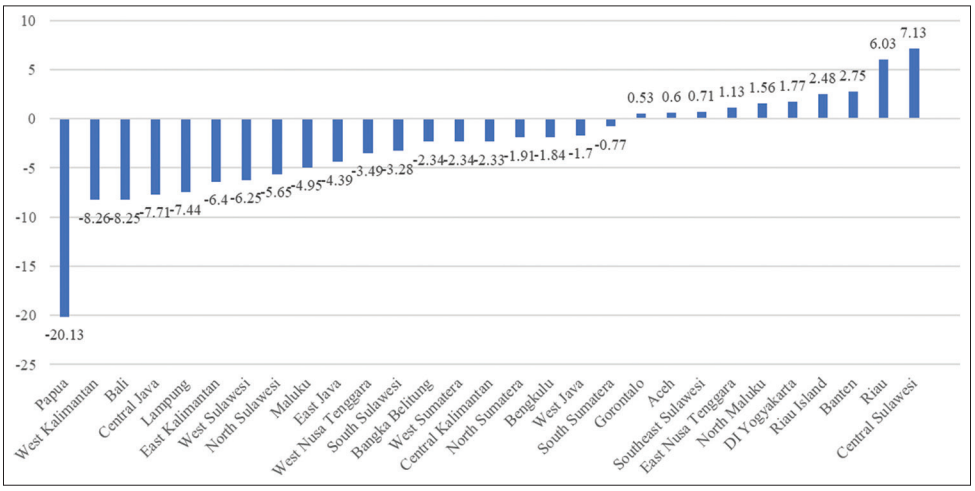
The detailed explanation is as follows: The model formed produces a constant value of 12,94745 and significantly has an effect on greenhouse gas emissions in the transportation sector. This means that if the role of GRDP growth per capita, people's mobility to workplaces, groceries and pharmacies, as well as recreation

Figure 4: Transport sector greenhouse gas emissions (tonnes CO_2 equivalent)



Source: BAPPENAS

Figure 5: GRDP growth per capita



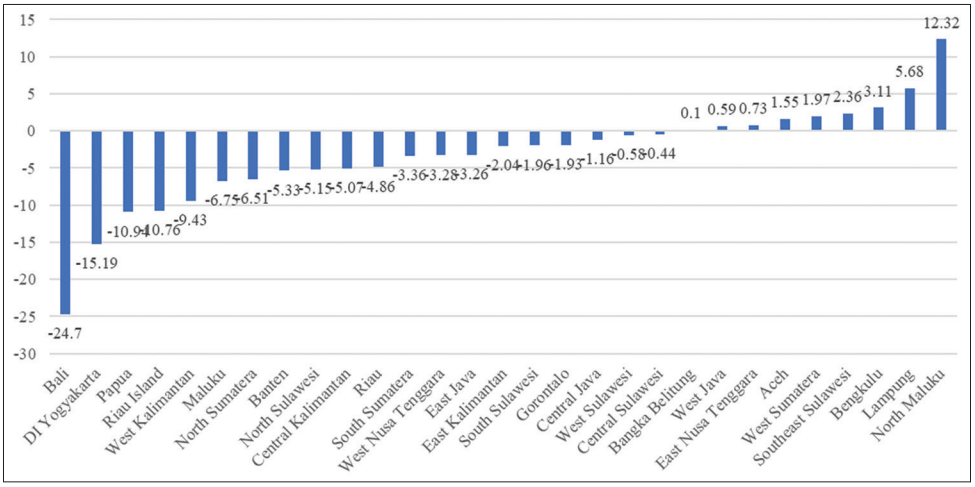
Source: Statistics Indonesia

and retail category are absent, then the transportation sector's greenhouse gas emissions is 12,94745 tonnes CO_2 equivalent.

The first variable that affects the transportation sector's greenhouse gas emissions is the GRDP growth per capita. Based on the results of GLM, it shows that the regression coefficient value of GRDP growth per capita is −0.10607 with a P = 0.01853. This result is significant at the P = 0.05 level, so it is said that GRDP growth per capita has a significant negative effect on the transportation sector's greenhouse gas emissions.

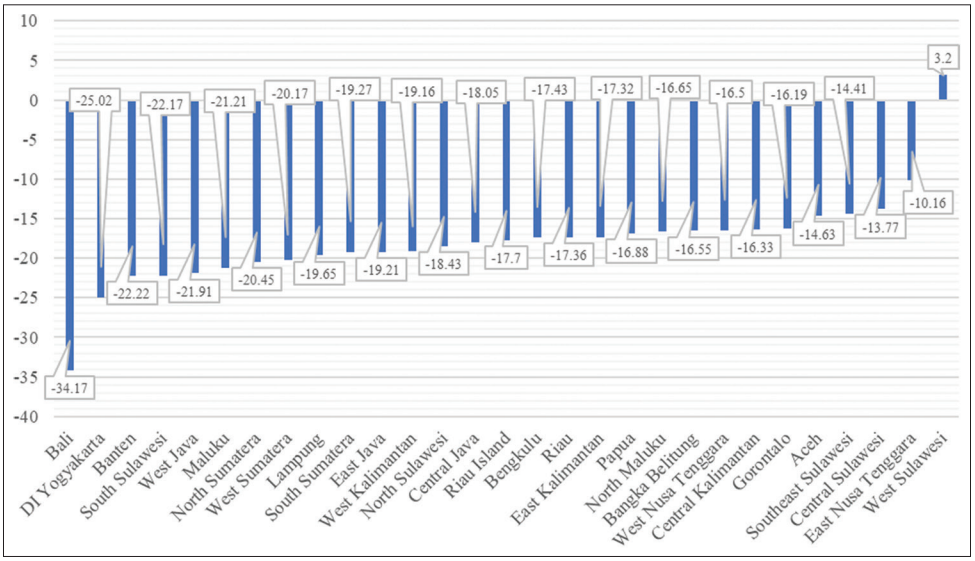
The effect of per capita GRDP growth is negative, meaning that when GRDP growth per capita increases, transportation sector greenhouse gas emissions will decrease, and vice versa when GRDP growth per capita is contracted, transportation sector greenhouse gas emissions will increase. If other variables are considered constant, ceteris paribus, then every one unit increase in GRDP growth per capita will cause the transportation sector's greenhouse gas emissions to decrease by 0.10607 units. This finding is consistent with that of Sarkodie and Strezov's research (2019), high economic growth is able to set aside a portion of development funds for various development activities that support environmental sustainability in order to reduce greenhouse emissions, and support low carbon emission activities. This finding was also reported by Sterpu et al. (2018) which says that the economic improvement of a country marked by improved economic growth is able to support the increase in renewable energy, energy consumption leads to a reduction in greenhouse gas emissions in all sectors. The increase in GRDP growth per capita is able to increase the use of transportation services together

Figure 6: Population mobility to groceries and pharmacies



Source: Google Mobility Index

Figure 7: Population mobility to workplaces



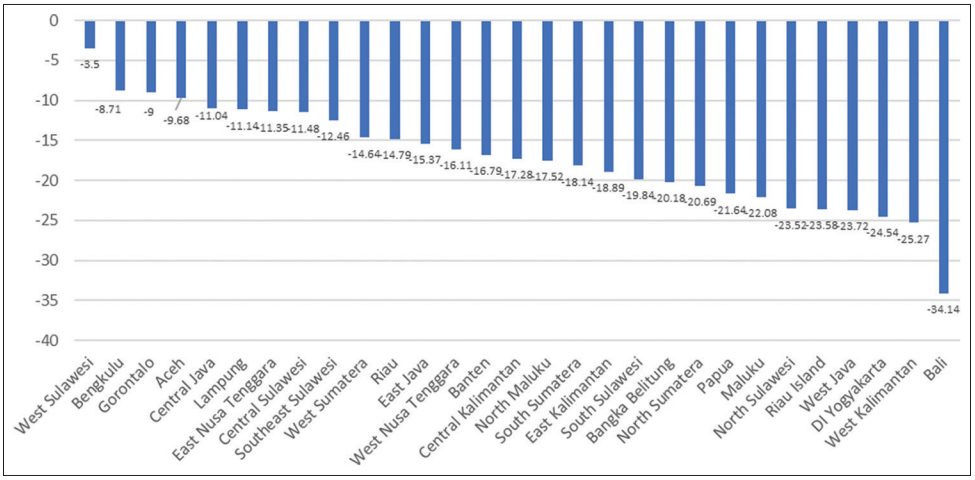
Source: Google mobility index

and will encourage the reduction of CO_2 emissions, but in other circumstances, the effect of per capita economic activity causes a shift in transportation modes which will be the main cause of encouraging the growth of CO_2 emissions in the transportation sector (Wang et al., 2011). This outcome is contrary to that of Simanjorang Bonataon (2013) research which says that GDP per capita has a significant effect on increasing CO_2 emissions. Rapid economic development and accelerating urbanization have caused the transportation sector to experience dramatic growth which causes excessive demand for fossil fuel energy and results in an increase in the greenhouse effect in the transportation sector (Achour and Belloumi, 2016).

Gross Regional Domestic Product is the total gross added value created from all economic sector activities in a region. From the amount of GRDP created divided by the total population in the region, it will produce GRDP per capita. GRDP per capita can be used to see the level of people's welfare in a region (Badan Pusat Statistik, 2022). Provincial GRDP per capita in Indonesia in 2020 is in the range of Rp. 12,960,950-Rp. 125,807,520. The province with the lowest GRDP is East Nusa Tenggara Province, while the largest is East Kalimantan Province. The details of Provincial GRDP per capita in 2020 can be seen in Figure 9.

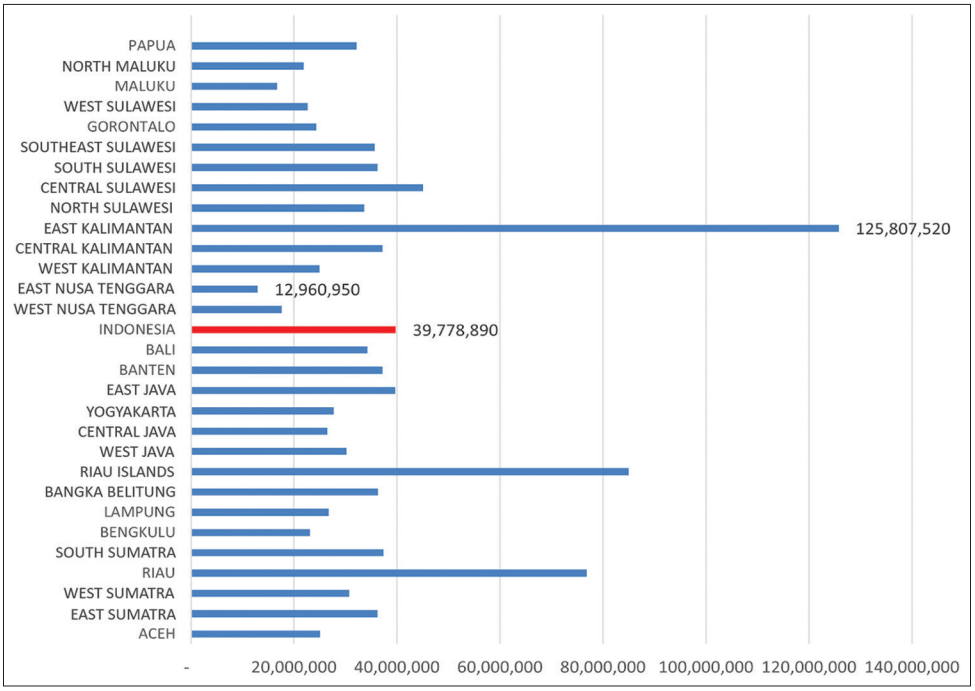
Economic growth is always used as an indicator of the success of development by calculating the amount of GRDP without considering its effect on natural damage. However, since the enactment of Law No. 32 of 2009 concerning Environmental Protection and Management where the preparation of Gross Domestic Product (GDP) and Gross Regional Domestic Product (GRDP) which includes natural resource depreciation and environmental damage, then all sectors involved are driven to generate added value by minimizing the natural damage factor. One example is in the electricity category, PLN is developing new and renewable energy (EBT)-based power plants, even committing to setting a target of Zero Carbon Emissions or Net Zero Emissions by 2060 (Tempo, 2022). In addition, in the transportation sector, the development of electricity-based transportation facilities is also

Figure 8: Population Mobility to Recreation and Retail Places



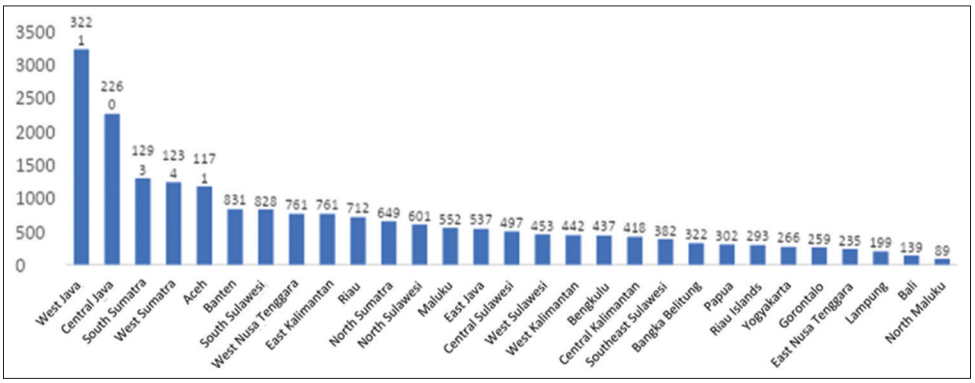
Source: Google mobility index

Figure 9: Provincial GRDP per capita in 2020



Source: Statistics Indonesia

Figure 10: Number of low carbon development actions



Source: AKSARA BAPPENAS

a form of implementing environmentally friendly transportation supported by increased economic growth. With the high per capita GRDP growth, the greater the opportunity for the government to increase various low-carbon development action plans in the transportation sector which will have an impact on reducing greenhouse gas emissions in the transportation sector. As depicted in Figure 10 on Number of Low Carbon Development Actions in 2020, there are 20,144 low-carbon development action plans spread throughout Indonesia. During 2020, the province that carried out the most low-carbon development action plans was West Java Province with 3,221 action plans, while the least was North Maluku Province with 89 low-carbon development action plans. This low-carbon development action plan includes the implementation of a car-free day, eco-driving training, and so on.

By using a text mining approach as aillustrated in Figure 11, to low carbon development action data from BAPPENAS using the orange program with the following stages:

The word cloud for the low-carbon development action plan was obtained as follows:

As shown in Figure 12, it can be seen that the most frequent low-carbon development actions in the transportation sector are training on intelligent transport systems, training and socialization of eco-driving or smart driving, implementation of car-free days,

Figure 11: Text mining analysis workflow with orange

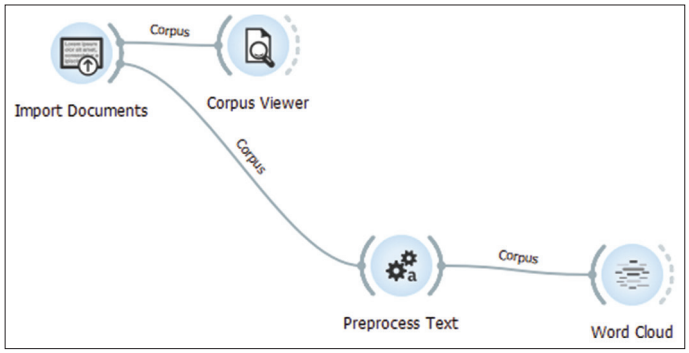
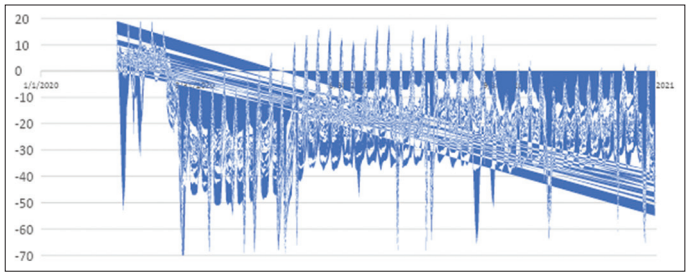


Figure 12: Word cloud for low carbon development action in transportation sector

Source: Results from orange

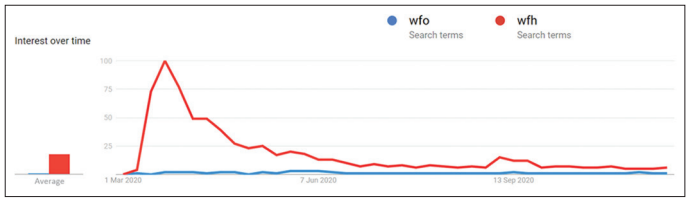
provision of school buses, implementation of exemplary service programs which are one of the activities to increase the quality of Human Resources (HR) as an effort to improve public transport services and traffic safety as mandated in Law Number 22 of 2009 concerning Road Traffic and Transportation Article 254 paragraph (1) which states that "Local Governments are obliged to provide services and facilities and guarantee Organizing education and training for mechanics and drivers and others, namely parking management, reforming the transit system and socializing the use of biofuels (Law No. 22, 2009). With the Low-Carbon Development action plan, it is hoped that greenhouse gas emissions from the transportation sector will be reduced. Low-Carbon Development

Figure 13: Google mobility index to the workplaces category



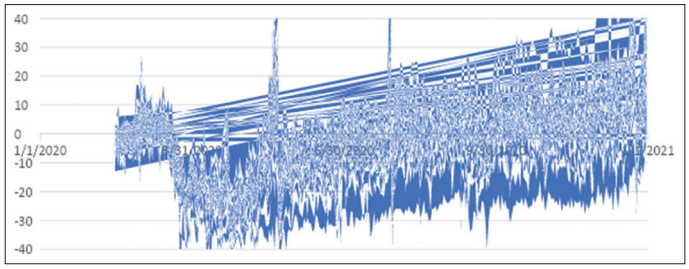
Source: Google mobility index

Figure 14: Google trends between WFH and WFO



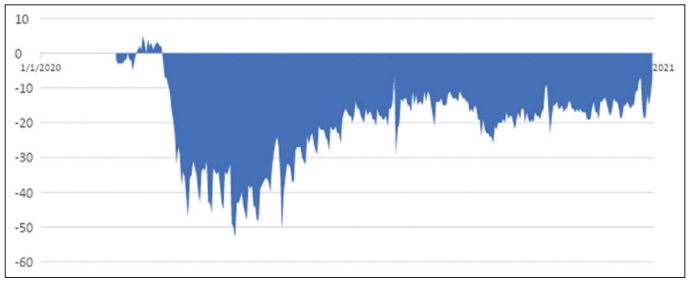
Source: Google trend

Figure 15: Google mobility index to the groceries and pharmacies category



Source: Google mobility index

Figure 16: Google mobility index to the recreation and retail category

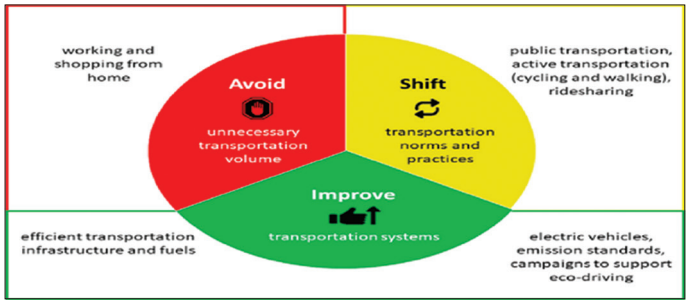


Source: Google mobility index

(LCD) is a national program enshrined in the 2020-2024 National Medium-Term Development Plan (RPJMN) (Peraturan Presiden (PERPRES) No. 88, 2021). The LCD is a strategic embodiment of the National Action Plan for Reducing Greenhouse Gas Emissions program as stipulated in Presidential Regulation No. 98 of 2021 (Peraturan Presiden (PERPRES) No.98, 2021). Low Carbon Development Policy as the basis for planning that is not only related to economic aspects but also takes into account aspects of the carrying capacity and capacity of the environment so as to create low-carbon and sustainable economic development.

The next variable is the google mobility index (GMI) to the workplaces category which describes people's mobility to workplaces. Based on the GLM results, it shows that the regression coefficient (GMI) to the workplaces category is −0.18786 with a P = 0.00439. This result is significant at the P = 0.05 level, so it can be concluded that (GMI) for the workplaces category has a significant negative effect on greenhouse gas emissions in the transportation sector. Since the outbreak of COVID-19 case, the terms WFH (Work from Home) and WFO (Work from Office) have emerged. When the GMI for the workplaces category is negative, it shows that the less intensity of employees coming to the workplace (office) or the higher the number of employees working from home. When the number of people working from home is high, greenhouse gas emissions will decrease. If other variables are considered constant, ceteris paribus, then every increase in one unit of population that works from home (WFH) will reduce greenhouse gas emissions in the transportation sector by 0.18786 units. However, the application of WFH cannot be applied to all job sectors because several jobs must be done in the workplace. COVID-19 has posed new challenges for transportation in the post-pandemic era. Social distancing with the aim of reducing the risk of contact, for example in public transportation, can actually worsen traffic congestion and emissions because many people prefer to use private vehicles. However, working from home can be a solution to reduce the negative effects of social distancing on greenhouse gas emissions or carbon emissions (Wang et al., 2021). Towards the end of the Covid-19 pandemic, the right policy for sustainable transportation needs to be thought out as carefully as possible. Working and shopping from home can reduce the use of excessive means of transportation which will ultimately help reduce greenhouse emissions resulting from the transportation sector (Griffiths et al., 2021). Working from home contributes to a reduction in workplace visits. This has an impact on reducing carbon emissions from the transportation sector (Rafiq et al., 2022; Stoll and Mehling, 2020).

Figure 17: A sustainable transportation program after the covid-19 pandemic



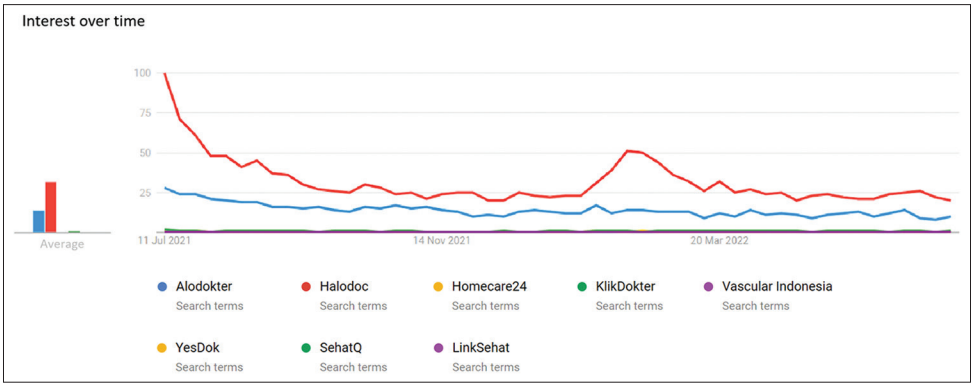
Source: Griffiths et al., (2021)

Based on data obtained from the google mobility index to the workplaces category for the period 15 February-15 December 2020 which is illustrated in Figure 13, it can be seen that there has been a decline in people's mobility to the workplaces since 15 March 2020 in line with the outbreak of COVID-19 cases in Indonesia followed by the Work from Home policy for several sectors of work. The lowest people's mobility to workplaces occurred in the period 15 April-15 June 2020 in line with the onset of COVID-19, where the government set policies to minimize mobility and crowds. People's mobility to their workplaces fluctuates in line with the policies taken by the government in handling COVID-19. When people's mobility is given leeway, the people's mobility to workplaces will also increase, and vice versa. With more and more people working from home, this will reduce greenhouse gas emissions, especially in the transportation sector.

Google Trends between WFH and WFO can be seen in Figure 14 below. The continued development of WFH compared to WFO is also illustrated by the results of Google Trend analysis where the WFH trend is higher than WFO, especially at the beginning of the Covid-19 pandemic.

The next variable that is thought to have an effect on greenhouse gas emissions in the transportation sector is the Google mobility index (GMI) to the groceries and pharmacies category, where this variable

Figure 18: Some telemedicine platforms in Google trend



Source: Google trend

indicates the people's mobility to groceries and pharmacies. Based on the GLM results, it shows that the regression coefficient value of people's mobility to the groceries and pharmacies is 0.09731 with a P = 0.03935. The P-value of people's mobility to groceries and pharmacies is smaller than = 5%, so it can be concluded that people's mobility to groceries and pharmacies significantly has a positive effect on greenhouse gas emissions in the transportation sector. The effect of people's mobility to groceries and pharmacies is positive, meaning that when people's mobility to groceries and pharmacies increases, then greenhouse gas emissions in the transportation sector will also increase, and vice versa, when people's mobility to groceries and pharmacies decreases, so the transportation sector's greenhouse gas emissions will also decrease. If other variables are considered constant, ceteris paribus, then every one unit increase in people's mobility to groceries and pharmacies will cause the transportation sector's greenhouse gas emissions to increase by 0.09731 units. This is in line with the research results of Griffiths et al. (2021), during the Covid-19 pandemic, shopping from home, both for the needs of daily life and buying medicines and supplements to maintain health so as not to be attacked by covid, was able to reduce the people's mobility to groceries or pharmacies, and will have an impact on reducing greenhouse emissions.

At the beginning of the Covid-19 pandemic, the Google Mobility Index (GMI) to the groceries and pharmacies category showed fluctuations in people's mobility to groceries and pharmacies. The fluctuations can be seen in Figure 15. In the period 15 April-15 May 2020, which was the beginning of the spread of COVID-19 in Indonesia, it was seen that people were reducing mobility to groceries and pharmacies, because at that time there were restrictions on people's activities, even in some areas a curfew was imposed. Public knowledge about the prevention and treatment of the impact of COVID-19 encourages people to move to places selling daily necessities and drug stores. People began to carry out activities at groceries and pharmacies in order to purchase medicines and vitamins to support health, so in the period from July 15 to the end of December 2020, this activity experienced an increase in frequency.

Based on Figure 16, the next variable that is thought to have an effect on greenhouse gas emissions in the transportation sector is the Google Mobility Index (GMI) to the recreational and retail category, where this variable indicates the people's mobility to recreational and retail areas. Based on the GLM results in Table 3, the regression coefficient of people's mobility to recreational and retail areas is 0.05072 with a P = 0.42006. The P-value of people's mobility to recreation and retail is ≥5%, so it can be concluded that people's mobility to recreation and retail has no significant effect on greenhouse gas emissions in the transportation sector.

This result may be explained by the fact that recreational activities are not activities that are carried out all the time, only carried out at certain times such as class promotion holidays, or maybe during holidays. So, it is very possible that recreational activities do not affect the greenhouse gas emissions of the transportation sector in Indonesia during the COVID-19 pandemic. Restrictions on people's mobility, starting from Large-scale social restrictions or LSSR (Indonesian: Pembatasan Sosial Berskala Besar or PSBB) and micro-scale public activity restrictions (PPKM Mikro), greatly impact the recreation sector, this is indicated by a negative value from March to December 2020 which is far below the baseline. This finding is contrary to several research results by Liu et al. (2021) which say that the quiet tourism sector can reduce bus use, even flights stop altogether, this will reduce carbon emissions that the tourism sector produces during the Covid-19 pandemic. Not a few means of transportation for travel in the tourism and goods sector, produce massive emissions of greenhouse gasses (GHG), for example, carbon dioxide (CO^2) (Ratanavaraha and Jomnonkwao, 2015). Travel during the Covid-19 pandemic is limited, which affects greenhouse emissions produced by various means of transportation that support tourism activities, greenhouse gas emissions from the tourism sector such as buses and so on are much reduced by limiting tourism activities (Islind et al., 2020).

Table 3: The estimated value obtained using GLM

Variable	Estimate	P-value
Intercept	12,94745	0.0000*
GRDP growth per capita	−0,10607	0.01853*
Google mobility index to the workplace's category	−0,18786	0.00439*
Google mobility index to the groceries and pharmacies category	0,09731	0.03935*
Google mobility index to the recreation and retail category	0,05072	0.42006
R square	0,3325	

Source: R program's results. GLM: Generalized linear model, GRDP: Gross regional domestic product

GLM analysis revealed that the most influential variables on the transportation sector's greenhouse gas emissions in Indonesia are people's mobility to workplaces, followed by the growth of GRDP per capita, and people's mobility to groceries and pharmacies.

From Table 3, a mathematical model can be formed for the equation for greenhouse gas emissions in the transportation sector, as follows:

$$\textit{Reenhouse gas emissions in the transportation sector}_i = 12{,}94745 - 0{,}10607\ \textit{GRDP growth per capita}_i - 0{,}18786\ \textit{workplaces}_i - 0{,}09731\ \textit{groceries and pharmacies}_i - 0{,}05072\ \textit{recreation and retail}_i \quad (3)$$

With i = Province

The value of the coefficient of determination is 33.25%, meaning that the transportation sector's greenhouse gas emissions are around 33.25118%, which can be explained or influenced by per capita GRDP growth, people's mobility to workplaces, people's mobility to groceries and pharmacies, and people's mobility to recreational and retail areas. While the remaining 66.75% is explained by other variables that are not used in the study.

5. CONCLUSION AND RECOMMENDATIONS

This study has shown that the growth of GRDP per capita and people's mobility to the workplaces have a negative effect on

greenhouse gas emissions in the transportation sector, population mobility to groceries and pharmacies has a positive effect on greenhouse gas emissions in the transportation sector, while people's mobility to recreation and retail has no effect on greenhouse gas emissions in the transportation sector. The mobility of people to workplaces has the greatest influence on greenhouse gas emissions in the transportation sector during the Covid-19 pandemic.

These findings provide the following insights for future research:

1. The creation of gross value added in several sectors related to the use of natural resources takes into account the factors of environmental depletion and degradation through the development of renewable energies towards Zero Carbon Emission.
2. Reducing greenhouse gas emissions in the transportation sector can be achieved by implementing a sustainable transportation program after the Covid-19 pandemic, including reference to the research of Griffiths et al. (2021). The detail of a sustanable transportation program after the covid-19 pandemic can be seen in Figure 17 below.
3. The sustainable transport program consists of several activities, including:
    a. Avoid unnecessary transport volumes. This can be done through working from home (WFH) or teleworking and shopping from home using existing e-commerce facilities. The means of transport may only be used for a specific purpose.
    b. Changes in transportation norms and practices. This is done, among other things, by supporting the use of public transport and the use of other modes of transport such as cycling and walking, or by using shared modes of transport such as ride-sharing.
    c. Improve the transport system. Consider improving efficient transportation infrastructure and using fuels that are efficient and environmentally friendly but have low greenhouse gas emissions. The promotion of the use of electric vehicles, emission standards, and even campaigns promoting environmentally friendly driving are relevant. Eco-driving is a driving style that can efficiently optimize fuel consumption.
4. In the sustainable transportation scheme developed by Griffiths et al. (2021), including the implementation of WFH. Implementation of Work from Home or Hybrid Workspace for several work sectors that allow work from anywhere needs to be used as a work culture not only during the COVID-19 pandemic, in order to reduce greenhouse gas emissions, especially in the transportation sector.
5. Facilitate licensing of drug sales online, to reduce people's mobility in the context of purchasing drugs, thereby reducing the need for transportation which will have an impact on reducing fuel consumption. Based on Figure 18, During the Covid-19 pandemic, the Ministry of Health has collaborated with various telemedicine platforms. This socialization related to telemedicine services needs to be developed. It needs to be disseminated more widely to the people because based on the results of google trends towards several existing telemedicine services, only Halodoc and Alodokter are already widely known by the public.
6. In order to support sustainable transportation, it can also be supported by the provision of environmentally friendly transportation facilities as a form of low carbon development, which can be realized through mass-based transportation such as school buses, biofuel transportation, parking management, shuttle facilities provided by employers. The use of integrated transportation can also support sustainable transportation, this is in accordance with research results (Achour and Belloumi, 2016).
7. Car Free Day activities need to be carried out. Apart from being a place for entertainment, they also have an effect on economic development and reducing greenhouse gas emissions.

In this study, data on greenhouse gas emissions in the transportation sector were obtained from BAPPENAS. When calculating these emissions using the LEAP approach, there are several provinces used as a baseline for the calculation of greenhouse gas emission projections for the transportation sector, namely Jambi for Sumatra island baseline, DKI Jakarta as Java island baseline, South Kalimantan as Kalimantan island baseline, West Papua as a baseline for the Sulawesi, Maluku, and Papua regions, while for the Kalimantan north region is still incorporated with East Kalimantan, so the data on greenhouse gas emission projections in the transportation sector only covers 29 provinces. The limitation of the amount of data has been overcome by using the Generalized Linear Model (GLM) Link Gamma. Further research might be necessary to calculate and visualize the data on greenhouse gas emissions in the transportation sector for all 34 provinces in Indonesia in order to have complete information from all over Indonesia. If possible, the calculation of greenhouse gas emissions from the transportation sector for several years is needed, so that a panel data regression can be used in the analysis.

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