Evaluating the Influence of Carbon Emission Policies on Manufacturing Industry Dynamics and Sustainable Development

Yingjie Dong

Undergraduate College, Wake Forest University, Winston-Salem, United States

dongy21@wfu.edu

Abstract. In today's context of global climate change, carbon emission policy is getting more and more attention. The impact of carbon emission policy on manufacturing is multi-dimensional, including environmental, social and cultural aspects. These policies not only have a profound impact on the environment, but also have a significant role in society and culture. This paper provides an analysis of the influence of carbon emission policies on the manufacturing industry, focusing on the environmental, social, and cultural implications of such regulations. It examines the impact of carbon pricing and technological innovation on reducing emissions within China's industrial enterprises, which shows that these factors can significantly bolster emission reduction efforts. The paper also explores how consumer behavior towards eco-friendly products in developing countries can drive industry changes and contribute to the shift towards a sustainable green economy. The study's findings indicate that policies and consumer behavior collectively have the potential to promote a green cultural evolution and encourage economic transitions toward sustainability.

Keywords: Carbon Emission Policies, Manufacturing Industry, Green Technology Innovation.

1 INTRODUCTION

Carbon emission has been a sole contributor to the formation of greenhouse gases, which cause damage to the environment. As they expand, the industrial sector is one of the sole contributors to generating carbon emissions. With the burning of fossil fuels and other energy uses creating more carbon emissions, the government-created policies, such as carbon pricing and carbon taxes, aim to reduce carbon emissions and incentivize firms to look for new technologies and methods that are more environmentally friendly.

Though more countries have taken up the process to reduce carbon emissions, there is always a general trend of increasing emissions of carbon dioxide CO2. Though facing a slight downward trend during COVID-19, carbon emissions have increased globally [1]. Governments planning to reach net zero in carbon emissions, such as the US, UK,

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and EU, are planning to do so by the year 2050 [1]. Human activities and Economic Growth positively correlated with carbon emissions that led to the generation of greenhouse gases [2]. While the industrial sectors generate more economic benefits for the people, they also produce more greenhouse gases, which trigger environmental damage [2]. The relationship that the manufacturing industry has with carbon emissions is complicated. This relationship links to multiple aspects, such as technological innovation, economic growth, and environmental preservation. Governments need to decide between having the industry generate profit while trying to limit pollution when making new policies. Companies also look at new technologies and other approaches when facing carbon pricing and taxes.

This paper explores how carbon emission policies impact the manufacturing industry and investigates the environmental, social, and cultural consequences of these regulations. Besides focusing on how setting prices on carbon emissions and encouraging new technology can help China's industries reduce pollution, this study considers how people's shopping habits in developing nations can push industries to innovate and help build a more sustainable, green economy. Overall, the results suggest that government policies and consumer behaviors can accelerate a widespread cultural shift toward environmental responsibility and promote sustainable practices.

2 CARBON EMISSIONS, MANUFACTURING, STATUS QUO ANALYSIS

The manufacturing industry has always been one of the sole contributors to carbon emissions and the creation of greenhouse gases. Though facing a downward trend in greenhouse gas emissions, which are solely composed of carbon dioxide, the manufacturing and construction industries generated 6.22 billion tons of greenhouse gases in 2020 [3]. One of the major contributors to generating carbon emissions would be the energy sources used by the industry. In the case of Indonesia, one of the main contributors to carbon emissions in the manufacturing industry is the burning of fossil fuels because the use of multiple types of fossil fuels combined with the general increase in manufacturing output are the main causes for the increase in emissions of greenhouse gases [2].

Countries across the globe are setting goals to reduce carbon emissions [1]. Carbon emission policies such as carbon pricing were used to limit and promote the reduction of carbon emissions for firms that generate carbon emissions. Carbon pricing policies, in general, are helping incentivize firms to reduce pollution as there is a cost for purchasing quotas. For example, in the case of China, with the introduction of the Emission-Trading-System (ETS) marking a price for emissions, the higher the price went, the more likely firms would reduce their carbon emissions [4]. It is also indicated that the effectiveness of carbon pricing policies is sector-specific. In different industrial sectors in China, there are cases where there are reductions in certain industries, while in other industries, it might not affect the extent of carbon emissions at all. The manufacturing sector contains a wide range of industries, and carbon pricing policies might trigger different responses to carbon emissions in those industries. As stated in one of

the studies, setting carbon pricing policies would help reduce carbon emissions [4]. However, across regional and sector disparities in certain industries, financial burdens might be added to the production side [4]. When considering the effects of carbon emission policies and their implementations in the manufacturing industry, there might be a wide range of responses to different carbon pricing policies, just like in China's case, where different industries had different responses to carbon pricing policies.

Technological innovations also have a significant influence on carbon emissions. With new technologies that were developed aiming for cleaner and more efficient use of energy, they also played a significant role in reducing carbon emissions in industries. According to the statistical estimations made by Chen et al., technological innovations could generate an additional 10% reduction in carbon emissions in certain industrial sectors [4]. Carbon prices can only generate less than 3% [4]. Though having significant effects in reducing carbon emissions, Chen et al. also pointed out that there is a pattern of regional disparities showing a trend in which industries located in East China are more likely to take on new technological measures for reducing carbon emissions. In contrast, in South China, industries are hesitant to take the technological innovation approach to reduce carbon emissions.

As nations are planning to move forward to a net-zero carbon emission economy, there needs to be a shift to a green and sustainable economy [1]. Manufacturing Eco-friendly products could notably influence the green economy [5]. Consumers are important as they play the role of consumption in purchasing eco-friendly products, which directly influences revenue for firms. A green and sustainable economy would be achievable if consumers were not hesitant to choose eco-friendly products [5]. As Mustafa et al. explores consumer behaviors when facing eco-friendly products, they investigate factors like environmental knowledge, social influence, cost value, effort expectancy, performance expectancy, and facilitating conditions. The study's results indicated that environmental knowledge significantly influences the behavioral intention to use eco-friendly products [5]. Social influence, cost value, effort, and performance expectancy positively impact consumer behavior toward these products [5]. The research also found that facilitating conditions strengthen the effect of effort expectancy on behavioral intention [5]. Mustafa et al. suggest raising public awareness about environmental issues and the benefits of eco-friendly products, advocating for governmental and organizational policies supportive of eco-friendly production and distribution, and introducing educational initiatives to increase environmental knowledge [5]. They also recommend providing financial incentives and subsidies for producers and consumers of eco-friendly products and establishing infrastructures and systems to ease the adoption of these products to promote the green economy [5].

The manufacturing of products with import and export activities and the carbon emissions that come with producing such products revealed the region's variations in carbon emissions. Meng et al. conducted a study that reveals the global emission patterns taken into consideration with trading. Developed nations' financial resources and advanced technologies, combined with renewable energy investments and strict environmental regulations, have more capabilities to mitigate emissions [6]. In contrast, developing countries resort to more emissions-intensive methods [6]. Relating production activities to developing countries such as China and India leads to higher carbon

emission intensities globally [6]. The differences in technology, emission intensities, industries, and policies are the main factors influencing the regional disparities of carbon emissions globally.

When moving toward a green economy promoting low carbon emissions, there are challenges in the manufacturing industry and all industries generating carbon emissions. There would be technological barriers when trying to implement new production methods or produce new products incorporating the idea of a green economy and clean energy. Söderholm listed several technological challenges industries might face when moving to a green economy [7]. One of the major challenges for technological change is the diffusion of emissions, as emissions are usually spread out in a wide range of regions with a wide range of industries, meaning there are scattered emissions sources [7]. It would be a challenge to implement technological innovation to reduce carbon emissions because a wide range of sources are generating carbon emissions.

3 ANALYSIS OF THE INFLUENCE MECHANISM OF CARBON EMISSION POLICY ON THE MANUFACTURING INDUSTRY

In the manufacturing industry, carbon emission policies impacted the aspect of regulation measures and incentivization of new technologies with ideas like green energies. The Emission Trading System (ETS) employed by the Chinese government incentivizes firms to optimize their emission and production to cope with the allowances of carbon emissions [8]. The use of the ETS system in firms has led companies to strive to reduce carbon emissions while trying to maintain and improve productivity in South Korea [9].

The response from the market to carbon emission policies is complex. The competition among manufacturing firms is striving for quality, cost, and carbon efficiency during production. With such conditions, competitors seeking to adopt green technologies in the earlier production process had an advantage. Therefore, there is a change in pattern across the globe in the manufacturing industry, and there is an increasing trend in firms based in China and the EU installing photovoltaic (PV) modules in response to carbon emission policies [10].

As manufacturing firms are taking emission regulations and green energy planning into consideration, they need to accommodate emission policies while striving to maintain profitability and market share. Firms need to incorporate practices that are energy efficient while incorporating new measures in response to emission policies. The photovoltaic (PV) and electric vehicle (EV) industries are examples of manufacturing sectors that adapted to environmental regulation policies while striving for growth and innovations [10].

The relationship between carbon emission policies and firms in the manufacturing industry and others is a two-way interaction system in which the practices of the industry shape the creation of policies while the adopted policies incentivize firms to adapt to new policy frameworks and strive for innovations. Firms in the manufacturing industry influence policymaking as the design of policies aims to reduce emissions yet

not generate pressure on firms' revenue-making [10]. The data coming from industries after they adapt to new policies would reflect on the influences of carbon emission policies as a form of feedback, which might be helpful for future policymaking [11].

There are also economic implications for the interaction of policies on firms. If carbon emission policies successfully drive innovation without affecting productivity negatively, there could be economic benefits. This pattern could be observed as firms adapt to ETS, which incentivizes them to adopt new policies and limit emissions while exploring new opportunities that are environmentally sustainable. As these firms become more carbon-efficient, they often discover cost savings through energy efficiency and waste reduction, leading to enhanced competitiveness in a global market that is more sensitive to environmental issues.

The environmental impacts being influenced by policies on industries could be substantial. The policies for carbon emissions have pushed firms to adopt green technologies and reduce carbon emissions as there are penalties. This was shown in countries' goals to reduce carbon emissions and also growing industries that contribute to such goals like the PV and EV industries.

China's adoption of carbon pricing and technological innovations enabled substantial reductions in emissions which is one of the prime examples of well-executed carbon emissions policies. The heightened environmental awareness and social influence are helpful as consumers' demands could be helpful in shaping producers' future scheme to produce more eco-friendly products.

4 CONCLUSION

In conclusion, the analysis presented in the study focuses on the intricate relationship between carbon emission policies and the manufacturing industry. Carbon emissions, as one of the major sources of environmental pollution, are generated mostly through industrial activities. The manufacturing industry and the industrial sector, in general, are facing the intersection of environmental regulations, technological innovation, and consumer demands.

Through explorations, it became evident which carbon pricing mechanisms have played a pivotal role in encouraging manufacturing enterprises to monitor and adjust their emission levels. The case of China's Emission Trading System exemplifies how market-driven approaches to carbon emissions can incentivize companies to limit and reduce emissions while maintaining productivity.

Moreover, technological innovations have proven vital in reducing carbon emissions. Technological innovations for cleaner and more efficient energy use have substantially reduced emissions across various industries. Implementing these technologies is crucial to achieving sustainability within the manufacturing industry. Consumer behavior, another significant facet of the analysis, has highlighted the influence of individual choices in driving industry changes. Consumers increasingly favor eco-friendly products, influenced by environmental knowledge, social influence, cost considerations, and performance expectations. Consequently, promoting environmental

awareness and supportive policies for eco-friendly production is important to fostering a cultural shift towards a green economy.

The analysis has also drawn attention to the global disparities in carbon emissions within the manufacturing sector. Developed nations, with their advanced technologies and rigid environmental regulations, have more capabilities to mitigate emissions than developing countries. Bridging these gaps and adopting cleaner technologies in developing countries will be fundamental to achieving global emission reduction goals. The interplay between carbon emission policies and the manufacturing industry is a dynamic and intertwined relationship. While responding to these policies, manufacturers also contribute to shaping future regulations through their feedback and experiences. This mutual interaction ensures that policies evolve to balance reducing emissions and maintaining economic viability.

Effective carbon emission policies can drive innovation and still maintain productivity in businesses. Companies that adopt these policies often find ways to save costs by being more energy-efficient and reducing waste. This not only helps them compete globally but also contributes positively to the environment. The connection between carbon emission policies, the manufacturing industry, and the impact on both the environment and society is complex. Governments, industries, and consumers must work together to move the manufacturing industry towards a more sustainable future.

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