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Green Growth and Employment: Unveiling the Macro, Micro, and Global Implications of the Electric Vehicle Evolution

Heram Zahra Amiri
Bard College

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by

Heram Zahra Amiri

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Abstract

This senior project examines the complex relationship between employment dynamics and environmental sustainability during the transition to a green economy, with a particular emphasis on the global supply chain dynamics between the United States and China in the electric vehicle industry. It conducts a multidimensional analysis to investigate the employment implications of electric vehicle manufacturing, including the change to high-tech, low-labor processes and the necessity for specialized skills, notably in the battery industry.

Using extensive data sources, this study reveals subtle disparities in employment practices between the United States and China. While the US promotes job creation and sustainability through regulatory initiatives, China focuses on quick growth, frequently employing automation and robotics in the electric vehicle industry. President Joe Biden's electric vehicle policy is a key point, demonstrating the complicated interplay of economic aims, sustainability goals, and employment outcomes.

This study emphasizes the importance of strategic planning and governmental interventions in navigating the difficulties and opportunities given by the green economy. It promotes a balanced strategy that reconciles economic imperatives with environmental sustainability, ensuring inclusive growth and equitable benefit distribution in the twenty-first century.

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Introduction

With the global demand for sustainable development growing broadly, the transition to a green economy has emerged as a critical strategy for countries around the world. This transition, motivated by the urgent need to reduce the negative effects of climate change and environmental degradation, attempts to not only protect the earth for future generations but also to alter economic structures for long-term prosperity. At the heart of this change is the complex interplay of the green economy and employment trends.

Despite the enthusiasm for green innovation and its potential to create job opportunities, it is critical to thoroughly analyze its impact on employment trends. While there is broad optimism that green growth would stimulate job creation and economic progress, it is critical to recognize the potential challenges and unintended consequences.

My argument is that ambitious notions like "green economy" frequently overshadow the complexity of their implementation, particularly in terms of employment. While green development may create short-term job opportunities, it may also increase structural unemployment and deepen skill inequality among workers.

This senior thesis aims to investigate the intricate relationship between green economy initiatives, with a special emphasis on the emergence of electric vehicles (EVs) and their consequences for employment dynamics. Guided by the overarching research question, "How do macro and micro effects of the green job economy interact with the proliferation of electric vehicles (EVs) across different nations?" this study aims to investigate how electric vehicle policies, such as those initiated by the Biden administration, shape employment dynamics within the green growth industry and the global supply chain.

This senior project, which consists of three interconnected chapters, intends to shed light on the complicated connection between green economy initiatives, electric vehicles, and employment dynamics. This research aims to provide significant insights into sustainable development and employment paradigms in the twenty-first century by combining macro and micro viewpoints, as well as an examination of policy initiatives.

The first half of this senior project is a thorough examination of this relationship, providing a macrocosmic picture of the broad consequences of green economy policies on employment. This chapter delves into the multifaceted interactions between economic growth, environmental sustainability, and labor market dynamics, using a thorough review of literature and empirical evidence to investigate how initiatives such as renewable energy adoption and green technology innovation affect job creation, workforce skill requirements, and overall employment trends.

Building on this core understanding, the following chapter presents a thorough case study of the influence of electric vehicles on employment dynamics in the United States and China. As the global automotive sector makes a big transition to electrification, it is critical to understand how this transformation affects employment patterns at the microeconomic level. This chapter examines the effects of electric car adoption in many sectors of the automotive industry, including production, supply chains, service, and maintenance, using meticulous research and comparative investigation. It also looks at the consequences for workforce skill levels and the creation of new job opportunities in green technology companies, providing significant insights into the employment landscape posed by the electric car revolution.

The final chapter focuses on the impact of policy interventions on changing employment dynamics in the era of electric automobiles. This chapter examines the impact of electric car

policies in the United States on employment at both the national and global levels. This chapter assesses how government initiatives influence job creation, industry competitiveness, and the trajectory of the green economy by conducting an in-depth analysis of President Joe Biden's electric vehicle policy and its ramifications. It also looks at how these policies may affect global supply chains, trade relations, and international collaboration in the effort towards climate change. This chapter illuminates the prospects and challenges of transitioning to a more sustainable transportation future by illuminating the complex interplay between policy, economics, and employment in the context of electric vehicle adoption.

This senior project aims to contribute valuable insights to the discourse on sustainable development and employment in the modern era by conducting a thorough investigation into the complex dynamics at work at the intersection of green economy initiatives, electric vehicles, and employment paradigms.

Chapter 1

Green Economy and Employment

The Macro Impact of Green Job Economy on Employment

The recent global climate change crisis has exerted significant pressure on industries, compelling them to transition towards a green economy to mitigate its adverse effects. Manufacturing companies, as major contributors to climate change, are now under scrutiny, leading to investigations and policies encouraging this crucial shift. However, these transitions are both costly and challenging, demanding a dedicated framework and careful planning. It is crucial to recognize that these changes impact the financial activities and profits of firms, as well as employment opportunities in the labor market, forming a complex relationship between green growth and employment.

Historical studies suggest that the relationship between green growth and unemployment at a macro level is intricate, necessitating a deeper understanding of the connections between economic growth, environmental impacts, and unemployment rates. Rapid economic growth has often had detrimental effects on the environment, with industrialization and increased consumption driving pollution, deforestation, and resource depletion. Addressing these environmental issues while promoting economic growth presents challenges due to geopolitical, economic, and systemic factors. Geographically, resource-intensive countries experiencing high GDP growth tend to consume more energy and materials, exacerbating environmental problems. Economic factors further complicate solutions as accessible resources become scarcer, leading to more polluting extraction methods. Systemic issues, such as rebound effects and unexpected consequences of environmental solutions, further hinder progress. (Antal 2014, 279 - 282). The rebound effect occurs when a manufacturing company invests in cost-saving processes, such as machinery upgrades, resulting in increased production efficiency. As the company's production costs decrease, the price of the goods or services also decreases. This reduction in price

stimulates greater demand in the market for goods or services. Consequently, the company finds itself producing more than before to meet the heightened demand. However, this intensified production can exacerbate environmental issues, heightening pollution levels. To address this environmental impact, governments may need to impose regulations to control the rebound effect, potentially resulting in the displacement of labor with automation. On the other hand, initiatives aimed at addressing one environmental issue may inadvertently give rise to another problem. As noted by Miklos Antal, while the adoption of renewable energy can effectively reduce carbon emissions, it might concurrently escalate concerns related to land use and water conflicts. (Antal 2014, 279). This illustrates the occurrence of unforeseen consequences in environmental solutions stemming from old-school ideologies. Overall, this implies that rapid economic growth negatively impacts the environment.

Conversely, there exists a negative correlation between economic growth and unemployment, as economic growth accelerates, the unemployment rate tends to decrease. This reduction in unemployment often comes at the cost of greater environmental impacts, indicating a trade-off between low unemployment rates and increased environmental degradation. Consequently, nations actively seek strategies to reduce unemployment without relying on conventional growth models, recognizing the environmental trade-offs involved.

Figure 1 illustrates the global trends in GDP and carbon dioxide emissions since 2000, showcasing a consistent rise in GDP alongside an analogous increase in CO2 emissions, in line with traditional economic predictions. (Varinsky 2016). Highlighting the pivotal role of CO2 emissions as a driver of global climate change, addressing this issue has become a pressing global challenge. Nations are actively engaging in solutions, employing green innovations, projects, and technologies to curb the impact of CO2 emissions and they have been successful, as

evidenced by the figure. Forward-thinking economists recognize this challenge as an opportunity to not only reduce emissions but also bolster employment and job prospects through innovative green projects. However, comprehending the intricate and multi-dimensional impact of these initiatives on employment requires a nuanced assessment, considering various factors at play.

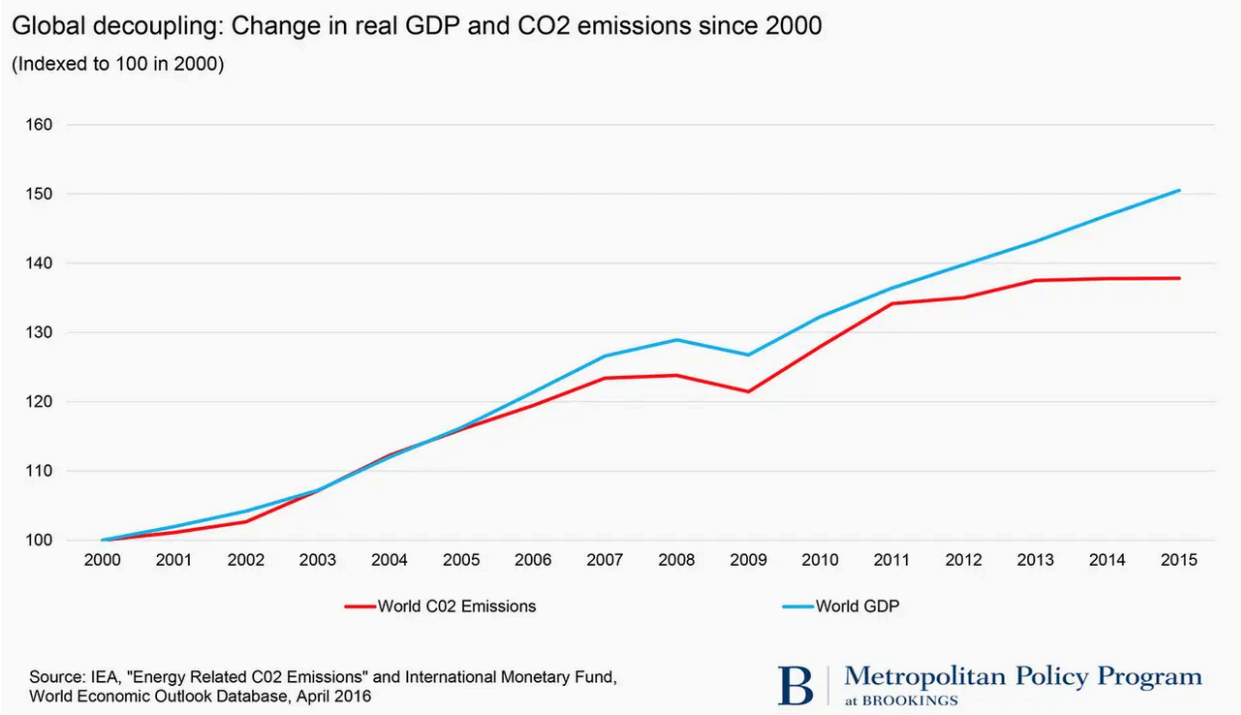

Figure 1. Global decoupling: Change in real GDP and CO2 emissions since 2000

Recent studies argue that investment in green innovation and economy creates job opportunities and enhances labor market productivity, albeit with the need for careful consideration and strategic planning in implementing these approaches. Green innovation, involving the development and implementation of environmentally friendly products, services, or processes, aims to provide long-term solutions to pressing environmental challenges such as climate change, resource depletion, pollution, and biodiversity loss, encouraging a more sustainable way of life. (Kunapatarawong and Martinez-Ros 2016, 1218). For example, the

Green New Deal stands as a contemporary proposal advocating for investments in green projects to curtail fossil fuel consumption and mitigate greenhouse gas emissions. Additionally, it seeks to create high-wage job opportunities within the scope of these green initiatives. (Friedman 2019).

Job Creation

Investing in green technology and the economy yields both short-term and long-term impacts. While the initial costs might appear extensive, the enduring benefits for companies are substantial, potentially resulting in reduced expenses. However, the transition to a green economy may displace workers due to the capital-intensive nature of green industries. Yet, the introduction of green innovation and technological reforms can significantly influence the labor market, enhancing productivity, distribution, and work quality.

The adoption of new technologies and eco-friendly practices prompts workers to adapt, potentially boosting their efficiency and productivity. This transformation in the labor market redistributes jobs and resources, aligning with the demand for skills in green technologies. Moreover, the integration of new technologies allows workers to focus on more creative, analytical, or interpersonal aspects of their roles, eliminating repetitive tasks. Nonetheless, this redistribution of jobs, driven by technological advancements and green innovation, may diminish traditional roles while introducing new positions focused on environmental sustainability, necessitating advanced skill sets and widening the skill gap among workers.

Evidence from China specifically highlights the correlation between increased investment in green innovation and a rise in employment opportunities within the country. China has strategically implemented policies focusing on green technology investments to address

longstanding unemployment issues, as demonstrated in the study titled "Influence of Ecological Innovation and Green Energy Investment on Unemployment in China: Evidence from Advanced Quantile Approach." While initial investments in environmental technology and clean energy may not immediately lead to a substantial increase in employment and could even result in job reductions, the adoption of environmental technology is projected to have a significant positive impact on job opportunities in the short run, particularly within China's energy sector. Despite the short-term negative employment impact, these investments are deemed crucial for addressing China's overall unemployment issue, suggesting that in the long run, the benefits of employment outweigh the initial drawbacks. However, it's worth noting that this paper does not delve into the skill requirements for workers in industries employing green innovations nor does it discuss the role of eco-friendly technologies that may displace labor with capital.

Investment in renewable energy sources such as solar and wind power generates jobs in manufacturing, installation, and maintenance. Green construction projects offer employment opportunities in architecture, engineering, and construction. However, it's important to recognize that these job opportunities are finite and are primarily short-term. Research and development in green technologies drive innovation and job creation but require highly skilled individuals, further exacerbating the gap between skilled and unskilled workers. The transition to green transportation options such as electric cars also boosts employment in manufacturing and maintenance. All the aforementioned sectors require both skilled and unskilled labor for manufacturing, installation, maintenance, and research and development, leading to job creation across various fields.

According to the International Renewable Energy Agency (IRENA), the renewable energy sector employed at least 11.5 million people directly and indirectly in 2019, creating

additional opportunities for skilled labor in installation and maintenance. Decentralized energy solutions generate a growing demand for energy auditors and consultants who assess the energy needs of businesses and homes, recommending appropriate decentralized renewable energy systems. This trend also fosters entrepreneurial opportunities, enabling individuals or small businesses to enter the market as installers, maintenance service providers, or retailers of renewable energy products.

Based on the analysis above, it can be argued that the green economy, characterized by green innovations and technology, offers opportunities. However, these opportunities may be temporary, as the adoption of new technology in the green economy could lead to job displacement through machinery and automation over time. While green innovation may increase productivity for some workers, it may also diminish certain positions, creating a gap between skilled and non-skilled workers. Overall, the impact of the green economy on a macro level is ambiguous, as it may displace some workers while opening opportunities for others who meet high requirements. However, the micro-level impact will be more significant, as discussed later in this project.

Green Skill Development

The green economy demands highly skilled labor, leading to the creation of more education and training opportunities for labor to reskill and upskill. The high job qualifications in the green economy create a gap between high-skilled and low-skilled labor. The shift of industries into a green economy necessitates investment in education and training programs to develop a skilled workforce, leading to increased employment in the education and training sector. Companies or industries intending to transition to a green economy must provide training

for workers to enhance their skills, aligning them with the requirements of new green technologies. Governments also invest in the educational system of schools and universities, enabling students to acquire the necessary skills, further enhancing their potential and capacity to work efficiently in the new green economy.

While investing in training programs and education to reskill or upskill labor is efficient for the economy, its effectiveness may vary between countries due to demographic differences and the educational background of the labor force. Workers previously engaged in agriculture, manufacturing, or construction might lack the basic knowledge needed for effective participation in upskilling programs.

Another factor that could impede training and education policies for reskilling and upskilling is the socioeconomic status of individuals. If these training programs are not provided free of cost, participation may be challenging for some people. Additionally, the allocation of government investment in the educational system needs to be considered. Is it directed towards specific types of schools or accessible to everyone in the country, ensuring students are equipped with the necessary skills for the job market? If access is limited, the socioeconomic status of individuals could pose a significant challenge for workers and people seeking to reskill or upskill to meet the requirements of the green job market.

This will have short-term and long-term consequences. The short term could be transition costs of retraining and providing skill development training and the long term would cause inequality among two skill groups: high-skilled and low-skilled workers. Consequently, it leads to structural unemployment in the economy which is caused by a mismatch between the worker's skills and the demanded skills by employers. Additionally, countries with aging populations face challenges in implementing these programs effectively. Thus, the relationship between the green

economy and employment concerning green skill development remains complex and multifaceted.

Conclusion

Ultimately, the complex relationship between green growth and employment highlights the problems and opportunities that companies and economies confront. As they transition to a more sustainable future, careful consideration is demanded. The urgent need to combat climate change has required a transition to a green economy, forcing firms to invest in green innovation and adopt environmentally friendly practices. While these transformations are expensive and time-consuming, they have the potential to provide major job opportunities, particularly in renewable energy, green construction, and technology innovation.

Green technology investments not only create jobs but also force the labor market to adapt, increasing efficiency and production. However, because the move to a green economy necessitates highly trained labor, there will be a skills gap between high-skilled and low-skilled people. As a result, effective education and training programs are critical to closing this gap and equipping the workforce with the required skills for future green occupations.

The Microeconomic Impact of the Green Job Economy on Employment

In the global pursuit to address climate change and its associated challenges, industries are emerging as pivotal players. Recognizing their role, these industries are now actively constructing a comprehensive framework that intertwines environmental sustainability with economic prosperity. This paradigm shift is poised to exert profound effects on the workforce within these sectors.

Kunapatarawong et al. dissect the facets of green innovation, distinguishing between the impact of the green innovation process and green innovation products on employment. (Kunapatarawong and Martinez-Ros 2016, 1219). The green innovation process involves the adoption of new or enhanced production and distribution techniques, necessitating a workforce with advanced skills for effective implementation. Notably, the green innovation process stands out for its employment generation capacity, as it involves the initiation of new projects that require a higher-skilled workforce to address environmental challenges through green initiatives. For example, waste recycling represents a green innovation process wherein the implementation and operational processes generate new job opportunities. In contrast, green product innovation serves as a paradigm of job displacement through automation. An illustrative example is the replacement of tasks once performed by individuals with the advent of green products. Take electric cars, for instance, which have the potential to diminish or insignificantly impact employment rates. The production of electric cars, for example, requires fewer labor resources compared to their traditional counterparts, resulting in a decrease in overall employment opportunities. Additionally, the US autoworkers' strike in 2023 was triggered by a surge in investment in advanced production technologies for electric cars. Many manufacturing companies find themselves grappling with the challenges of a "costly transition from gas guzzlers to electric vehicles" (Krisher, Housholder, Seewer 2023). In this shift, high wages are being replaced with green technology, exemplifying a scenario where innovative green products impact both employment rates and wages.

The researchers underscore the dichotomy between "voluntary versus compliance-driven green innovation" (Kunapatarawong and Martinez-Ros, 2016, p. 1220). Firms that willingly embrace green innovation policies not only experience heightened profitability and enhanced

market competitiveness but also demonstrate a minimal impact on unemployment. These forward-thinking companies strategically invest in clean energy, effectively reducing costs and concurrently increasing demand, thereby ensuring sustained employment and potential expansion. A case in point is Johnson & Johnson, whose steadfast commitment to green practices and innovations has led to a consistent increase in its employment rate over time. Figure 2 vividly illustrates the substantial difference in the employment rates between 2010 and 2022, suggesting that voluntary green innovation plays a pivotal role in shaping a company's employment trajectory. (Macrotrends n.d.).

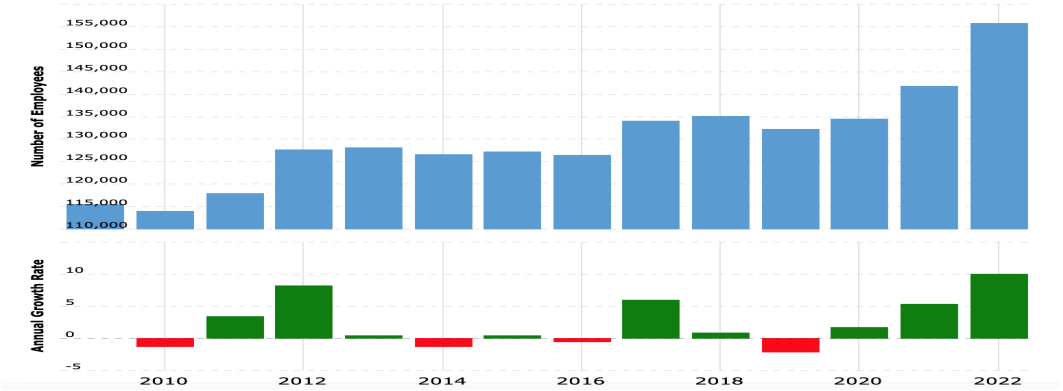

Figure 2. Johnson & Johnson Company Number of Employees from 2010 - 2022

Conversely, firms compelled by regulatory pressures to adopt green innovation may resort to cost-cutting measures, including layoffs, to reallocate funds toward compliance. In such instances, the adverse effects on employment are compounded by diminished competitiveness and increased operational costs. Take, for example, Unilever, a company mandated to adopt green policies by regulations. Despite being labeled a greenwashing firm—employing green incentives to promote products while adhering to mandatory regulations—the company has experienced a notable decline in its employment rate over the years. This is clearly depicted in Figure 3, highlighting a significant drop in Unilever's employment rate from 2010 to 2022.

(Stock Analysis 2023). The evidence strongly supports the argument that the mode of embracing green innovation, whether voluntary or compliance-driven, profoundly influences a company's employment dynamics.

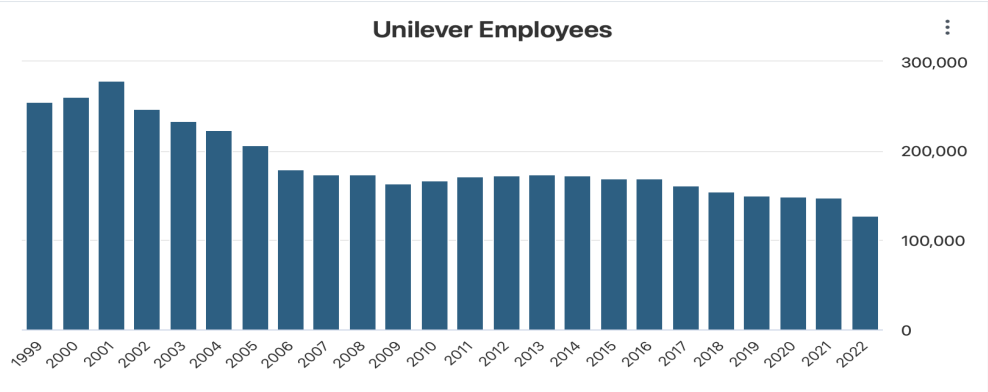

Figure 3. Unilever Company Number of Employees

While these theories offer a broad understanding, it is crucial to recognize additional factors influencing the effectiveness of green innovation policies. Different employment sectors exhibit diverse responses to the adoption of green innovation, with some benefiting while others may not. The geographical context also plays a pivotal role, as different countries and regions react uniquely to these policies. Moreover, the green job economy has disparate effects on high and low-skilled labor, potentially enhancing productivity for one group while displacing the other.

Understanding the intricate relationship between the green economy and employment requires an exploration of these nuanced factors. The subsequent illustrations will delve deeper into these dynamics, providing a detailed explanation of the complex interplay between green economy and employment.

The Impact of the Green Job Economy on Employment Across Sectors

The expansion of the green job economy exerts diverse effects on various sectors, both positive and negative. This impact becomes evident when categorizing industries into two distinct sectors: "dirty" industries, encompassing the manufacturing sector, and "clean" industries, representing the service sector. (Kunapatarawong and Martinez-Ros 2016, 1219). Keep in mind that the distinction between “clean” and “dirty” industries is ambiguous. As Table 1 shows there are manufacturing sectors that count as part of clean industries such as the textile Industry, clothes, shoes, hat manufacturing, and others. (Shan and Wang 2019, 6). Therefore, there is no clear distinction between these two sectors. However, evaluations by various economists consistently suggest that the employment impact on the "dirty" sector surpasses that on the "clean" sector. Green innovations lead to job replacement and loss in "dirty" industries while concurrently enhancing the productivity of "clean" industries.

Clean Industries	Dirty Industries
Agricultural and sideline food processing	Coal mining and dressing
Food production	Extraction of petroleum and natural gas
Beverage production	Ferrous metal mining and dressing
Tobacco products processing	Non-ferrous metal mining and dressing
Textile industry	Non-metallic mining and dressing
Clothes, shoes, and hat manufacture	Papermaking and paper products
Leather, furs, down, and related products	Petroleum processing, coking, and nuclear fuel processing
Timber processing, bamboo, cane, palm fiber, and straw products	Raw chemical material and chemical products
Furniture manufacturing	Medical and pharmaceutical products
Printing and record medium reproduction	Chemical fiber
Production of cultural, educational, and sports articles	Rubber and plastic products
Metal products	Non-metal mineral products
Ordinary equipment and manufacturing	Smelting & pressing of ferrous metals
Transportation equipment and manufacturing	Smelting & pressing of non-ferrous metals
Electrical machines and apparatuses manufacturing	
Communication equipment, computers, and other electronic equipment	
Communication equipment, computers, and other electronic equipment	

Table 1. Composition of Industry Categories (Data from Shan and Wang 2019)

Source: Wei, Shan, and Jingyi, Wang. 2019 “The effect of environmental performance on employment: evidence from China’s manufacturing industries.” *Journal of Environmental Research and Public Health, 16 (12):2232.* *https://www.mdpi.com/1660-4601/16/12/2232#*

For instance, Yaqian et al. highlight that the expansion of renewable energy may result in job displacement within the electricity sector. Their research estimates that "if wind power and solar PV expand, 210 and 320 jobs will be lost" (Mu et al. 2018, 264). Most of the studies have been agreed with this statement. This underscores that while green innovation creates job opportunities, the associated cost of job replacement or loss outweighs the creation of new jobs through green projects. It also emphasizes the finite job creation capacity of the green job economy, as further expansion of these technologies escalates the marginal cost of generation. (Mu et al. 2018, 265).

As mentioned earlier, the renewable energy sector, specifically wind power and solar PV, leads to job losses, but the operation and maintenance of electricity—classified under the service sector—remains unaffected. Individuals previously employed in these sectors can retain their positions through upskilling strategies. While the adoption of green innovation can create employment opportunities in the clean energy sector, it often requires highly skilled labor, potentially exacerbating inequalities across sectors. Conversely, labor and capital-intensive and highly technical tasks may be replaced by new technology and Artificial Intelligence (AI).

Green innovation projects and the clean energy sector are gradually supplanting jobs in the fossil fuels sector, leading to a reduction in labor positions within production. For instance, traditional coal industries which is a mining industry, once reliant on human labor, are being replaced by automated machinery. As Figure 4 shows over time from 1940 to 2018 employment in the mining sector which is a dirty industry has changed. (Gibbs and Bazylik 2022). This sector

was labor intensive before but it has been changed in recent years, this shift underscores the transformative impact of machinery and green innovation on jobs in traditionally "dirty" industries.

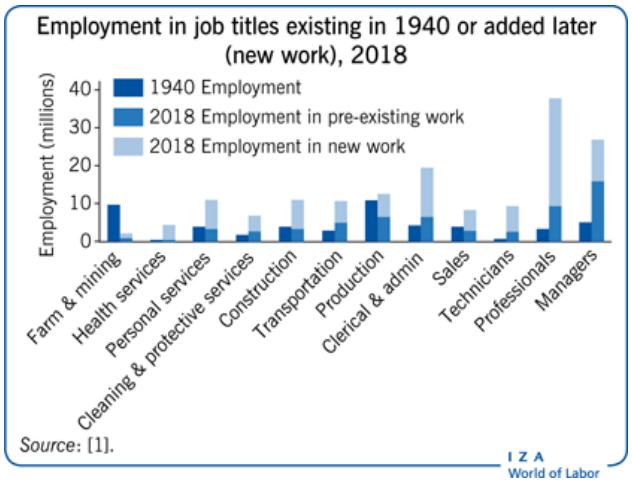

Figure 4. Employment in job titles existing in 1940 or added later (new work), 2018

Despite the job displacements in "dirty" industries, green innovation significantly boosts productivity in "clean" industries despite the fact that it also replaces labor. The International Renewable Energy Agency reports that "it takes a technician an average of about 10 hours to inspect 1 megawatt (MW) of solar modules, but drones could reduce this to an estimated 15-18 minutes/MW, a pace 38 times faster" (International Renewable Energy Agency 2020, 33). This illustrates how green innovations enhance productivity and facilitate cost-saving processes in the "clean" sectors while replacing labor.

The Impact of Green Job Economy on Employment Across Skill Groups

There exists a spectrum of opinions concerning the relationship between the green economy and the unemployment rate. Some contend that the establishment of a green economy,

reliant on highly skilled labor, may introduce increased unemployment rates for low-skilled workers. This divergence arises from the prevailing notion that the transition to green growth is driven by high-tech incentives, necessitating a workforce with advanced skills. Consequently, a divide emerges between these two labor sectors within an economy.

Green growth not only generates job opportunities but also enhances labor productivity in a high-skilled economy. This setting enables individuals to undertake basic tasks through cutting-edge technological innovations, freeing up their time and labor energy to contribute to companies' productivity through creative, analytical, and innovative approaches.

However, the implementation of green innovation and projects incurs high costs, impeding economic growth. Additionally, the demand for highly skilled labor further widens the gap between low-skilled and high-skilled workers. The intricacies of green technology necessitate individuals with advanced education and skills, posing a challenge for those engaged in low-skilled jobs, which may eventually be replaced by automation and technology. As Figure 5 shows the number of green jobs has increased over time however the number of employees who have green skills which are considered high skills in the job market is low. (Holger 2023). This picture conveys a skill gap between laborers which would lead to inequality and ultimately to the replacement of jobs with AI.

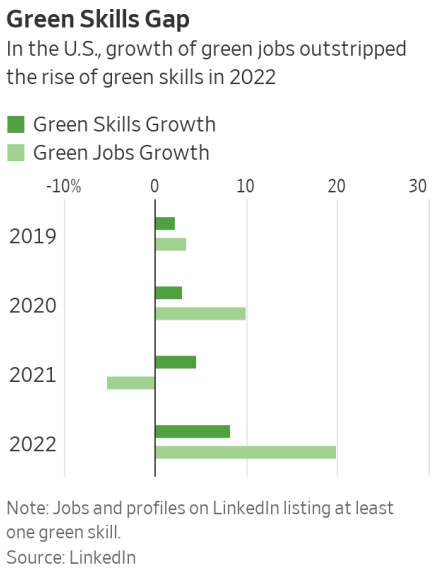

Figure 5. Green skills gap: the gap between green growth and green skills

Firms heavily invest in green technology, often leading them to phase out low-skilled workers in favor of higher-skilled labor capable of effectively utilizing the technology within shorter time frames. This shift streamlines operations and contributes to overall efficiency, as one high-skilled worker may replace two or three low-skilled laborers.

The disparity between high-skilled and low-skilled labor becomes pronounced in countries or regions where access to high education or skill development programs is limited. This scarcity of high-skilled labor jobs creates a void in the job market, particularly affecting developing countries. To fill this gap, these nations often resort to hiring foreign workers, thereby exacerbating unemployment rates.

To sum up, the impact of the green job economy on employment dynamics is multifaceted. While it opens avenues for skilled workers, the transition poses challenges for low-skilled laborers. Addressing these challenges requires a balanced approach that considers the economic growth potential of green technology alongside strategies to bridge the skills gap and ensure inclusive employment opportunities.

Conclusion

In conclusion, an assessment of the microeconomic impact of the green job economy on employment indicates a complex interaction of elements that has a considerable impact on workforce dynamics across many sectors and skill levels. The change in perspective toward environmental sustainability and economic prosperity emphasizes the importance of an in-depth understanding of the employment consequences of green innovation.

There is also a conflict between the influence of the green innovation process and green innovation products on employment. While the use of environmentally friendly industrial techniques necessitates advanced skills and may increase workforce efficiency, the manufacture of green products such as electric cars may result in fewer total job prospects. Green innovation's voluntary versus compliance-driven nature adds nuance, with voluntary adoption leading to increased profitability and low unemployment impact, but compliance-driven adoption may result in cost-cutting measures and job losses.

The sectoral analysis divides industries into "dirty" and "clean" sectors, with the "dirty" sector undergoing job relocation and loss, notably in areas such as fossil fuels. While producing new job opportunities, the renewable energy sector also replaces positions in the power sector, underlining the importance of upskilling measures. Despite increasing productivity, the renewable energy sector requires highly skilled personnel, potentially worsening inequality across industries.

Examining the impact across skill categories reveals the possibility of a labor divide between high-skilled and low-skilled workers. The shift to a green economy, fueled by high-tech incentives, may result in the displacement of low-skilled workers in favor of higher-skilled labor, expanding the gap between the two groups. The demand for advanced education and abilities in

green technology causes issues for those working in low-skilled jobs, particularly in areas where education and skill development programs are restricted.

Chapter 2

Case Study: Electric Vehicles Production and Employment

Case Study - Evolution of Electric Vehicles as a Green Growth Innovation

Electric and hybrid vehicles in the automobile industry represent a revolutionary leap in green innovation worldwide. These vehicles are battery-powered, consisting of a battery for energy storage and electronic engine controllers that propel the wheels. (Dijk and Yarime, 2010, 1376). The adoption of electric vehicles has witnessed significant growth in recent years, with individuals embracing them for various ideologies and objectives. Some view using electric vehicles as a personal responsibility to mitigate carbon emissions, contributing to environmental preservation and societal well-being. Electric vehicles are perceived as a socially responsible choice, serving as a solution to air pollution, a recognized health hazard linked to environmental pollution.

The California Air Resources Board (CARB) responded to severe health issues in Los Angeles, California, by implementing policies favoring electric vehicles in 1990. (Dijk and Yarime, 2010, 1380). Additionally, economic considerations drive the adoption of electric vehicles, particularly in regions with high gasoline prices. For example, Iceland, where gasoline prices are steep, has seen a substantial shift towards electric vehicles for cost-saving purposes. According to Reykjavik Cars, in 2020, electric and hybrid vehicles accounted for over half of new car purchases in Iceland. (Sigurðardóttir, 2022).

Furthermore, government policies, especially in the US, play a pivotal role in promoting electric vehicle usage. Buyers of electric vehicles receive tax credits, further incentivizing the shift from traditional gasoline-powered vehicles. (U.S. Department of Energy). These diverse factors underscore the multifaceted motivations behind the growing popularity of electric and hybrid vehicles.

The following graph depicts the sales share yellow line and market share in bars of electric vehicles from 2017 to 2020. According to the graph, there has been a consistent upward trend in both the sales and market share of electric vehicles during this period. Notably, Chinese companies are actively increasing their production of electric vehicles. The global market share of electric vehicles has risen significantly from 17% in 2017 to 24% in 2020, indicating a substantial shift in the automotive industry towards electric mobility. This remarkable increase underscores the growing commitment of companies worldwide to embrace and contribute to the electric vehicle market.

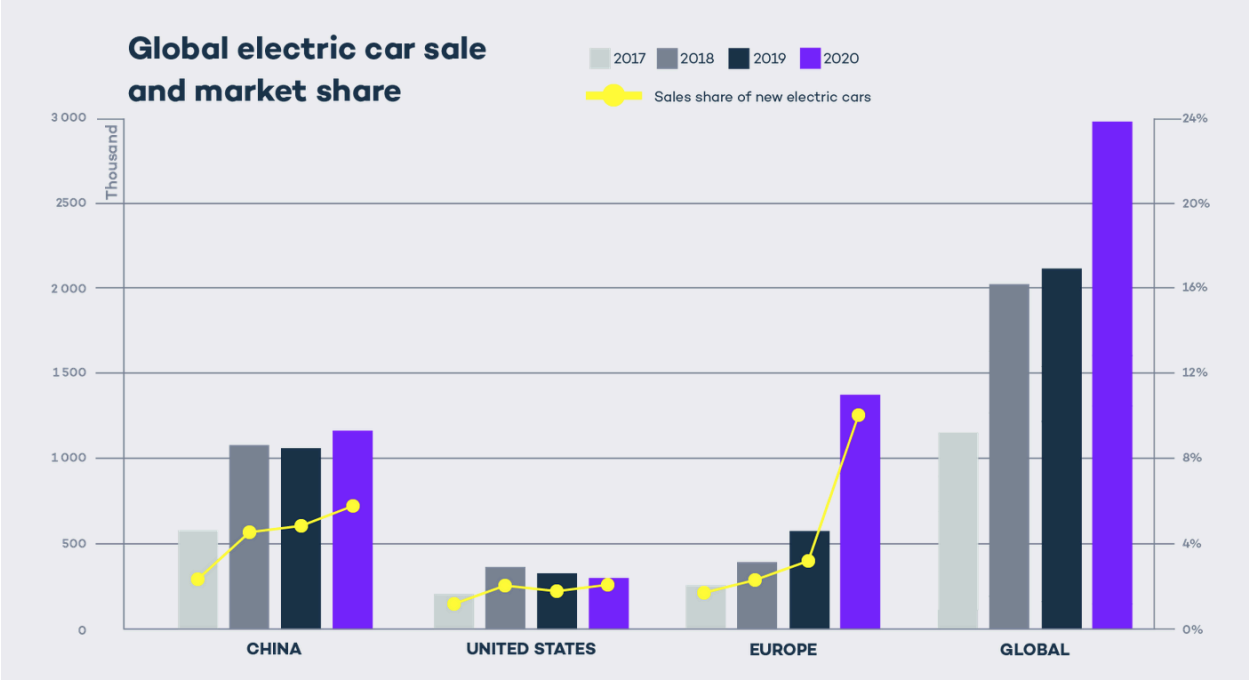

Figure 6. Global Electric Vehicle Sale and Market Share 2017 - 2020

Considering the aforementioned advantages of electric and hybrid vehicles, it is evident that an increasing number of people are inclined to purchase these vehicles. This marks a revolutionary transformation driven by green innovation in our contemporary world. However, diverse opinions exist among economists and the public regarding this innovation. Some

perceive it as a solution to climate change, while others view it as a lucrative business opportunity.

Manufacturers see the green innovation of electric and hybrid vehicles as beneficial for current customers, an attraction for new customers, and an avenue for creating a high-demand market with continuous development. By aligning production with a burgeoning demand for electric vehicles, manufacturing companies perceive this as a strategic business opportunity for profit maximization.

When examining the supply side, a notable trend emerges among manufacturing companies, with a predominant focus on electric vehicle production due to its cost-effectiveness compared to gasoline vehicles. The manufacturing process for gasoline vehicles involves numerous intricate body parts, demanding a substantial labor force for their production. In stark contrast, electric vehicles, centered around a key component—the battery—do not entail the complexity of assembling myriad body parts. Bearing this in mind, although the fixed costs of production remain high, the marginal cost is lower due to the streamlined assembly process with fewer body parts and reduced labor costs. Furthermore, the transition from a labor-intensive workforce to a more streamlined team of skilled workers is a distinct advantage in electric vehicle production. The integration of new technologies into the electric vehicle manufacturing process has significantly augmented production capabilities. These cutting-edge technologies contribute to expediting the production process when compared to traditional gasoline vehicles. This acceleration is particularly noteworthy in mitigating the time-intensive aspects of vehicle production. Consequently, manufacturers can now produce a greater number of electric vehicles with a reduced labor force compared to the labor-intensive production requirements of gasoline vehicles.

An additional factor influencing the supply dynamics of electric vehicles is the surge in consumer demand. The escalating desire for electric vehicles incentivizes more manufacturing companies to enter the market, seeking to capitalize on this growing trend and enhance their profitability. A notable example is the establishment of Tesla, a company exclusively dedicated to producing electric vehicles, driven by the substantial demand for this eco-friendly mode of transportation. Even today, there remains palpable excitement surrounding the ownership of a Tesla. Consequently, a shift towards increased production of electric vehicles has transpired over the years, propelled by the interplay of cost-efficiency, technological simplicity, and heightened market demand.

Nevertheless, the impact of the green innovation of electric or hybrid vehicles on society can be assessed by examining its implications across various aspects of people's lives. This case study will specifically investigate the relationship between this innovation and employment rates. It aims to determine whether this innovation truly opens new opportunities for people or, conversely, serves as a solution to climate change while negatively affecting employment.
The scope of this green innovation extends beyond small businesses with just two stakeholders, buyers and sellers. Numerous actors are involved in the process, including car manufacturers, engine component suppliers, car users, car repair shops, researchers, banks, shareholders, and policymakers. This case study will examine the relationship between the innovation of electric or hybrid vehicles and employment rates and will focus on three key actors: car manufacturers, engine component suppliers, and the research and development sector. Additionally, it will touch upon the role of car repair shops in this complex network.

The Interplay between Electric Vehicles and Employment

The production dynamics of electric and hybrid vehicles differ significantly from traditional gasoline vehicles, influencing the interaction between capital, labor, and energy. Unlike traditional vehicles, which involve extensive manual labor for various components, electric vehicles have a streamlined structure, primarily centered around the crucial component - the battery. This structural distinction leads to a substitution effect between capital and labor, with machines (capital) assuming many tasks traditionally performed by human labor.

For instance, if the transition from traditional to electric vehicles occurs at the same rate as imported powertrain parts and maintains the current domestic auto market share, a substantial portion of jobs in the industry could be jeopardized. Presently, “the share of powertrain components for electric vehicles produced in the US is below 45%, whereas the equivalent figure for traditional gasoline vehicles exceeds 75%.” (Barrett and Bivens, 2021). Consequently, this transition poses a significant risk of extensive job losses within the industry.

The shift from traditional to electric vehicles entails fundamental changes for manufacturing companies and their workforce. Jobs generated in the electric vehicle industry are predominantly related to the energy sector, demanding high skills and offering competitive hourly wages. Proficiency in network and IT skills becomes imperative, creating a challenge for workers from the gasoline vehicle industry who lack these qualifications. This transition not only signifies a revolution in the employment sector but also accentuates the skill gap between low-skilled and high-skilled workers, potentially leading to increased unemployment.

The shift towards a green economy, especially in the realm of electric vehicles, holds the potential for job creation, but it also exacerbates the divide between skilled and unskilled workers. According to the Natural Resource Defense Council, the electric vehicle industry

comprises three primary sectors: design and development, battery manufacturing, and charging network development and maintenance. The design and development sectors demand skilled professionals, including software developers, electrical engineers, and chemical engineers, indicating a clear need for high-skill labor. (Cosier, 2024). Similarly, the other two sectors within the electric vehicle industry also rely on a workforce with advanced skills.

However, opportunities for unskilled labor are limited, primarily confined to construction roles within the charging network development and maintenance sector. Unfortunately, these jobs are typically temporary, as once construction concludes, the need for such labor diminishes. Vehicle maintenance, on the other hand, requires individuals familiar with the intricate technologies and systems employed in production. Consequently, a substantial gap emerges between high-skilled and low-skilled workers, perpetuating unemployment and fostering discrimination.

This gap not only sustains elevated levels of unemployment but also contributes to the skill gap among workers. Those possessing the necessary skills secure higher-paying jobs, leaving others grappling with obstacles like age, financial constraints, and limited opportunities. Addressing these challenges is vital for achieving a more inclusive and equitable transition to a green economy.

One of the most promising avenues for job creation within the electric vehicle industry is the development of charging infrastructure to support electric transportation. However, it is essential to note that these employment opportunities may be short-lived. Tasks such as equipment installation, shipment, and station construction are typically one-time procedures, offering immediate job prospects. Yet, in the long run, the employment landscape may revert to its initial state or witness a decline in employment within the sector.

Additionally, the manufacturing process of electric vehicles requires fewer workers compared to traditional vehicles due to their technological foundation and streamlined design. The emphasis on technology, coupled with the reduced number of components, results in a decreased need for manual labor. To gain a deeper understanding, an analysis of Ford's workforce and the proportion of its electric vehicle sales was conducted, comparing the years 2018 and 2022. A perusal of the annual reports for these periods reveals that in 2018, Ford employed 199,000 individuals, and electric vehicle sales constituted only 0.39% of its total sales. Conversely, in 2022, Ford's workforce was reduced to 173,000 employees, while electric vehicles accounted for 3.5% of the annual sales. (Ford Annual Report). This example illustrates that as the market share of electric vehicles increased within Ford, the number of employees in this sector decreased. There might be other factors involved however the electric transition is a significant one because now electric vehicles do not need many employees to work in the manufacturing sector.

Manufacturing companies, having already invested significantly in research and development (R&D) and battery purchases, may opt for employee layoff policies to redirect funds toward R&D and technological restructuring. While this approach enhances the efficiency of electric vehicle production, it simultaneously leads to employment losses. The potential expansion of the electric industry poses a risk to existing jobs, with increased demand for electric vehicles having a potentially adverse effect on employment within the sector.

Cross-Country Perspectives - Global Supply Chain

In the production of electric vehicles, three key stakeholders play vital roles in facilitating the transition from gasoline to electric power: research and development, car manufacturers, and engine component or battery manufacturers.

The United States

Research and Development:

The historical timeline of electric vehicles underscores the United States' early commitment to producing such vehicles. The federal government initiated a research and development program focused on electric vehicle batteries, led by the Vehicle Technology Office (VTO). This comprehensive program encompasses project areas such as electric motor R&D, power electronics R&D, benchmarking, testing, analysis, advanced packaging R&D, and EDT materials R&D, all aimed at advancing electric vehicle production (Boyd and Howell, 2016, 1).

A notable initiative from the Department of Energy involved collaboration with the US Advanced Battery Consortium (USABC), the world's largest research and development program for advanced automotive batteries. This partnership positioned the US as a leader in advancing battery technology globally. (Weinstock, 2002, 472).

These programs not only drive technological advancements but also create employment opportunities in various fields. Positions within the research and development sector demand specific skill sets, education, and experience tailored to the electric vehicle industry. Scientists, hired to enhance the industry through research, typically work in office and laboratory settings. Their work involves planning, recording, reporting, and equipment testing before implementing their findings. Collaboration between scientists and engineers is crucial to achieving common objectives. According to the US Bureau of Labor Statistics, the qualifications for the R&D field

in the electric vehicle industry vary: "A doctoral degree is a necessity for scientists conducting original research and developing new products. However, other scientific workers may find jobs with a bachelor's or master's degree. Computer skills are essential for scientists to perform data analysis, integration, modeling, and testing. Certification or licensure is not necessary for most of these scientists." (Hamilton).

In addition, workers in this industry earn a median wage ranging between $68,320 and $84,720 per year based on 2010 statistics.

Considering the outlined requirements for job opportunities and the expansive R&D programs that create more employment opportunities, it becomes apparent that these initiatives contribute to job creation. However, a potential downside is the emergence of a skill gap which leads to employment skill gap and structural unemployment. Despite the positive impact at the macro level, the median wage of $68,320 annually may not be sufficient for individuals who have invested in acquiring skills through advanced education. Consequently, while these programs positively affect employment rates at a broader level, the micro-level implications are leading to structural unemployment and the employment gap between skilled and unskilled workers.

Manufacturing:

The transition from gasoline vehicles to electric vehicles addresses sustainable development issues such as climate change; however, it raises concerns regarding inequalities in the job market in terms of skills and accessible decent work opportunities for workers in the U.S. Manufacturing labor is particularly impacted, with workers facing significant challenges. Considering the construction and body structure of electric vehicles, it's evident that they have fewer components compared to gasoline vehicles. For example, according to figures from Ford

Motor, electric vehicles have about 30 percent fewer components. (Scheiber, 2021). This means that manufacturing gasoline vehicles, with their greater number of components, requires a substantial amount of labor to assemble them effectively. In contrast, electric vehicles require less labor due to their simpler assembly process, aided by technology.

This situation was highlighted in the United States when autoworkers launched a nationwide strike on September 15, 2023, due to concerns about employment prospects during the transition from gasoline to electric vehicles. Charles Dickerson, an autoworker, serves as a temporary replacement, known as a supplemental worker, for a full-time employee on leave. Dickerson contends that the absence of full-time positions is indicative of the company's exploitation of temporary workers, who receive lower wages than their full-time counterparts (More Perfect Union, 2024). It is evident that companies are capitalizing on the demand for electric vehicles by utilizing temporary workers to fulfill tasks in a shorter timeframe and for reduced compensation compared to full-time employees. This exploitation has become a significant concern for autoworkers nationwide.

Despite the reduced labor requirements for electric vehicles, the assembly of their components takes less time than gasoline vehicles. Consequently, this affects the number of shifts available to workers in manufacturing plants. For instance, a company manufacturing gasoline vehicles with two shifts (AM and PM) may reduce shifts to only AM with the production of electric vehicles, reflecting the efficiency of the production process.

Furthermore, as manufacturing companies transition to producing electric vehicles, they must invest heavily in research and development sectors and acquire new technologies. This allocation of the budget towards technological advancements affects the wages of manufacturing workers. In the past, jobs in gasoline vehicle manufacturing were well-paid and required minimal

skills. High school graduates interested in the industry could secure high-paying jobs without extensive skill development. However, manufacturing electric vehicles necessitates highly skilled workers due to the complexity of the production process. According to the U.S. Bureau of Labor Statistics, most positions in the electric vehicle industry require training, and "industrial production managers typically hold bachelor's degrees in engineering disciplines such as mechanical or industrial engineering, along with years of experience in the automobile manufacturing industry." (Hamilton).

Despite the increased skill requirements, wages for workers in electric vehicle manufacturing are lower compared to gasoline vehicle manufacturing. The reason for the low wages could be automation and market competition. For instance, as of May 2010, electrical and electronic equipment assemblers in the electric vehicle manufacturing industry earned a median annual salary of $29,470. This disparity in wages is due to manufacturing companies allocating funds towards technology adoption rather than employee wages. For example, "Ford recently cut 3,000 highly paid salaried and contract workers to redirect funds towards transitioning to electric vehicles" (Charette, 2023).

Additionally, electric vehicle body parts are often produced by specialized small industries across the globe and sold to larger manufacturing companies, requiring significant investment. Unlike gasoline vehicles, which can often be entirely manufactured domestically, the components of electric vehicles, particularly their battery components, may not be as cost-effective or readily available within a single country. Manufacturing companies also invest in training programs to familiarize workers with new technologies and processes used in electric vehicle production. However, this investment in training does not always translate to higher

wages for workers, contributing to inequality and low wages in the industry, ultimately leading to unemployment among manufacturing workers.

Battery:

As mentioned battery is the most significant part of electric vehicles but the United States lags behind in its manufacturing industry as it's not a producer like China and Europe. This shortfall presents challenges as the US imports batteries from these regions, raising production costs for electric vehicles domestically. This reliance on imports disrupts the supply chain and negatively impacts the US economy, leading to higher prices and decreased demand for electric vehicles, thus affecting employment within the industry. The consequence of elevated prices incentivizes companies to invest in importing batteries rather than domestic production, resulting in potential layoffs or reduced wages for workers in electric vehicle manufacturing.

Efforts are underway to establish battery manufacturing industries in the US, potentially creating job opportunities. However, it's crucial to acknowledge that these industries require highly skilled employees, which could exacerbate skill gaps and inequalities among workers.

China

Research and Development:

For quite some time, Chinese economists have pondered the notion of establishing a new automotive industry capable of rivaling the United States, Japan, and other global leaders in automotive manufacturing. However, China lacked the necessary infrastructure to compete on par with these nations. In response, the 863 research and development project program was initiated in 1986, bringing together Chinese automakers, suppliers, universities, and independent laboratories. By 2006, the focus of this initiative had shifted towards "New Energy Vehicles,"

aiming to position China competitively within the global automotive market. The project was structured into five distinct components, as detailed below, encompassing power system technology platforms, vehicle products, key components, common basic technologies, and public support platforms.

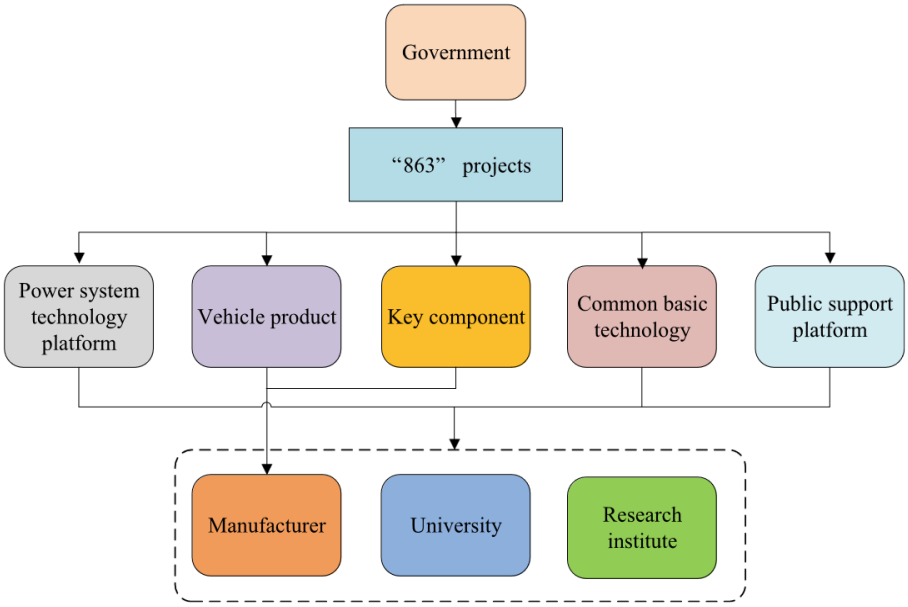

Figure 7. R&D Investment Policy of Electric Vehicles in China

Ultimately, this endeavor successfully achieved its objective of developing new vehicles, including battery electric vehicles, plug-in hybrid vehicles, and hydrogen fuel-cell electric vehicles. (Graham et al. 2021). This program realized China's aspiration to lead the automotive industry on a global scale, with China now commanding a 70% share of the global electric vehicle market. This achievement stands as a testament to the efficacy of governmental policies in fostering such advancements, further exemplified by subsequent initiatives such as subsidies aimed at bolstering electric vehicle production within the country.

Considering the employment ramifications of the 863 project in China, particularly within the realm of electric vehicle R&D, it becomes evident that this project did not entail the

formation of entirely new stakeholders, researchers, or scientists. Rather, it represented a redirection of existing stakeholders towards a new goal. While some additional employment opportunities may have arisen as a result, the scale of job creation was not substantial compared to the inception of an entirely new project. Consequently, it can be argued that the R&D sector neither impedes nor significantly expands employment opportunities within the country.

There is evidence that BYD, the largest electric vehicle automaker in China, hired "around 31,800 fresh graduates" at the start of 2023, "more than 61% of whom have master's or doctoral degrees, and over 80% of whom will work on R&D projects" (Shen, 2023). This evidence suggests that despite the skill gap among workers, R&D in electric vehicles is effectively combating youth unemployment in China.

Manufacturing:

China's electric vehicle manufacturing sector is the world's largest and fastest-growing market. Over the past few decades, numerous electric vehicle manufacturing factories have been established in China. The construction and expansion of these facilities necessitate skilled electricians and robotic specialists to facilitate industry growth. However, recruiting individuals with the requisite expertise is a significant challenge in China, as reported by The New York Times, citing a scarcity of experienced personnel in the industry. (Bradsher, 2023). This scarcity stems from the high skill requirements for factory construction and expansion. Despite this demand, the education and training levels within the electric vehicle industry are often insufficient to meet the needs of these specialized positions, resulting in a shortage of qualified individuals for manufacturing roles.

Furthermore, as certain sectors of China's economy decelerate, there is a pressing need to transition workers to rapidly growing industries like electric vehicle manufacturing. However,

Beijing faces obstacles in vocational training and a surplus of university graduates uninterested in factory work. (Bradsher, 2023). Consequently, many employees in China's electric vehicle manufacturing sector hail from rural areas or are migrant workers, lacking the skills for higher positions, which exacerbates structural unemployment among the elderly and skill disparity among the youth. The challenge of youth unemployment among recent university graduates further compounds the issue, with a significant gap between job opportunities and desired fields of employment.

To mitigate structural unemployment, the Chinese government encourages youth to pursue vocational education and work in electric vehicle manufacturing. While initially conceived as a solution, this approach faces resistance from educated families who prefer white-collar careers for their children, perceiving manufacturing as undesirable.

The challenges of structural unemployment persist due to the rapid growth of electric vehicle manufacturing in the country, necessitating immediate labor without sufficient time for comprehensive training. This time constraint, coupled with the industry's exponential expansion, poses a significant challenge for employers in developing their employees' skills. Consequently, many factories in China are grappling with hiring issues, with the process of finding qualified workers proving to be time-consuming.

Another contributing factor to the skill gap, as previously discussed, is the aging population in China. With a dwindling number of skilled young workers graduating from college, the demand for qualified employees in manufacturing industries exceeds the available supply. Moreover, the aging population faces challenges in skill development, further exacerbating the scarcity of skilled workers. Despite the abundance of jobs in the electric vehicle

manufacturing sector, companies struggle to find adequately qualified personnel to fill these positions.

Furthermore, in response to these challenges, the Chinese government is exploring the introduction of robotics in the electric vehicle industry. In 2022, Chinese electric vehicle manufacturing companies surpassed all others globally in installing industrial robots, as reported by The New York Times. (Bradsher, 2023). However, the implications of this shift towards automation on future employment dynamics remain uncertain. In China, the correlation between electric vehicles and employment is primarily attributed to a shortage of supply in the employment sector rather than a lack of demand. As a solution to this issue, companies are increasingly opting to implement robots and artificial intelligence to perform tasks, which could potentially undermine employment prospects in the future. Such installations entail a one-time payment and may prove cost-effective for companies compared to hiring human workers in the foreseeable future. Given that the manufacturing of electric vehicles constitutes one of the largest industries in China, preserving manufacturing jobs is critically important for sustaining employment opportunities in the country. Comprehensive research initiatives from diverse perspectives are necessary to assess the potential ramifications of increasing robotization in the job market.

Battery:

According to the International Energy Agency, China currently dominates global battery cell production, accounting for two-thirds of the world's output. Moreover, as the below figure shows, recent data indicates that as of the 2022 report, China's share in battery cell manufacturing stood at an impressive 77%, solidifying its position as the leader in the electric vehicle battery supply chain market worldwide.

Rank	Country	2022 Battery Cell Manufacturing Capacity, GWh	% of Total
#1	China	893	77%
#2	Poland	73	6%
#3	U.S.	70	6%
#4	Hungary	38	3%
#5	Germany	31	3%
#6	Sweden	16	1%
#7	South Korea	15	1%
#8	Japan	12	1%
#9	France	6	1%
#10	India	3	0.2%
	Other	7	1%
	Total	**1,163**	**100%**

Figure 8. Battery Manufacturing Capacity By Country in 2022

Given the pivotal role of batteries in the structure of electric vehicles, their manufacture holds paramount importance, particularly for countries heavily invested in electric vehicle production. China stands out prominently in this regard, showcasing remarkable success in battery production within its borders.

Concerns have surfaced regarding potential labor exploitation within China's electric vehicle battery supply chain. A report by CNBC highlights allegations of coercion involving ethnic minorities in China, who are reportedly compelled to participate as "transfer laborers" within the battery industry's supply chain. (Ng, 2022). The crucial raw materials for manufacturing battery electric vehicles, namely lithium carbonate and cobalt, necessitate mining work. China extracts lithium carbonate from Xinjiang in northwest China and cobalt from the Democratic Republic of Congo (DRC). Human Rights Watch notes, "The Chinese government has sought to make Xinjiang an industrial hub even as it expanded abuses against Uyghurs." (Human Rights Watch, 2024). Consequently, the exploitation of labor in Xinjiang is on the rise,

potentially contributing to China's competitive advantage as workers are forced into labor under conditions that prioritize flexibility in working hours and lower wages.

Additionally, cobalt extraction in the DRC involves child labor, as stated by the Labor Department, which indicates that China imports nearly 90 percent of its cobalt from the DRC, where informal mines employ children. (Karim, 2022). This situation represents a violation of child labor laws and involves paying lower wages to African countries while compelling them to work longer hours.

These allegations stem from several factors, including a shortage of skilled labor, decreased interest in the industry, and an aging workforce within China. Although the Chinese government refutes these claims, their veracity remains uncertain. Nonetheless, considering China's competitive stance against the US and Europe in the electric vehicle market, it is plausible that various tactics may be employed to maintain dominance.

China is positioned to establish a global monopoly on electric vehicle batteries, propelled by its substantial manufacturing capacity. Notably, China not only meets domestic demand but also exports batteries to other regions. While this surge in battery production presents employment opportunities, China faces recruitment challenges due to its vast population and specific workforce demographics.

In short, while China's ascent in the electric vehicle battery industry brings economic benefits and job prospects, concerns persist regarding labor practices within its supply chain. As China navigates the competitive landscape of the electric vehicle market, addressing these concerns becomes imperative to uphold ethical standards and ensure sustainable growth.

Maintenance in both countries (the US and China)

When considering electric vehicle maintenance, significantly impacts repair shops. Electric vehicles eliminate the need for oil changes and engine repairs, reducing the frequency of visits to repair shops. According to the NRDC, many electric vehicles are equipped with regenerative braking systems, further decreasing the necessity for repair shop visits. (Lindwall, 2024).

Essentially, electric vehicles require minimal maintenance, typically only once or twice a year. Consequently, the frequency of visits to repair shops is notably lower compared to gasoline-powered vehicles, directly impacting the revenue of repair and maintenance shops. This decrease in revenue may result in employee layoffs or necessitate a shift in business strategies.

Furthermore, the electric vehicle industry demands highly skilled labor for repair shop employees. Tasks such as battery replacement and vehicle maintenance require specialized training and expertise. Consequently, there exists an employment inequality in terms of skills among workers within the industry, as only those with the necessary skills can effectively perform these maintenance tasks.

Comparative Analysis

To understand the differing impacts of the electric vehicle transition on employment in the United States and China, we can examine the resources available in each country. In the United States, there's a notable limitation in resources for battery production, a crucial aspect of electric vehicles. Despite significant electric vehicle production in the US, the majority of batteries are imported from other countries.

This reliance on imported batteries affects vehicle pricing and entails additional costs and risks. Since battery production in the US doesn't match the demand, imports are necessary, involving transportation and potential risks during transit. This adds layers of intermediaries and small companies to the procurement process, raising overall costs.

Moreover, battery manufacturing, a labor-intensive aspect of electric vehicle production, presents a missed opportunity for employment in the US. With fewer parts in electric vehicles compared to traditional vehicles, the manufacturing process requires less labor. Although efforts are underway to establish battery manufacturing facilities domestically, this is a slow process still dependent on importing raw materials.

China, on the other hand, dominates the electric vehicle market and battery production. However, it faces challenges in finding qualified individuals to fill these positions, leading to structural and youth unemployment due to disinterest in available job opportunities.

From an American perspective, three key realignments in the workforce emerge a shift to more capital-intensive processes in electric vehicle production, a demand for high-skilled labor, and a potential substitution of high-wage American workers with lower-wage Chinese counterparts.

In summary, the transition to electric vehicles impacts employment differently in both countries, with variations among firms and job categories. While electric vehicle-related careers demand high skills, contributing to structural unemployment, assessing the overall impact requires precise data due to its complexity.

These disparities are rooted in specific factors unique to each country. In the US, challenges include limited access to essential resources for battery manufacturing and relatively low wages for high-skilled green jobs, partly due to automation. Conversely, in China, factors

like an aging population and job concentration in specific fields contribute to disparities in employment impact, with certain jobs being undervalued and resembling forced labor.

Conclusion

In conclusion, the development of electric vehicles as a green growth innovation marks a fundamental transition in the global automobile industry. Electric vehicles have changed the way we think about mobility, from their early adoption driven by environmental concerns to their subsequent growth fueled by economic incentives. This case study investigated the numerous motivations driving the growing popularity of electric and hybrid automobiles, emphasizing the critical role of government policies, economic concerns, and societal ideology.

The rise of electric vehicles along with their technology, particularly batteries, has created both opportunities and challenges on a worldwide scale. China's supremacy in battery cell manufacture highlights its critical role in the electric vehicle market, but concerns about labor exploitation inside its supply chain cast doubt on this achievement. In contrast, the United States confronts challenges in developing domestic battery manufacturing capabilities, resulting in reliance on imports and significant economic ramifications.

In summary, examining the relationship between electric vehicles and employment rates reveals a complicated picture affected by technology improvements, skill gaps, and global supply-chain dynamics. While the shift to electric vehicles has the potential to create jobs in industries such as research and development and charging infrastructure development, it also raises concerns about structural unemployment, skill gaps, and wage discrepancies.

Chapter 3

Electric Vehicle Policy in the United States

Electric Vehicle Policy in the United States

The extensive efforts involved in developing electric vehicle policies, both in the United States and around the world, emphasize their varied ramifications. Nations spearheading such policies seek to increase the adoption of electric vehicles by carefully addressing both demand and supply factors in their economies in order to encourage both producers and consumers.

The primary goal of the electric vehicle policy is to reduce the environmental issues caused by the increase in carbon emissions produced by traditional gasoline-powered engines. Electric vehicles provide a critical solution by simplifying the shift from gasoline dependence to energy use. Environmental sustainability advocates strongly support these policies.

Beyond their environmental benefits, electric vehicle policies have profound implications. Notably, they have the potential to reduce a country's reliance on fossil fuels, which is a vulnerability shown in countries that rely substantially on oil imports. This dependence exposes countries to geopolitical risks such as disruptions in the global oil supply chain, political instability, conflicts, and volatile oil prices.

Furthermore, electric vehicle policies boost infrastructure development, resulting in investments in charging stations and road infrastructure that promote electric vehicle use. These programs aim to over time enhance transportation systems. Equally important is the potential for electric vehicle policies to promote employment creation. Policymakers that support such efforts anticipate an explicit reduction in unemployment rates by promoting infrastructure projects and increasing electric vehicle manufacturing.

In this regard, the implications of electric vehicle policy are overwhelmingly beneficial, including protecting the environment, reducing dependency on fossil fuels, infrastructure improvements, and job development. This chapter looks into the specifics of President Joe

Biden's US electric vehicle policy and its substantial impact on employment creation both domestically and beyond the global supply chain.

The Biden Administration's Electric Vehicle Policy

In April 17, 2023, President Joe Biden unveiled two pivotal electric vehicle policies aimed at reshaping America's transportation landscape. One policy focused on the nationwide deployment of charging infrastructure for electric vehicles, while the other set forth criteria to accelerate the adoption of electric vehicles throughout the United States. This strategic shift away from traditional fossil fuel vehicles holds the promise of significant economic, national security, and environmental benefits, stemming from a reduced reliance on oil. The widespread adoption of eclectic vehicles is expected to generate new employment opportunities, enhance air quality, and mitigate greenhouse gas emissions. (Electrification Coalition).

Central to President Biden's electric vehicle policy is the ambitious goal of ensuring that 50 percent of all new vehicle sales by 2030 are electric. To realize this vision, the White House has unveiled a series of public and private commitments aimed at facilitating the transition from internal combustion engine vehicles to electric vehicles. These commitments are aligned with the overarching objectives of the Investing in America agenda, which seeks to increase domestic manufacturing, strengthen supply chains, enhance U.S. competitiveness, and foster the creation of well-paying jobs for American workers. An initial assessment by the White House indicates a 40 percent increase in electric vehicle usage since Biden took office. (The White House, 2023).

In order to incentivize consumers to embrace electric vehicles, President Biden introduced a tax credit policy as part of the Inflation Reduction Act. Under this policy, electric vehicle purchasers are eligible for a tax credit of up to $7500. This incentive has proven

instrumental in increasing demand for electric vehicles, effectively lowering the barrier to entry and making electric vehicles a more financially viable option compared to traditional gasoline-powered counterparts. However, eligibility for the tax credit is contingent upon certain conditions imposed on both consumers and manufacturers. Notably, vehicles must undergo final assembly within the United States, and the minerals and battery resources utilized in their production must not originate from nations hostile to U.S. interests. (CBS News, 2023).

The final assembly of an electric vehicle involves the integration of various components, including the battery pack, chassis, motor, and electronic systems. (How Products are Made). To streamline the process of claiming tax credits, the Internal Revenue Service mandates that qualified manufacturers enter into written agreements with the Secretary of the Treasury, thereby facilitating the submission of periodic reports containing essential vehicle information, such as identification numbers. (IRS).

In addition to incentivizing consumer adoption, the electric vehicle policy also extends support to manufacturers through funding initiatives aimed at facilitating the transition to electric vehicle production. The U.S. Department of Energy reports that the Biden administration has allocated a substantial $15.5 billion package of funding and loans, primarily earmarked for retooling existing factories to accommodate electric vehicle production. “This funding includes $2 billion in grants and up to $10 billion in loans,” with the aim of supporting automotive manufacturing conversion projects and spurring increased production of electric vehicles within the country. (Department of Energy, 2023).

However, amidst efforts to increase domestic production, the electric vehicle policy imposes restrictions on the sourcing of components from countries deemed hostile to U.S. interests. Notably, China, a key player in the global electric vehicle market, finds itself in the

target of potential tariffs aimed at safeguarding American jobs and national security interests. Treasury Secretary Janet Yellen has hinted at the necessity of imposing tariffs on Chinese electric vehicle goods to mitigate the impact of Beijing's overproduction, which poses a threat to both the domestic job market and national security. (Renshaw, 2024). The overproduction could be a threat to the world because China has subsidized electric vehicle manufacturing industries, leading to an excessive amount of electric vehicle production within the country. This, in turn, may eventually flood foreign markets with cheap products, undercut competitors, and potentially destabilize industries in other countries.

In other words, the Biden Administration's electric vehicle policy represents a multifaceted approach aimed at catalyzing the transition to sustainable transportation alternatives. By incentivizing consumer adoption, supporting domestic manufacturing, and safeguarding national interests through strategic trade policies, the United States aims to position itself as a global leader in the electric vehicle revolution.

Impact Analysis of Biden's Electric Vehicle Policy

Employment

President Biden's electric vehicle policy aims to create job opportunities, thereby reducing the unemployment rate. Examining its various components reveals that perhaps the most impactful aspect lies in the installation of electric vehicle infrastructure, particularly charging stations. These installations require a diverse workforce including construction workers, technicians, electricians, and engineers. While these positions do provide immediate job openings, it's important to recognize that they are short-term and finite. Once the installation

phase is complete, these job opportunities will diminish. Therefore, while they may temporarily alleviate unemployment, they do not offer a sustainable, long-term solution.

Furthermore, these green jobs demand highly skilled labor, raising questions about the readiness of the U.S. labor market to meet these requirements. Training programs can bridge this gap, but considerations such as the duration and cost of training, as well as who bears these costs, must be addressed. Despite the potential benefits, it's clear that the green economy alone cannot resolve unemployment issues. The transition to green jobs may be costly and temporary, necessitating a deeper examination of its efficacy as a long-term solution.

Additionally, the policy's requirement for the final assembly of electric vehicles to occur domestically may not significantly impact employment. This process is capital-intensive rather than labor-intensive, primarily relying on automation and machinery. As mentioned by Turner Cotterman et al. that “ten employees are needed to build a diesel system, three for a gasoline system, and only one for an electric vehicle.” (Cotterman et al. 3). Thus, contrary to expectations, it may not generate substantial job opportunities for American workers.

Moreover, transitioning workers from gasoline vehicle production to electric vehicles poses challenges. Electric vehicle production requires fewer laborers due to streamlined processes, potentially leading to layoffs for those lacking the necessary skills. This transition necessitates intensive training programs, which, despite government subsidies, may disrupt company revenues and pose challenges for both workers and manufacturers.

A German car factory grapples with the challenge of workforce restructuring as it shifts from gasoline vehicles to electric ones. While the transition does not significantly impact overall employment, the factory resorts to laying off part-time and temporary workers. However, the number of full-time and permanent employees remains unchanged. It's crucial to note that the

factory has invested in training its labor force to adapt to the new technology post-transition. (Ewing, 2024). The duration required for workers to master these skills remains uncertain.

Additionally, the factory's location in a small town with a limited population poses challenges in sourcing skilled workers externally. Hence, the company relies heavily on training its existing workforce to meet the demands of the new technology. However, replicating this approach in larger urban centers or in countries like the US presents hurdles due to the competitive nature of the employment market. Companies may opt to recruit skilled workers rather than invest resources in training existing staff, given the availability of a larger pool of skills.

Politics of Global Supply Chain

The U.S. intends to ban on Chinese electric vehicle and its components imports which leave the US with two options such as investing in domestic battery production or establishing trade relationships with other advanced battery producers. For example, Tesla, one of the largest electric vehicle manufacturers, sources its batteries from Japan and Korea, rather than from China. Investing domestically in battery manufactruitng could create jobs but faces challenges sourcing minerals essential for battery production. Unlike China, the U.S. lacks significant mining investments in Africa, potentially leading to higher production costs due to limited access to essential minerals. Extracting minerals domestically is feasible but may not significantly impact employment as mining operations are capital-intensive.

Moreover, the substantial increase in electric vehicle production by China has sparked trade tensions between China and the US. China faces accusations of flooding the global market with an excess of electric vehicles, causing concern among US companies about their ability to

compete. There's a prevailing notion that China is engaging in the practice of dumping cheap green technology onto the global market. (Johnston). The US electric vehicle policy, based on the conditions it sets, aims to diminish China's dominance in the global electric vehicle market. This policy is expected to directly impact employment in the electric vehicle sector in China.

Considering the global level, long-term implications suggest that while the U.S. may benefit from increased employment, China's employment may suffer due to decreased production. This zero-sum game underscores the strategic implications of trade policies on global unemployment rates.

Crucially, each country's goals differ. China prioritizes growth, employing questionable labor practices and automation to achieve it. In contrast, the U.S. aims to boost employment through green initiatives. While China pursues growth at any cost, the U.S. prioritizes sustainable job creation alongside environmental concerns.

Conclusion

Ultimately, a review of President Joe Biden's electric vehicle policy reveals a multidimensional strategy targeted at leading to a shift to sustainable transportation alternatives in the United States. While this approach has the ability to create jobs and reduce unemployment rates through infrastructure development and domestic manufacturing, it also introduces obstacles and complications that must be handled. The implementation of electric vehicle infrastructure, while creating immediate work opportunities, may only provide short relief, prompting further study of long-term employment alternatives. Furthermore, the policy's emphasis on domestic manufacturing and strategic trade policies underscores the complex global interplay of economic interests, environmental sustainability, and geopolitical factors.

In summary, the electric vehicle policy in the US could potentially impact global unemployment rates negatively, while also presenting opportunities for American workers. However, these opportunities may be short-lived, and the high skill requirements could contribute to structural unemployment within the country.

Conclusion

Conclusion

As we conclude this senior project, it becomes clear that the transition to a green economy is a multidimensional process, with numerous difficulties and opportunities that must be carefully considered. This research has taken us through the intricate interplay of economic, environmental, and social factors, with the goal of illuminating the road to a more sustainable future.

At the macroeconomic level, the analysis encompasses the changing landscape where economic expansion intersects with the imperatives of environmental sustainability. The need to battle climate change and prevent environmental degradation has triggered a paradigm shift in economic thinking, forcing a shift away from traditional models and toward a more holistic approach. Our analysis has highlighted the important role of strategic planning and policy interventions in managing this transformation. The move to a green economy provides several chances for job creation and increased labor productivity, but it also comes with inherent obstacles, such as the possible displacement of laborers in traditional sectors and the need for retraining and reskilling programs.

Delving deeper into the microeconomic realm, our analysis of electric vehicle production revealed the revolutionary potential of green innovation in specific industries and labor markets. The transition to electric vehicles represents not only a technological achievement, but also a fundamental shift toward sustainability in the automobile industry. Our research has revealed the numerous effects of this transformation on various parts of the workforce, ranging from the creation of high-skilled jobs in R&D to the potential displacement of low-skilled workers in traditional manufacturing. Furthermore, ethical concerns about raw material sourcing and labor

methods within the electric vehicle supply chain have arisen as critical variables in determining the path of sustainable development.

Furthermore, our analysis of President Biden's electric vehicle policy sheds light on the complex strategy aimed at promoting the transition to sustainable transportation options in the United States. The policy's emphasis on job creation and unemployment reduction through programs like infrastructure development and local manufacturing incentives shows great promise for economic regeneration. However, navigating the complexities of this transition requires a profound understanding of trade-offs and global trends.

For instance, the policy's impact on the global supply chain can be viewed as a zero-sum game on a global scale. While it creates opportunities for employment in the US, it may reduce the import of electric vehicles from China, thereby potentially affecting Chinese employment negatively. Additionally, China's policies such as overproduction or trade dumping further complicate the global supply chain, making it challenging for other companies to compete with Chinese electric vehicles.

To ensure inclusive growth and equitable benefit distribution, it is essential to balance economic imperatives with environmental sustainability through strategic policies and stakeholder participation. This requires careful consideration of the interconnectedness of economies and the need for cooperative approaches to address challenges in the global supply chain.

Finally, this senior project contributes significantly to the conversation on sustainable development and employment in the twenty-first century. By combining macro and micro viewpoints and assessing policy actions, it provides a sophisticated knowledge of the problems and opportunities associated with the transition to a green economy. In essence, this senior

project culminates with the assertion that the green job economy presents both short-term job opportunities and long-term challenges. While initiatives aimed at promoting sustainability and combating climate change hold the promise of immediate employment gains, they also risk exacerbating structural unemployment and skill gaps among workers over time.

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