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Corporate environmental management and GHG emissions changes: Empirical study of multinational automobile companies

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Abstract:

This study investigates and compares the financial and environmental performance development of two major car manufacturing companies, Volvo Car Corporation and Hondo Motor Corporation, over the last decade. These two companies consist of one with close historical ties and most of its business in Asia and one mainly located in Europe but that is in the process of expanding production in the Asian region. Using data mainly from corporate reports to perform a decomposition analysis, it is shown that these companies have both undertaken measures to decrease their environmental impacts but in different manners and that Volvo Car Corporation has been more successful in lowering its emissions of greenhouse gas (GHG) over the studied period. The difference in the strategies chosen to reduce environmental impact and the results from the measures taken are believed to have been caused mainly by the innate differences between the European and Asian energy markets, as well as the more stringent demands of stakeholders and legislation in Europe.

Keywords: greenhouse gas emission, decomposition analysis, automotive corporation, corporate environmental management, carbon leakage

1. Introduction

Ever since the European Industrial Revolution, our ever increasing emissions of carbon dioxide and other greenhouse gases (GHGs) have contributed to changes in the global climate and degradation of the natural environment. To this day, the average global surface temperature has increased by almost 1°C compared to the pre-industrial average, and it is believed that an increase of more than 2°C will cause lasting damage that will reduce our planet's hospitability to humans (IPCC, 2014). To prevent global warming from reaching levels of irreversible damage, it is of the utmost importance that we reduce our combined global GHG emissions, which means increasing energy efficiency and shifting from the use of fossil fuels to renewable energy sources.

Industries that use a high amount of primary energy and energy-intensive raw materials also play important roles in achieving our climate goals, and the automotive industry is one such example. The product of the automotive industry, motor vehicles, contributes greatly to GHG emissions and does so mostly while in use, but the production itself also has a significant impact; with more cars produced every year, this impact might grow larger still.

Different car manufacturers have addressed the issue of reducing their environmental impact in various fashions and to varying extents so far. However, with the introduction of new and stricter legislation, it is only a matter of time before all of the actors on the market will have to undertake measures. This study aims to analyze and compare the financial and sustainable development of two multinational car manufacturing companies over the last decade using a decomposition method to explain the underlying causes of the trends observed. Additionally, this study examines the existence of evidence for the carbon leakage theory by comparing GHG emissions before and after plant relocations to developing countries.

The remainder of the paper is organized as follows. Section 2 introduces the background of this study. Section 3 explains the methods used. Section 4 describes the dataset. The results of decomposition analysis of GHG emissions are discussed in Section 5. The paper concludes with Section 6.

2. Background

2-1. Research question and target company selection

In this study, we focus on two multinational automobile companies: Volvo Car Corporation (Volvo CC) and Honda Motor Corporation (Honda MC). The reasons for choosing Volvo and Honda specifically are that they are diverse and provide a broad representation of the automotive industry as a whole. The two companies are different in production scale, the locations of their headquarters and the locations of their production facilities (see table 1). Honda is one of the largest automotive companies in the world, and it is mainly based in Asia, while the Volvo Car Corporation is a much smaller producer and has most of its facilities in Europe (see table 2).

<Tables 1 and 2 about here>

The different locations of the production facilities are especially interesting in this case because the different energy markets in Asia and Europe engender innate differences in conditions for environmental performance. Table 2 shows that Volvo mainly produces its products in Europe, where electricity is generated using low carbon energy sources, while Honda mainly produces their cars in Asian countries, where electricity is generated by high carbon intensity energy sources.

In this case study, we compare the financial and sustainable development of the Volvo Car Corporation from Sweden and the Honda Motor Corporation from Japan using decomposition analysis methods. The goal is to be able to identify any external or internal

factors that might have caused the changes in the companies' development. These factors could be anything from world economic events, such as a financial crisis or the increased prices of fossil fuels, to greater legislative demands or simple changes in corporate policy.

<Table 3 about here>

In table 3, examples are shown of national or global events that might have influenced these specific companies or the automotive industry as a whole. For example, the plateau in oil production in 2006 initiated an increase in crude oil prices that would continue until early 2008. Such a dramatic change might have caused distress among the corporate leadership and shifted interest toward the production of eco-friendly cars and energy efficient production. Some of these events might apply to only one of the two companies, but most of the events are general. To obtain a better understanding of the companies studied and their respective starting points as of 2006, a brief introduction to each company follows.

2-2. Volvo Car Corporation

Volvo Car Corporation, originally Volvo AB, started as a subsidiary of the Swedish ball bearing company SKF, and it was founded in 1927. Production of automobiles started the same year in Gothenburg, Sweden. In 1928, the company started to produce trucks, a business that would be the lifeblood of the company for years to come. In the coming decades, the company grew and broadened its activities to include production of boat engines, airplane engines, forestry equipment, mining

equipment, military vehicles, tractors and busses. The company continued to grow after the Second World War and was, during the 1950s, a major international player in the automotive industry.

In 1982, the Volvo CC was formed as a subsidiary of Volvo AB as part of a major restructuring of the company. In 1999, the Volvo CC was sold to the Ford Motor Company because of increasing competition and decreasing profitability; thus, it was separated from the main company Volvo AB. Volvo CC remained with Ford until 2010, when the company was sold to the Chinese Zhejiang Geely Holding Group. In 2014, the Volvo Car Corporation had net revenue of 17.4 billion US dollar and employed more than 26 thousand people. The Volvo CC currently has production in Sweden, Belgium, China and Malaysia, with Sweden and Belgium having the largest plants, with recent greater investments made in China, where new plants will be fully operational during 2015.

In 1972, the company's then-CEO, PG Gyllenhammar, recognized the impact that industry activities had on the environment, and Volvo's first environmental policy was introduced. This policy set goals for future investments in environmental performance, and since then, the company has worked hard to be on the forefront of eco-friendly car production. In 1987, Volvo modified the waste management system at their main plant in Torslanda and was able to reduce the amount of harmful effluents by 90%. In 1988, Volvo founded the Volvo Environment Award to create incentives for green innovation. In 1989, Volvo hired its first internal environmental auditor. In 1991, the paint shop at the Torslanda factory was rebuilt with intensive focus on being environmentally friendly, and it was considered a global benchmark.

During the 1990s, Volvo started implementing environmental management systems (EMS) according to the ISO 14001 standard, which also increased the demands for environmental performance among dealers and suppliers. During the mid-2000s, Volvo CC made large investments in lowering emissions from their production plants (especially in Europe), and by 2008, the company could declare that all of their European production facilities used no energy produced from fossil fuels. Since this feat was completed, most of its effort has been placed on increasing energy efficiency in production. During 2014, Volvo CC undertook steps to start implementing its European management system in China as well, including the introduction of EMS and efficiency measures.

Today, Volvo CC's environmental strategy goals for production can be divided into the following categories:

- Zero environmental accidents;
- Water conservation and better water emission performance;
- Energy efficiency and climate-neutral operations;
- Emissions to air;
- Total waste management;
- Soil and ground water management
- Sustainable transport solutions

In its environmental statement, the following sentence can be found describing the vision of the company: *"Our environmental work is based on respect and concern for the individual, society and nature."*

2-3. Honda Motor Co., Ltd.

Honda is a Japanese company founded in 1948. Honda Motor Co., Ltd, the multinational corporation, is well known for the production of cars or automobiles, motorcycles, and other power source equipment products (Honda home page, 2015a). Since the year 1959, Honda has been the world's largest producer of Motorcycles. Currently, Honda is the eighth largest automobile company in the world. In 2014, Honda had capital of approximately 694 billion US dollars, with major products of motorcycles, automobiles, and power products, including scooters, motorcycles, all-terrain vehicles (ATVs), bikes, standard sized vehicles, generators, and agriculture engine products.

In 2014, the production share among Honda's major products was 77% automobile sales, 14% motorcycle sales, 2.6% power product sales, and 5.9% other sales, such as financial services. Honda has multinational manufacturing plants in many different regions, including Japan, the United States, India, China, Europe and others, and Honda employed 198,561 people in 2014 and earned total sales of

115 billion US dollars. In 2014 alone, Honda consumed total energy of 47,500 TJ, and it produced carbon dioxide emissions of approximately 4.3 million tons (Honda Motor Corporation, 2014).

Honda Corporation has a vision and statement on environmental aspects that it attempts to be responsible for the society of which it is a part and the global environment. The company is concerned about any effects that contribute to the environment and human health. In each stage of Honda's activities, the company will attempt to minimize the impacts on human health and the environment from the start of the process to the finish line. The following are Honda's principles (Honda homepage, 2015d):

1. To undertake efforts to recycle materials and to minimize the resource and energy use at every step of the production of products and services from start to finish;
2. To undertake efforts to minimize and find suitable and efficient methods for the disposal of the waste and contaminants that are generated from the production, use and service of its products;
3. To undertake efforts to preserve the global environment and human health and to act responsibly to ensure the company's policy; and
4. To consider the impacts that the company's activities have on the environment and society and to attempt to develop and improve the social standing of the Honda Company.

Therefore, the main goals of Honda regarding aspects of the environment are to minimize the use of traditional fossil fuels and non-renewable resources, which have bad effects on the environment, and to transition to using renewable energy or energy resources that have less impact on human health and the environment. Honda believes that these measures can minimize the impacts on the environment, such as greenhouse gas emissions (Honda homepage, 2015b).

3. Methodology

This study applies a decomposition analysis framework to clarify the changing factors underlying GHG emissions changes in two multinational automobile companies. To decompose GHG emissions changes, we use three indicators: (1) the carbon intensity of energy sources (CI); (2) the

energy intensity to create economic value (EI); and (3) the scale of production (SCALE). We define the CI indicator as the GHG emissions divided by energy consumption. This indicator increases if the consumption of high carbon fossil fuels, such as coal and petroleum, increases more rapidly than that of low carbon energy sources, such as renewables and nuclear power. Therefore, CI reflects the corporate environmental strategy in the fuel choice to reduce GHG emissions.

Next, the EI indicator is calculated by the total energy use per revenue. This indicator reflects the energy efficiency of corporate performance, including production processes, transportation of finished products, and administration activities in offices. EI can be decreased by reducing the total energy consumption while keeping the total revenue constant or by increasing the total revenue without growth in total energy consumption. Thus, EI reflects energy saving activities to reduce GHG emissions.

Finally, the SCALE indicator shows the changes in amounts of production. It is difficult to collect data on product amounts by type of product. Therefore, total revenue data, deflated by 2006 prices, are used as a proxy for production amount data. Generally, the volume of GHG emissions depends on the energy consumption amounts that generate CO_2 emissions during combustion processes. Furthermore, energy consumption is also strongly correlated with production amount because the automobile sector requires energy use for its production processes. As a result, the production scale becomes one factor for determining GHG emissions.

The amount of GHG emissions (GHG) is decomposed using the energy consumption (ENERGY) and the total revenue (Revenue) as in Equation (1):

$$\mathrm{GHG} = \mathrm{GHG/ENERGY} \times \mathrm{ENERGY/REVENUE} \times \mathrm{REVENUE} = \mathrm{CI} \times \mathrm{EI} \times \mathrm{SCALE}. \quad (1)$$

Here, we consider the change in GHG emissions from year t (GHG^t) to year t+1 (GHG^{t+1}). With Equation (1), the growth ratio of GHG emissions can be represented as follows:

$$\frac{\mathrm{GHG}^{t+1}}{\mathrm{GHG}^{t}} = \frac{\mathrm{CI}^{t+1}}{\mathrm{CI}^{t}} \times \frac{\mathrm{EI}^{t+1}}{\mathrm{EI}^{t}} \times \frac{\mathrm{SCALE}^{t+1}}{\mathrm{SCALE}^{t}}. \quad (2)$$

Equation (2) is transformed into a natural logarithmic function, thus obtaining Equation (3):[1]

$$\ln\mathrm{GHG}^{t+1} - \ln\mathrm{GHG}^{t} = \ln\left(\frac{\mathrm{CI}^{t+1}}{\mathrm{CI}^{t}}\right) + \ln\left(\frac{\mathrm{EI}^{t+1}}{\mathrm{EI}^{t}}\right) + \ln\left(\frac{\mathrm{SCALE}^{t+1}}{\mathrm{SCALE}^{t}}\right). \quad (3)$$

Multiplying both sides of Equation (3) by $\omega_i^t = (\mathrm{GHG}^{t+1} - \mathrm{GHG}^{t})/(\ln\mathrm{GHG}^{t+1} - \ln\mathrm{GHG}^{t})$ yields Equation (4), as follows:[2]

$$\mathrm{GHG}^{t+1} - \mathrm{GHG}^{t} = \Delta\mathrm{GHG}^{t,t+1} = \omega_i^t \ln\left(\frac{\mathrm{CI}^{t+1}}{\mathrm{CI}^{t}}\right) + \omega_i^t \ln\left(\frac{\mathrm{EI}^{t+1}}{\mathrm{EI}^{t}}\right) + \omega_i^t \ln\left(\frac{\mathrm{SCALE}^{t+1}}{\mathrm{SCALE}^{t}}\right). \quad (4)$$

Therefore, changes in GHG emissions (⊿GHG) are decomposed into changes in carbon intensity (⊿CI, first term), energy intensity (⊿EI, second term), and production scale (⊿SCALE, third term). The term ω_i^t operates as an additional weight for the estimated volume of GHG emissions. This weighting function reflects the scale of GHG emissions to ⊿CI, ⊿EI, and ⊿Scale, which are not reflected in the absolute value of GHG emissions data.

This decomposition technique, known as the logarithmic mean Divisia index (LMDI), was developed by Ang et al. (1998). Ang (2004) noted that the LMDI is the preferred method for decomposition analysis because of its theoretical foundations, adaptability, ease of use, ease of interpretation, and absence of residual terms, such as those generated by Laspeyres-type methodologies.

[1] Zero values in the dataset cause problems in the formulation of the decomposition because of the properties of logarithmic functions. To solve this problem, the literature on LMDI suggests replacing zero values with small positive numbers (Ang and Liu, 2007).

[2] $\omega_i^t = 0$ if $\mathrm{GHG}^{t+1} = \mathrm{GHG}^{t}$.

4. Data

This study uses GHG emissions, energy consumption, and revenue data from corporate reports published by the Volvo Car Corporation (Volvo Car Corporation, 2006-2014) and the Honda Motor Co., Ltd. (Honda home page, 2015c). The corporate reports of Volvo and Honda include the company profiles, financial statistics and analysis, and statistical reports of the company performances in environmental aspects, including the amount of carbon dioxide produced, the energy consumption annually of the company, etc. These documents also include the general strategic plans of the company regarding how to minimize GHG emissions and increase overall environmental performance.

<Figure 1 about here>

Figure 1 above shows the development of the three different indicator values studied from Volvo CC. All of the original data in table 4 are shown as relative to 2006 values and can thus be easily displayed in a single graph. From this graph, it is evident that Volvo CC's total CO_2 emissions decreased greatly during the studied period. Between 2009 and 2013, we can see a very close relationship between the production scale and the other two values, but during the periods of 2007-2009 and 2013-2014, there was definite decoupling. During these "extraordinary" periods, there was a high probability that something changed in the production line, and they are therefore particularly interesting.

Figure 2 and table 4 indicates the changes in total revenue in between 2006 and 2014 relative to the greenhouse gas emissions produced by the company and the energy consumed by the Honda Motor Corporation around the world. In table 4, it is shown that the sales or the production revenue increased yearly from 2006 to 2008. In 2009 – 2010, we can see from figure 2 that the sales decreased, but carbon dioxide emission increased, this goes against reasonable expectations and we will analyze this further later on in the text. In 2011, Hondas total sales increased but energy and carbon intensity decreased which resulted in a decrease in total GHG emissions as well. In 2012 Honda saw another drop in production, but this trend didn't last and during 2013-2014 the production increased again.

<Figure 2 about here>

<Table 4 about here>

As we can see from table 4, there is a strong general connection between production value and the two other factors. When the sales increase or decrease, naturally so does the amount of greenhouse gases produced and the energy consumed in each year. This is because a higher energy input is needed when the company produces a higher quantity of products and more energy used means higher emissions of GHG if that energy is being produced through a process which uses carbon-based fuels. How strongly the changes in production affects the energy consumption and greenhouse gas production can vary however, because there are also other factors to take into account, such as the introduction of new technology that increases energy efficiency and produces less emissions. By using the information in table 4 and looking at those other factors such as economic or technological change, we can explain the changes in GHG emission levels in greater detail.

5. Results

5-1. Results of Volvo CC

In figure 3, you can see the results of the decomposition analysis of the Volvo CC data. From 2006 until 2014, all of the values are normalized to the 2006 values as a reference; thus, the development is displayed in values relative to the reference point. As seen in the line chart, there was a marked decline in the accumulated change ratio of total GHG emissions, compared to 2006 emissions. Summarizing the bar chart as equal to the line chart value, this decrease is mostly due to a smaller production scale and lower carbon intensity, which dramatically decreased between 2007 and 2008. After 2008, there

was a slight increase in CO_2 emissions as production increased, but thereafter, we can see a small but steady decreasing trend to the present day.

<Figure 3 about here>

In table 5, we have listed some of the major changes made to the Volvo production line that are likely to have effects on energy use and ultimately on CO_2 emissions. In the data segment, we discusses decoupling between the production scale and the CO_2 emissions, as well as energy use during 2007-2009 and 2013-2014. From table 5, it is quite clear that the major difference in carbon intensity from 2007 to 2008 was due to the large investments in wind power in Belgium, as well as the change in electricity supply to renewable sources, which was also undertaken mostly in Belgium (because the energy mix in Sweden is already dominated by renewables, which can be seen in table 2).

<Table 5 about here>

The difference that we observed between 2013 and 2014 was smaller but still distinct, and 2014 saw the most energy efficiency investments from Volvo in recent years (Volvo Car Corporation, 2014). There is also a possibility that the expansion of new production facilities in China, which started in 2013 and continue to expand, led to greater energy efficiency because more modern technology and equipment were used. The total sales of Volvo cars over the last decade have depended mainly on spending power in the brands' major markets (USA, China and Sweden) and the exchange rate between the US dollar and the SEK, and the large decrease in production that can be seen between 2006 and 2010 can be contributed to the financial crisis, which affected many industries negatively, not least the

automotive industry. After the recession, production saw a recovery to values close to those of 2006, and it has since varied only slightly from year to year.

The data collected and the decomposition analysis show that Volvo CC has implemented several efficient measures to reduce the carbon and energy intensity of its car production. While the production scale in 2014 was almost equal to that in 2006, total CO_2 emissions were reduced by approximately 63% over the period and total energy use by approximately 20%. 2014 saw a positive trend for Volvo, and with the latest years of heavy investment in production facilities located in China, Volvo certainly has the means to meet increasing demand. With these changes in mind, it will be very interesting to see whether this ongoing shift from Europe to Asia will affect the company's environmental performance negatively, which is in agreement with the carbon leakage theory as discussed by Paroussos et al. (2015).

In the data collected for this study, no such negative trend can be observed, but during this period, the Volvo plants in China had not yet become fully operational. This change in location, however, was not a result of the introduction of new and stricter emissions legislation in Europe; rather, it was a decision made as a reaction to the company's growing market share in China and as a mean to actually increase efficiency in all sectors, according to Volvo CC itself. This account is probably at least partially true because the company has also invested millions in updating its production facilities in Sweden since 2010, and European Volvo factories were already producing GHG emissions at levels well below the EU requirements.

5-2. Results of Honda Motor Corporation

Figure 4 shows the results of decomposition analysis for Honda Motor Corporation between 2006 and 2014. Table 6 represents the major activities to save energy and to reduce GHG emissions by the Honda Motor Corporation. All of the data are equivalent to the data from 2006 as a reference point. Thus, the data shown in figure 4 start from a reference point with a value of zero. Starting in 2006, the level of carbon dioxide emissions continuously increased from 2006 to 2008 due to changes in both the

scale of production, carbon intensity and energy intensity. From 2008 to 2009, the carbon dioxide emissions increased due to the much higher level of carbon intensity, and it continued to increase slightly from 2009 to 2010. From 2010 to 2012, the carbon dioxide emissions decreased, and from 2012 to 2014, they continuously increased again. It can be seen that the overall trend of the carbon dioxide emissions is that they have gone up during the studied period and is continuing to rise to the present time.

<Figure 4 about here>

<Table 6 about here>

The changes in carbon dioxide emission levels could be influenced by many factors. As figure 4 shows, the carbon dioxide levels increased from 2006 to 2008 because the production scale was larger, in this case producing higher levels of carbon dioxide emissions.

In 2006, the manufacturing plant for Honda in India started using a new type of incinerator as a model for all other Honda factories around the world. Honda believed that this new model of incinerator could decrease fuel consumption and reduce carbon dioxide emissions by up to 45% or more, compared to the old model (Honda Report, 2006). In 2007, Honda opened two new green factories in China, which focus mainly on environmental responsibility and good ergonomics. They have increased production efficiency and reduced carbon dioxide emission levels (China CSR Map, 2015).

In 2008, Honda increased its sales from the beginning of the year, and because of a larger scale of production, the carbon dioxide emission levels also increased, but Honda was affected by the financial crisis at the end of the year, which caused a serious downturn in economy that affected the production scale greatly in 2009 and 2010 (CBC News, 2008). From 2008 to 2009, sales decreased by approximately 8% because of the global financial crisis, which began in late September 2008 and affected the Honda Motor Corporation greatly for three years (Havemann, 2011). From 2009 to 2010,

the company's production scale also decreased due to the global financial crisis, which led to automotive industry crisis. However, because of higher carbon intensity, Honda increased its level of total carbon dioxide emissions. Even with the economic downturn, Honda was investing in greener technology, and a major improvement in 2009 was that Honda installed a new transformer in Japan to reduce carbon dioxide emissions from its production plants in the country.

By 2010, the level of carbon dioxide emissions started to decrease due to the low production scale as an effect of the automotive industry crisis. In 2011, Japan was struck by a major earthquake and the following tsunami, which would negatively affect the country's energy sector and economy, and Thailand was also struck with a major flood, which also affected the economy very severely. Both these events had significant impact on Honda's production and sales. Because of the floods, Thailand started a new campaign to reduce the taxes for buying a first normal size vehicle, especially for flood victims (The Excise Depepartment of Thailand, 2012). The number of car orders in Thailand enormously increased, which was a major factor behind the increase in the total sales of Honda Corporation in 2011.

In 2012, Honda experienced a major recall crisis due to defects in manufactured airbags (Safety Reserach and Strategies, INC., 2014). Honda recalled millions of cars to fix the problem, which had enormous effects, including high levels of carbon dioxide emissions in 2012. In the same year, Japan stopped its operation of several nuclear reactors as a reaction to the nuclear power plant accident following the 2011 earthquake. This caused a sudden loss in energy production capacity which was mainly replaced with coal and gas, therefore the carbon intensity level for Hondas production in Japan increased in that year. As the scale of production increased from 2013 to 2014, the level of carbon dioxide emissions increased. However, the carbon intensity has remained stable, even though the production scale was very different. This lack of change is due to the fact that Honda's green automobile plants started to produce pleasant results, these new factories were able to achieve a 30% reduction in per-unit energy consumption and other Honda plants have started to follow the green factory plan (Honda Worldwide site, 2015). If the carbon intensity and production scale of 2013 and 2014 are compared, it can be seen that, in 2014, Honda had lower carbon intensity but a larger production scale.

Honda Motor Corporation is attempting to be green and responsible for minimizing its environmental impact. The main principle of Honda is to minimize the resources and energy used from production to the final product and for maintenance. Honda's main concerns are about reducing carbon dioxide in every year possible to reduce the environmental impact. In only the first quarter of 2014, Honda promoted hybrid cars and sold more than 4,000 units (Payne, 2014). Honda also claimed, in its annual environmental report of 2012, that they almost exceeded all of its main goals for emissions reduction.

Honda has introduced new green technology to help minimize the environmental impact, including in 2007 in China, where Honda has started two new green auto plants that have succeeded and that demonstrated good environmental practices in 2013. Honda has spread green technology worldwide for the purpose of minimizing environmental impact. Nevertheless, its carbon dioxide emissions level continues to grow yearly, because of increases in productions and sales.

5-3. Comparison of the two multinational automobile companies

Comparing the results from both of these companies, we can see two very different trends. Honda has increased its production and total CO_2 emissions, while Volvo has decreased in both of these areas over the studied period. Looking first at the production values, it is noteworthy that the two companies responded to the great financial crisis of 2007-2009 differently, as a result of the different areas in which the companies are most active. The crisis started in the USA, which was then Volvo's largest market, and then spread to Europe, which is Volvo's home base; only slightly later did the recession hit Japan and Asia, where Honda has most of its facilities. Sweden was one of the European countries that was affected least by this financial crisis, which is most likely the reason why Volvo saw a turning point as early as 2009, while Honda did not until 2011.

More interesting, however, is to examine the intensity factors, which are unrelated to the scale of each company, and here we also see two very different results. Honda has seen an increase in carbon intensity but a decrease in energy intensity from 2006 to 2014, while the opposite is true for Volvo,

indicating different corporate strategies to address environmental issues. Both companies have made heavy investments into increasing their environmental performance over the studied period, but while Volvo mainly took the approach of minimizing its use of fossil fuels for its energy supply, Honda attempt to decrease its overall energy consumption (which can be seen in tables 5 and 6). It is clear that these different strategies have produced different results, and it is also evident when comparing emissions reductions that Volvo has performed better.

Why did Honda and Volvo choose to take these different routes? Were these simply arbitrary strategic decisions made by corporate leaders without forethought? Probably not. The most likely explanation is that the decisions were made based on research and knowledge of different preconditions and in response to the changing market. The availability of electricity produced from renewable sources in the Asia-Pacific region is much less than in Europe. A shift from fossil fuel-based energy to renewables, like that made by Volvo in the mid-2000s might simply be impossible or at least financially unviable for Honda currently. The main motives behind the changes made might also have been slightly different, which could also have affected these choices. Measures that increase energy efficiency are almost always also cost-efficient in the long term, while limiting the choice of energy provider might very well not be.

The 2011 Fukushima accident also caused a dramatic change in Japan's energy policy. The closing down of several nuclear reactors made energy produced from non-carbon sources an even rarer commodity for the years that followed, and the Japanese government rationed power and advocated energy efficiency. From this perspective, we can argue that Honda's investments in reducing its environmental impact were also clearly meant to increase cost efficiency and to adapt to the changing environment. Volvo, in contrast, might have experienced more pressure from its stakeholders in Europe, where the environmentalist movement is very strong, so it might have seen this major change as a very long-term investment, helping to obtain both good-will and security against future stricter emissions legislation changes, which are planned by the EU. For example, the EU has set ambitious targets for reducing climate change, outlined in the 20/20/20 climate vision, which states that, by 2020, the emissions of GHG should be reduced by 20%, 20% of all energy in the EU should be produced from

renewable sources, and energy efficiency should be increased by 20%, compared to 1990 levels. The EU's emissions trading scheme is also constantly developing, making it increasingly expensive to be a heavy producer of GHG. Looking back at all of these arguments, it becomes clearer why the companies undertook the measures that they did.

6. Conclusions

This study examined the corporate environmental management and the greenhouse gas emission changes of two multinational automobile companies, Volvo Car Corporation and Honda Motor Corporation, on a global scale from 2006 to 2014. We applied a decomposition analysis framework to examine the changes in greenhouse gas (GHG) emission in these two companies. There are three main factors to be considered in the decomposition analysis framework: carbon intensity, energy intensity, and production scale. These factors are used to study the trends in performance of the two multinational automobile companies. We clarified and gave examples of relevant factors that were likely to have caused changes in production scale for both companies during the specific period of time and gave an introduction to different technologies or methods implemented to the companies' production systems, which could have had an effect on the energy use and carbon dioxide emission levels. Through this study, we obtained the following results.

The Volvo Car Corporation's total carbon dioxide emission declined during the studied period, mainly because of a lower production scale and a large decrease in carbon intensity. The trend was a steady decrease from 2006 to 2014. The major change that had an effect on the energy used and carbon dioxide emission levels of the Volvo Car Corporation was that company invested heavily in changing the electricity supply to its production facilities from non-renewable sources to renewable sources, and the company invested in its own green wind power production. The trend for Honda Motor Corporation regarding carbon dioxide emission levels was the opposite to that of Volvo.

The total carbon dioxide emissions of Honda Motor Corporation increased during the studied period because of an increase in production scale and higher carbon intensity. The main differences between the two companies are that Honda focused its sustainability measures solely on lowering overall energy consumption, while Volvo focused mainly on the minimized use of fossil fuels and on maximizing the use of renewable energy. The reason for these differences between Honda and Volvo regarding reductions in carbon dioxide emissions can be explained by the difference in the locations of their respective productions and the available energy sources in these different regions: Europe for Volvo and the Asia-Pacific region for Honda. In Europe, the energy production sector has a low carbon intensity level compared to that of the Asia-Pacific region.

Volvo and Honda have employed different methods and technologies to reduce their respective GHG emissions, and there are many factors that could affect the GHG emissions of the two multinational automobile companies, rendering a complete analysis of this development somewhat complex. Further research is needed to explore all sides of this problem, which could have improved the overall results. For example, it would have been very interesting to examine the actual investments that Volvo and Hondo made in emissions reduction/energy efficiency and to investigate the return on that investment and compare these data between the two companies. Such a comparison could have provided a more nuanced perspective on which choice of strategy is actually preferable. Another possible fault in this study that came to mind during the progress of the work is whether total sales is actually the best indicator with which to measure the yearly production scale, which is linked to GHG emissions and energy use. There could possibly be some instances of lag between sales and production that make the link between sales and GHG emissions weaker; perhaps looking solely at the number of produced cars per year or some similar key value would have been more appropriate for the scope of this study.

As have been shown in this study, both these companies are showing positive trends with regards to production scale over the last two years, and looking forward it will be interesting to see how they will continue to develop, will the trends observed in this study continue? The negative effects of

the Fukushima disaster on the Japanese renewable energy supply are abating, providing Honda with more opportunities to reduce its carbon intensity, and it is likely that the company will continue investing in energy efficiency because it is also cost efficient. These two factors should provide the company with a good opportunity to improve its environmental performance further. The Volvo Car Corporation has had production in China for several years, but there have been new heavy investments made since the company was acquired by Geely in 2010. The first new Chinese factory was completed in 2013, and more are nearing completion. It is interesting to note, however, that since 2013 there has been no marked increase in carbon intensity as might have been expected; the Chinese energy mix still contains approximately 70% non-renewable sources, but it is likely that Volvo has taken special care to avoid purchasing energy from such sources in accordance with its environmental policy and that it will continue to do so, thus indicating that we should not expect a marked increase in GHG emissions from Volvo Car Corporation and that this expansion into China is not a case of carbon leakage from Europe to Asia.

In conclusion, Volvo Car Corporation and Honda Motor Corporation are companies trying to adapt (or some would say stay ahead of the curve) in response to a changing corporate and political climate and this study indicates that they have good possibilities to continue to do so. Global climate change and other similar environmental issues are a growing concern for many people around the world and they are looking to the big corporations for a higher level of awareness and response. Ordinary people are also exercising their consumer power to choose those companies which comply with their view of “eco-friendly” to a greater extent, making public perception a growing factor for corporate success.

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Table 1. Corporate profiles

	Volvo Car Corporation	Honda Motor Co., Ltd.
Year of foundation	1927	1948
# of employees (2014)	26,080 people	198,561 people
Total sales (2014)	18.9 billion US dollar	115.5 billion US dollar
Product portfolio (2014 year)	Passenger car (100%)	Passenger car (77.5%) Motorcycle (14%) Power products and other (2.6%) Financial services (5.9%)

Table 2. Plant location distribution and electricity sources share in each country

Company	Plant location	Production share in 2010	Share of energy source for power generation in country		
			Fossil fuels	Renewable	Nuclear
Volvo Car Corporation	Sweden	38%	4%	57%	39%
	Belgium	57%	39%	9%	52%
	China	5%	79%	19%	2%
Honda Motor Co., Ltd.	Japan	27%	62%	12%	26%
	China	19%	79%	19%	2%
	USA	26%	70%	11%	19%
	Others	28%	Not available	Not available	Not available

Table 3. History of policies, disasters, and international events related to car production

Year	Event
2005	- The European market for carbon credit trading is initiated.
2006	- Crude oil production plateaus.
2007	- Fourth IPCC report presents further evidence for of a between anthropologic emissions of GHG and climate change. - UN climate change conference in Bali sees the USA join an international agreement for an environmental policy road map. - State subsidy program for eco-friendly vehicles is introduced in Sweden.
2008	- Global financial crisis leads to the automotive industry crisis of September 2008. - Crude oil prices reach an all-time high.
2009	- Automotive industry from 2008 (Honda sales dropped)
2010	- Deep Water Horizon explodes in the Gulf of Mexico, resulting in the largest marine oil spill in history.
2011	- The Great East Japan Earthquake - Thailand floods - First Thai car reduces tax policy
2012	- State subsidy program for eco-friendly vehicles in Japan - Honda product recall
2013	- For the first time in recorded history, the laboratory at Mauna Loa Hawaii measures atmospheric CO_2 concentrations greater than 400 ppm. - Chinese government pledges first major emissions reduction plan, investing 250 million US dollar over 5 years.

Table 4. Data description

	Volvo Car Corporation			Honda Corporation		
Year	GHG	Energy	Sales	GHG	Energy	Sales
2006	137	3,419	121,620	3,800	42,920	9,907
2007	127	3,300	92,453	3,902	46,160	11,087
2008	68	2,940	90,026	3,934	46,277	12,002
2009	59	2,567	103,918	4,080	40,400	10,011
2010	68	3,016	114,203	4,370	42,900	8,579
2011	63	2,935	113,023	4,330	42,600	8,936
2012	62	2,875	110,811	4,200	39,700	7,948
2013	60	2,796	107,525	4,950	45,200	9,877
2014	50	2,684	112,742	5,210	47,500	11,842

Note 1: The units of GHG, energy, and sales are 1000 tons, terajoules (TJ), and million Swedish krona for the Volvo Corporation and billion Japanese yen for the Honda Corporation. Sales data is deflated in 2006 year price by using GDP deflator in Sweden and Japan.

Note 2: The energy consumption data is not available in the transportation of completed automobiles and administration sector in Honda from 2006 to 2008. To estimate these energy use data, we apply the following method using GHG emissions and energy consumption in production process:

Energy (transportation) = {GHG (transportation) / GHG (Production)} x Energy (Production)

Energy (administration) = {GHG (administration) / GHG (Production)} x Energy (Production)

Table 5. Major energy savings and GHG reduction activities at Volvo

Year	Region/Country	Activities
-1990	Sweden	District heating installed for all production facilities
1996	Belgium/Sweden	EMS introduced to European production facilities
2000-2006	Sweden	District heating shifted from fossil fuels to biofuels
2007	Belgium	Volvo builds three wind turbines to supply Ghent factory with electricity
2007-2008	Belgium/Sweden	Restructures electricity supply to 100% renewable sources
2008-2014	Belgium/Sweden	Further minor energy efficiency measures (recycling of heat, improved ventilation, etc.)

Table 6. Major energy savings and GHG reduction activities at Honda

Year	Region/Country	Activities
2006	India	New type of incinerator to meet global emissions standards
2007	China	Start of operations at two new green factories
2008	Europe	Established new emission standard
2009	Japan	Changed transformer of the factory to reduce CO_2 emission
2011	USA	New green high performance manufacturing plant to save energy
2012	Japan	Supporting CO_2 emissions reductions by spreading our advanced environmental technologies globally
2012	USA	Reducing CO_2 emissions at the source and more renewable energy
2013	China	Second plant performs well for green factory in China
2014	Japan	New facility achieve a 30% reduction in per-unit energy use, compared to other Honda plants

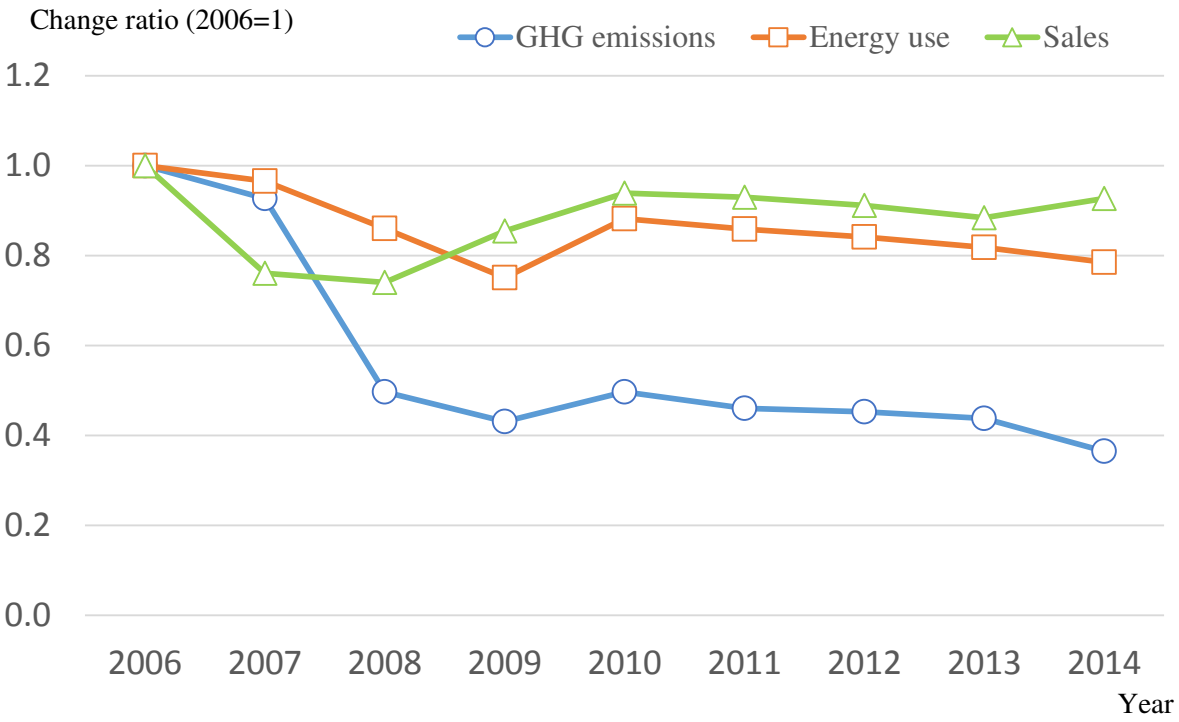

Figure 1. Time trend of corporate performance in Volvo Car Corporation

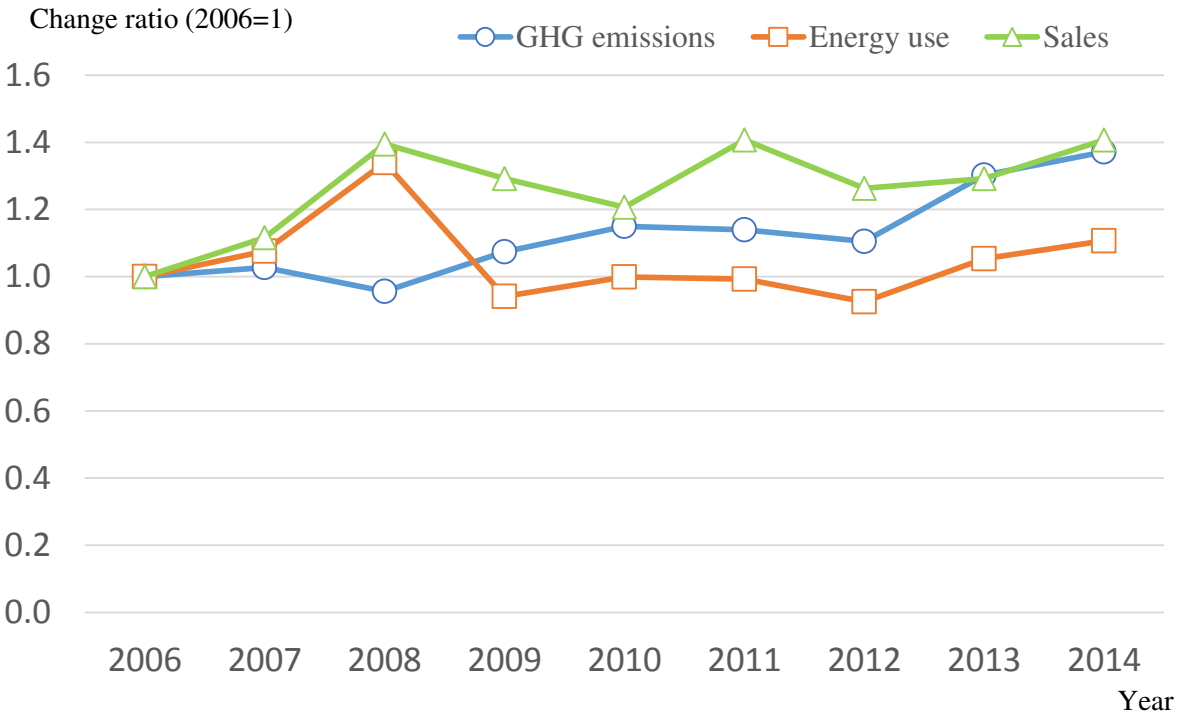

Figure 2. Time trend of corporate performance in Honda Motor Co., Ltd.

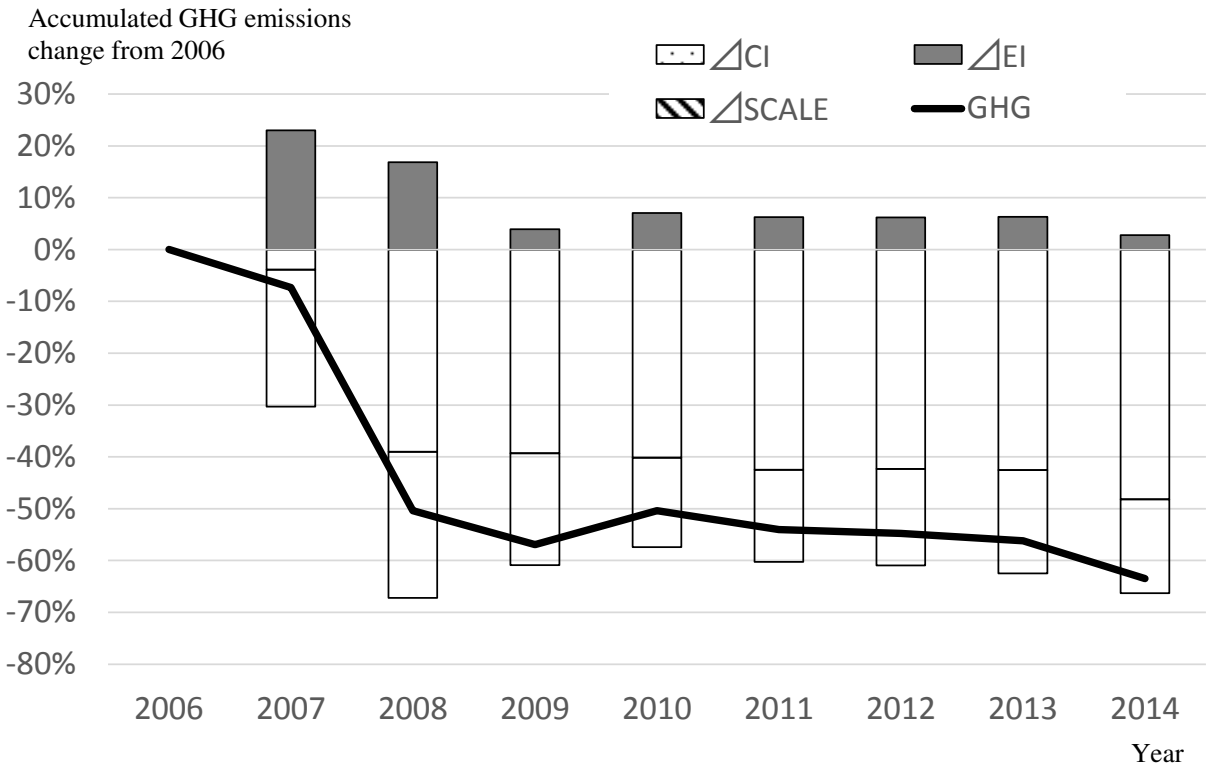

Figure 3. Result of decomposition analysis in Volvo Car Corporation

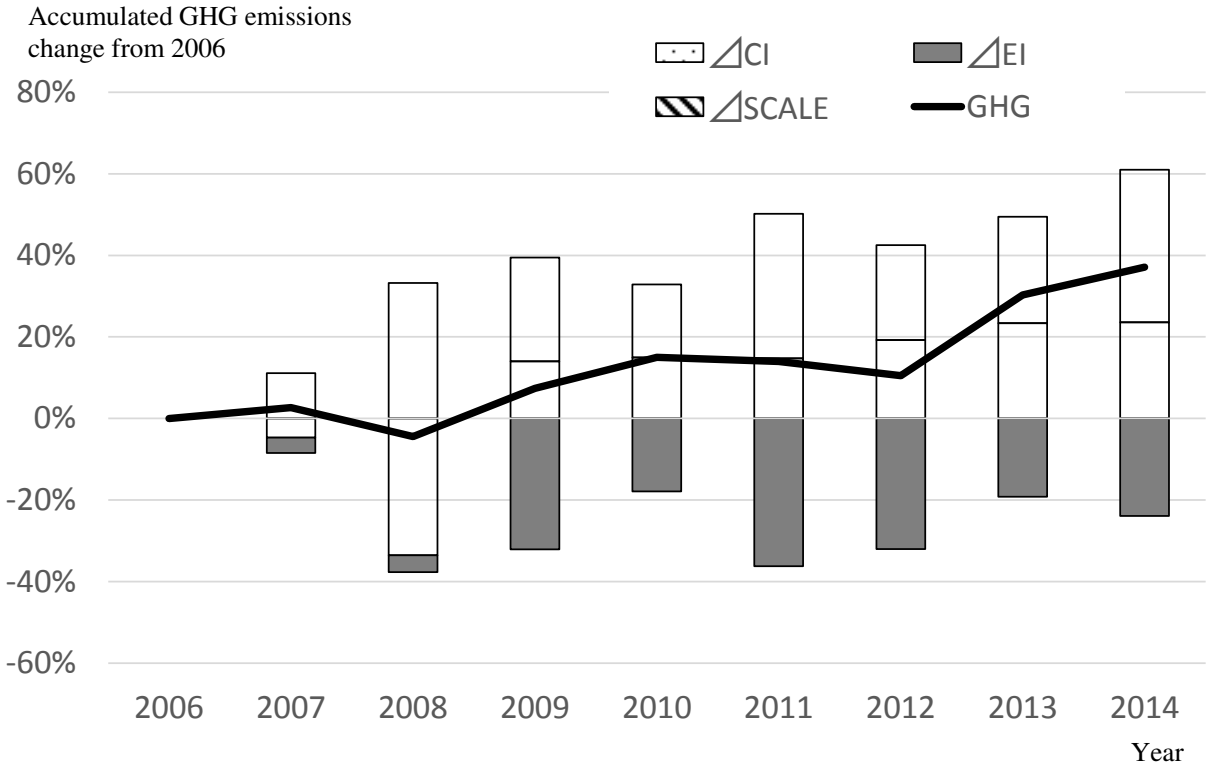

Figure 4. Result of decomposition analysis in Honda Motor Co., Ltd.