Title
The Electric Vehicle Revolution–The Impact of Globalization Upon a Disruptive Industry

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Publication Date
2022-12-09

Data Availability
The data associated with this publication are within the manuscript.

Peer reviewed

University of California, Los Angeles

The Electric Vehicle Revolution–The Impact of Globalization Upon a Disruptive Industry

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GLBL ST 199A: Directed Individual Research in Global Studies

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December 9, 2022

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Section 1: Introduction

1.1 Overview

To solve the climate crisis, the automotive industry is currently undergoing a radical transformation to accommodate a greener future. Concomitant with the increasing ubiquity of electric vehicles (or EVs) and hybrid vehicles worldwide is the expectation that Internal Combustion Engine (hereinafter referred to as ICE) vehicles will eventually become unsustainable and therefore obsolete. Especially in prominent economies with stringent emissions laws and government incentives, the popularity of EVs has reached unprecedented levels. China continues to lead the EV revolution by acquiring key EV inputs and manufacturing more vehicles than any other country in the world, but the United States is gradually gaining ground (Carlier). Consumer demand for EVs has also rapidly increased in Europe as the region struggles with an energy crisis caused by the Russia-Ukraine conflict (Browning). Even in Europe, Norway and Sweden distinguish themselves from their counterparts due to progressive regulatory action (Ernst & Young).

1.2 Outline of Key Issues

This paper seeks to provide a holistic view of the multifaceted nature of the globalized EV industry, which has expanded because of various environmental policies and initiatives to combat climate change. Although EVs provide a multitude of environmental benefits, manufacturing these vehicles emits various harmful pollutants while expending large amounts of electricity, often generated by fossil-fuel based sources such as coal and natural gas. Moreover, EV production perpetuates similar labor issues that have occurred centuries prior as a result of neocolonial practices. For example, Chinese companies extract rare earth metals from Africa's untapped reserves to produce batteries used in EV manufacturing. Although China is not technically a part of the Global North, this practice exemplifies some of the negative aspects of resource grabs on the part of industrialized countries impacting the Global South. Consequently, EV production fundamentally affects labor markets and the global political economy and aggravates climate debt.[1] The geopolitical implications of this issue are also critical. Arguably, the rivalry between China and the United States with respect to EVs serves as a microcosm of their ongoing trade war and diplomatic tensions. This paper examines both countries' methodologies to achieve a significant reduction in carbon emissions for the future.

1.3 Thesis

The concerted transition from fossil fuels to green energy brought on in part by the increased adoption of EVs appears promising. However, this change must be predicated upon the thorough evaluation of several key issues. Although EVs may contribute to decreased greenhouse gas emissions over the medium and long term, critical path improvements to the procurement supply chain, manufacturing process for vehicles (especially battery technology) and labor and geopolitical issues will need to be addressed. The proliferation of EVs in the United States, China and internationally must be accompanied by other climate control initiatives promulgated by the Paris Agreement.

[1]At the COP27 meetings on November 22, 2022 involving world leaders at Sharm El-Sheikh, Egypt, Pakistan's Prime Minister Shehbaz Sharif decried the overwhelming impact of rising borrowing rates upon emerging markets due to the climate debt trap (Mazumdar and Burgess).

Section 2: EVs and the Environment

2.1 Overview of the Impact of EVs

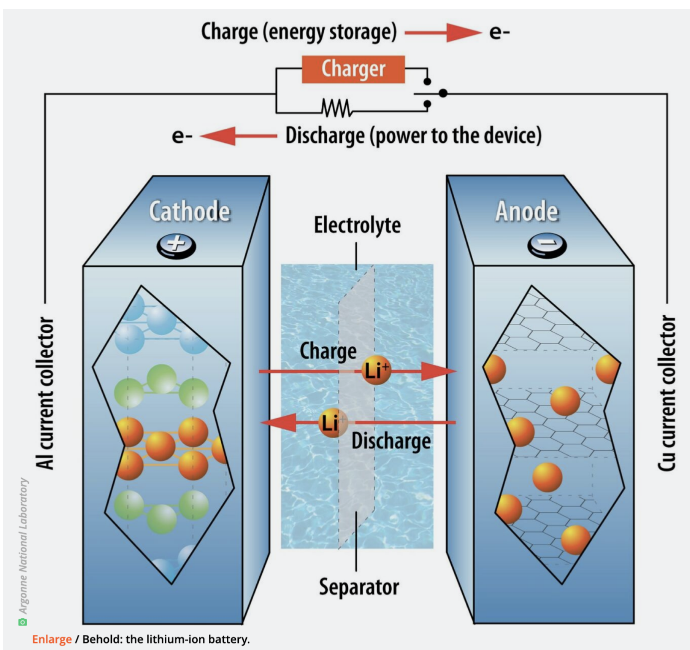
Scottish chemist William Morrison designed the first ever electric carriage in 1890, but its speed topped out at only 14 miles per hour (Q.ai). Despite the advent of this vehicle, it could not compete with the more affordable and powerful gas-powered cars of the era, such as Henry Ford's Model T, released in 1908 (Q.ai). For the majority of the 20th century, ICE vehicles dominated the automotive industry. Only after the release of the world's first hybrid EV in 1997, the Toyota Prius, did consumer interest in EVs increase (Q.ai). More than a quarter of a century later, the landscape of the automotive industry continues to change rapidly. Whereas 2.7% of the auto market's total sales in Q2 of 2021 were from EVs, that metric more than doubled to 5.6% a year later (Q.ai). As highlighted by a 2018 survey, 77 percent of respondents believe that "the majority of vehicles will be powered by something other than gasoline by 2050" (Ramlet et al.). Given the emergence of EVs, it is critical to evaluate their benefits and potential downsides both from the consumer and environmental standpoints.

2.2 Key Components of EVs

Although an ICE vehicle utilizes the ignition and combustion of fuel such as gasoline, diesel, propane or ethanol to create work and propel itself, an EV is powered by rechargeable batteries (Melito). Embedded in the EV chassis, the battery pack contains thousands of cells and serves as the largest, heaviest and most expensive part of the vehicle. Potentially, it could account for up to 15-20% of the total cost of an EV (Hart). For instance, the manufacturer's suggested retail price for the widely popular Tesla Model Y is approximately US$60,000. Thus, the battery costs approximately US$9,000-US$12,000 (Hart). Figure 1 displays the structure of a typical battery pack, which comprise several critical components:

- The cathode, which carries a positive charge, is important because its material affects the range and performance of the car and regulates the temperature of the battery itself. The most common compositions of chemicals used in cathodes are lithium nickel cobalt aluminum oxide, lithium nickel manganese cobalt and lithium iron phosphate (Bhutada). On average, the cost of materials for a cathode, combined with manufacturing, totals to approximately 51% of the entire battery (Bhutada).
- The anode, on the other hand, is negatively charged, and is primarily composed of graphite (Coffin and Horowitz). Other materials, such as silicon, are being proposed as alternatives for the future production of anodes, but these projects are undergoing research and development (Munster and Mulberg). An anode constitutes roughly 12% of the battery cost (Bhutada).
- The separator is a permeable film of plastic between the cathode and anode whereby liquid electrolytes can travel (Coffin and Horowitz). This part constitutes approximately 7% of the battery cost (Bhutada).
- The electrolyte provides an electrical linkage between the cathode and anode, and regulates lithium ion diffusion. This part is composed of carbonate and lithium salts as well (Coffin and Horowitz). The electrolyte constitutes approximately 4% of the battery cost (Bhutada).
- The remaining battery costs (26%) are allocated towards manufacturing and depreciation, electrolyte, housing and other materials (Bhutada).

Figure 1: Structure of a lithium-ion electrochemical cell



Source: Johnson, "Eternally five years away? No, batteries are improving under your nose."

2.3 Primary Advantages of EVs

1. **Increased efficiency of the vehicle.** The differences between ICE power sources and EV motors are twofold. Not only are ICE power sources significantly heavier than EV motors, they contain many more parts as well, causing unnecessary vibration and friction. On average, ICE vehicles are only 30% efficient because they "convert the reciprocating, or up-and-down, movement of pistons into rotary motion" (Melito). As such, this process causes excessive resistance within the engine. On the contrary, EVs are up to 50% more efficient because the electric motor is designed in such a way that it rotates on its own without the conversion of energy, which allows the vehicle to generate much more torque (Melito). If a diesel-powered vehicle and an EV were at a traffic light, the diesel vehicle would need to accelerate considerably to generate the same amount of torque as the EV would (AFStaff).[2]
2. **Electricity is cheaper than gas.** According to the U.S. Energy Information Administration, average gas prices in the nation were $2.53 a gallon in February 2020 (prior to the COVID-19 lockdowns), $1.94 a gallon in April 2020 (in the middle of lockdowns), $4.21 in April 2022 (post-lockdowns) and $5.01 in June 2022 (after the onset of the Russia-Ukraine war) (U.S. Energy Information Administration). Other factors that influenced gas futures include OPEC+'s agreement to cut petroleum production by two million barrels per day and major oil refineries in the United States temporarily closing due to maintenance work (Isidore and Egan). As of November 2022, gas prices have fallen due to decreased demand for oil caused by the economy's recession (Cooban). Evidently, a mix of geopolitical and economic factors in recent years have

[2]An ICE vehicle's drivetrain comprises 2000-plus moving parts as compared to approximately 20 components in an EV (Raftery).

caused gas prices to fluctuate considerably. Conversely, electricity prices have remained relatively stable in recent years (Kirk). If the amount of electricity in an EV battery were to be represented in the units of an ICE vehicle's gas tank, or gallons, then one "gallon" of electricity would cost $1.41, according to researchers at Yale University in June 2022 (Kirk). Regardless of whether gas prices rise or fall, it will still be significantly more expensive than electricity. Purchasing EVs allows users to avoid the volatility of gas prices and perhaps even save more money in the long run, assuming the longevity and build quality of the vehicle.

3. **Reduction in local air pollution.** Notwithstanding EV manufacturing processes, driving these vehicles reduces air pollution because they do not release tailpipe emissions, employ a regenerative braking system and utilize a "one-pedal driving" system, obviating the need to replace brake pads frequently. Whereas ICE vehicles have a standard braking mechanism, which requires the driver to step on the brakes manually for it to slow down, EVs use regenerative braking, which allows the driver to release pressure on the accelerator pedal in order for the vehicle to slow down gradually. Once the vehicle comes to a complete stop, the hydraulic brakes prevent it from moving until the driver accelerates. The intended effect of regenerative braking is not only to eliminate particulate matter from brakes which pollute the local environment, but also to recapture a large portion of the kinetic energy generated by the vehicle, which extends battery range (Choksey).

2.4 Primary Disadvantages of EVs

1. **Low energy density of the battery, which yields low range.** Whereas fuels such as gasoline or diesel are lightweight and generate significant power, EV batteries are

weighty, and individually do not create much power. Because of this, ICE vehicles are known to have a high energy density while EVs have low energy density (Melito). Thus, a major concern for consumers has been the limited range of EVs. As shown in Figure 2, the average range of all 10 models shown is 228 miles on a single charge (Lozanova), which is far less than the 300 mile average range of ICE vehicles ("What Are Extended Range Electric Vehicles?"). At the time the Lozanova article was written (January 2021), all of these vehicles were priced under US$50,000 (prices have since increased due to inflation):

Figure 2: EV Range of Selected Electric Vehicles under US$50,000

Earth911 Electric Vehicle Comparison

Vehicle	Range (miles)	Starting Price	Seats	2020 ACEEE Green Car Rating	2021 EPA Fuel Economy (1 gal. gasoline=33.7 kWh)	Battery Capacity (kWh)
Tesla Model Y - Long Range AWD	326	$49,990	7	N/A	125	74.0
Hyundai Ioniq EV	170	$34,500	5	65	133*	38.3
Nissan Leaf	149	$31,620	5	63	111*	40.0
BMW i3	153	$44,450	4	63	113*	42.2
Electric Mini Cooper	110	$29,900	4	63	108*	32.6
Kia Niro EV	239	Not released yet	5	62	112*	64.0
Hyundai Kona Electric	258	$37,190	5	61	120*	64.0
Chevy Bolt	259	$36,500	5	57	118*	66.0
Tesla Model 3 - Standard Range	263	$37,990	5	55	141*	54.0
Tesla Model 3 - Long Range	353	$46,990	5	54	134	79.5

Earth911 *2020 model

For additional information, please visit Earth911.com.

Source: Lozanova, "The Best Electric Vehicles on the Market."

The low energy density of EV batteries remains one of the main areas of concern for manufacturers and researchers. Not only is electricity used to power movement, it is also used for the functioning of air-conditioning or heating and headlights, which diminishes range. In other words, the normal range of any EV is degraded significantly if operated in extreme hot or cold climates, both of which require air conditioning or heating for the cabin (Shah et al.). To compound the problem, EVs are susceptible to gradual battery capacity loss: "Assuming ideal charging/discharging, the batteries will degrade by 2-3 percent per year for a reasonably priced EV" (Shah et al.). Additionally, if vehicles such as buses, trains or trucks that carry passengers and freight were powered by electricity alone, they may not be able to function properly given the limited range and power (Melito).[3]

Manufacturers are attempting to solve this potential problem, but no viable solution has materialized as of yet. Simply increasing the number of cells to the battery pack will not suffice because of space and weight constraints within the EV chassis (Skill-Lync). Some experts have suggested that the primary material of the anode should be lithium instead of graphite (University of Houston Energy Fellows). Though this may sound promising, there is a serious limitation. Whenever an EV battery is charging, the anode constantly expands and shrinks. Thus, if anodes are made of lithium, charging would cause it to cause lithium dendrite to build up, which would decrease the battery's lifespan (University of Houston Energy Fellows).

2. **Long charging times.** ICE vehicles may require only several minutes to fill their tanks. Conversely, charging EVs can take several hours. For instance, the Tesla Model S Long Range needs several hours of charging with a Level 2 charger for a range of only 120 miles (Shah, et al.). With the exception of fast-charging stations such as Tesla Superchargers and select Electrify America fast chargers, most charging stations are slow.

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[3]That said, Tesla is scheduled to unveil its long-heralded Tesla semi-electric truck on December 1st, 2022 (Power).

For Tesla drivers, charging at high speeds by continually using Superchargers will degrade the battery more quickly (Shah, et al.).

3. **Environmental and societal ramifications in the short run.** The general consensus among avid EV enthusiasts and experts is that while such vehicles may reduce local air pollution, the adverse environmental effects of battery production cannot be overlooked. According to an author for the MIT Climate Portal, "for every tonne of mined lithium, 15 tonnes of CO_2 are emitted into the air" (Crawford). Mining inputs requires extreme levels of heat that can reach more than 1,000 degrees Celsius, which also necessitates fossil fuel burning (Crawford).

    Fortunately, old EV batteries can be refurbished and repurposed to create new batteries. This is a far more efficient alternative than mining for EV inputs. Even after prolonged use, manufacturing companies can easily restore the performance and capacity of lithium-ion cells (Dunn). They can also be used for less intensive applications such as stationary storage. This entails creating an array of batteries to provide backup energy for an emergency or create renewable energy by capturing and storing solar electricity throughout the day, then providing energy at night. After this, batteries can be recycled ("Recycling Lithium-Ion Batteries").

    Despite the large initial carbon footprint of battery manufacturing, what is important to consider is that the EV industry is currently undergoing a transitional period. But in the long run, provided that more electricity sources will be renewable, EVs will eventually prove to be significantly more sustainable than ICE vehicles. As one journalist states, "the [initial] higher environmental costs are offset by EVs' superior energy efficiency over time" (Choudhury).

Section 3: The EV Value Chain in the Global Political Economy

3.1 Developing Economies–the Sources of Key Materials Used in the Production of EVs

Key inputs for the production of EV batteries, such as cobalt and lithium, are undeniably scarce in countries leading the EV revolution such as China and the United States. Therefore, a crucial narrative to examine is how governments and companies based in developed countries exploit resources in developing countries to acquire these inputs. The sheer irony is that even in the pursuit of greener energy and a sustainable future, such developed countries may be more motivated by national interests and monetary gain. This situation is reminiscent of neocolonial practices decades ago. To construct Fat Man and Little Boy, the atomic bombs that devastated Hiroshima and Nagasaki to force the end of World War II, the United States sought the assistance of the Democratic Republic of Congo (DRC). Exposed to unhealthy levels of radiation, impoverished Congolese workers were forced to extract large amounts of uranium, which were then shipped to several Manhattan Project locations (Lewis).

In November 2021, a powerful Chinese-based mining corporation named China Molybdenum purchased Kisanfu, one of the world's largest untapped cobalt reserves, located in the DRC, at a cost of US$550 million (Searcey et al.). Ironically, a controversial Arizona-based mining company, Freeport-McMoRan, owned the reserve. The Central African country, which contains at least two-thirds of the world's cobalt, has been at the center of a fierce competition between China and the United States. China, which has historically been a dominant force in the acquisition of rare-earth minerals, has been attempting to undermine the U.S. objective to advocate a carbon-free agenda by driving mining corporations out of African countries including the DRC (Searcey et al.). Because of growing tensions amidst the resource grab, a geopolitical and economic fallout ensued. Evidently, the "cycle of exploitation, greed and gamesmanship" fueled by China's quest for dominance in the EV revolution fundamentally altered the markets for EV inputs (Searcey et al.). The EV industry is not the only sector culpable for these practices. Moreover, the Global North and its chief competitor, China not only harm the Global South by exploiting commodities but also by offshoring high polluting industries as well (Zhou).

3.2 How the EV Value Chain Reinforces the Power Divide between Developed and Developing Countries

Because the EV value chain operates within a neocolonial framework that binds countries of the Global North and South together, it is therefore likely to reinforce inequalities within the global economy. In February 2022, the Congolese government indicted and ousted China Molybdenum from its ownership of Tenke Fungurume, one of the world's largest cobalt and copper mines, due to several reasons. Firstly, the company allegedly failed to repay the Congolese government billions of dollars in royalty payments, an issue which the company is currently disputing (Lipton and Searcey). Auditors at Gécamines, a Congolese mining and commodity trading company, asserted that China Molybdenum, a state-owned enterprise (SOE), did not "declare hundreds of thousands of tons of copper and cobalt reserves buried at the site, depriving [them] of significant annual payments required when new reserves [were] found and verified" (Lipton and Searcey). Secondly, under China Molybdenum's ownership, numerous Congolese mine workers asserted that they had been treated unfairly and even assaulted (Lipton and Searcey). Further, several safety inspectors reported numerous cases of bribery to cover up work-related incidents at the mine (Lipton and Searcey). An additional concern is that a negative externality–toxic chemicals seeping into the neighboring groundwater resources as a result of cobalt extraction–remains unaddressed (Searcey et al.). These troubling concerns could be a result of both neocolonial practices and a corrupt, poorly managed firm.

This story is just one example of how the success of Chinese corporations in the production of EVs is derived from illegitimate means. In fact, in 2020, such corporations owned almost 80% of Congolese mines (Lipton and Searcey). The concern is that even as the DRC recovers from decades of economic turmoil and continued armed conflict, it receives negligible monetary benefits from its own natural resources and minerals (Lipton and Searcey). By possessing such a significant financial stake in Congolese mining resources, China has amassed near-total control over the supply chain for EV cobalt inputs. Though Congolese officials already instituted legal proceedings against China Molybdenum, the dispute is still yet to be remedied. With the backing of the Biden Administration, the officials continue to scrutinize company contracts in hopes of securing additional evidence for further indictment (Lipton and Searcey). Amidst China Molybdenum's blatant corruption, a positive note for the Congolese government is that they have demonstrated an ability to counter Chinese interests and assert more authority as they attempt to increase their involvement in the EV revolution.

Prominent EV companies such as Renault, Tesla and Volvo are also not immune to widespread criticism due to their incessant desire to secure cobalt supplies from the DRC, extracted from the earth at excruciatingly low wages (Pattinson). Nonetheless, evidence suggests that some EV companies are developing ways to address unethical practices and hazardous working conditions in these mines. Companies such as Volkswagen, Trafigura and BASF joined the Cobalt Action Partnership in order to raise awareness and develop practical solutions to empower miners and eradicate unfair labor practices (Posner). Tesla has made a concerted effort to ensure their inputs are "responsibly sourced" by establishing "targeted due diligence procedures," as stated in their 2018 Conflict Minerals Report (Tesla). The company even mentioned its intention to reduce the amount of cobalt in their batteries. However, experts suggest it will take several years for other viable inputs to be utilized at scale (Posner). Tesla's commitment to their cobalt promise is questionable because the company recently partnered with Glencore, a multinational commodity trading corporation that mines cobalt in the DRC (Posner). Due to numerous abuses on activists and environmental policy infractions, Glencore currently has the "worst human rights record among miners of metals used in renewable energy" (Sguazzin).

3.3 How This Issue Directly Affects Climate Debt

Thus far, this paper has conveyed that in recent years, the approach of developed countries towards EV production as a means of reducing harmful emissions in the long-run is one of enthusiasm and urgency. However, as this section indicates, it is critical to examine an era before EVs experienced an unprecedented surge in popularity worldwide. During this time, developed countries often demonstrated egregious negligence in regards to global warming. Central to this issue is climate debt, whereby Global South countries argue that Global North countries need to compensate them monetarily for their role in climate change, which adversely affects their economies and standard of living.[4] In any event, the deleterious effects of EV industry corruption only exacerbates the climate debt controversy; even an industry purported to alleviate climate change fundamentally relies on the all-too-familiar narrative of powerful countries and SOEs capitalizing on developing countries.

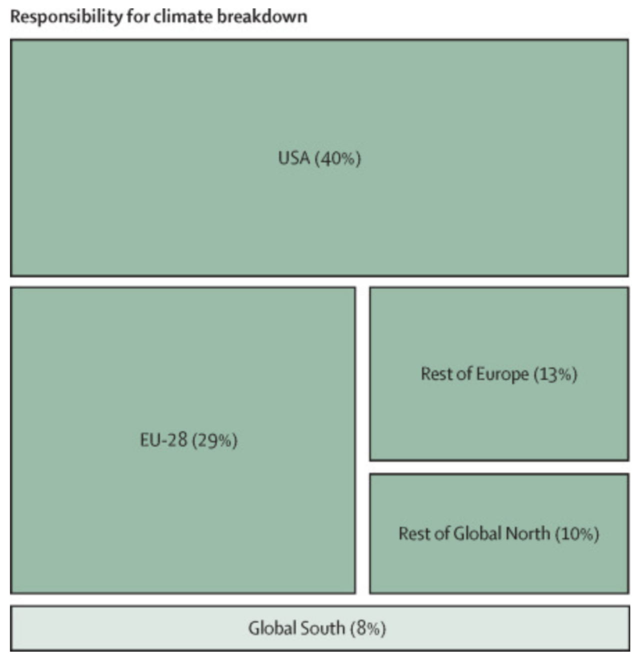
[4]"The term Global North refers to the USA, Canada, Europe, Israel, Australia, New Zealand, and Japan, whereas the term Global South refers to the rest of the world: Latin America, Africa, the Middle East, and Asia" (Hickel).

Although a plethora of evidence suggests that industrialized countries are primarily responsible for emitting the majority of greenhouse gasses worldwide, they often absolve themselves from the responsibility to make amends and instead direct the blame towards developing countries, who, historically, have suffered the most as a result of these emissions (Adow). Because rich countries wield more power on the global stage, they have the ability to alter the climate change narrative in their favor. When prompted to address their shared responsibility to create an actionable plan to alleviate global warming at the 2011 United Nations Climate Change Conference, the representatives of developed countries instead urged developing countries to implement their own plans (United Nations Environment and AMCEN). What is most hypocritical is that such representatives have the audacity to instruct other countries in this way, even as developed countries use taxpayer money to fund businesses that rely on fossil fuels (Adow).

Globally, countries spent almost US$5.9 trillion dollars on the subsidization of the fossil fuel industry alone in 2020 (Parry et al.). In addition, representatives of developed countries deliberately avoided ratifying treaties to reduce greenhouse gas emissions during the 2009 United Nations Climate Change Conference (Adow). Collectively, these examples demonstrate that climate reparations have historically remained largely unresolved because of an environmental deadlock caused by government inaction. Delegates discussed establishing the world's first "loss and damage" fund as late as November 2022 at the COP27 conference (Tigue). Participating countries of the global fund only pledged a paltry US$250 million annually, which is inadequate given the United Nations' goal of US$200 billion required to rectify climate debt. Notably, China and the United States did not commit to this fund (Tigue).

The argument that developing countries should reduce greenhouse gasses is invalid because of two main reasons. Firstly, although many of their industries directly rely on nonrenewable energy such as fossil fuels, the amount of carbon they emit pales in comparison to that of developed countries. Secondly, firms in industrialized nations offshore the heaviest polluting industries and stages of value chains to emerging economies in efforts to reduce their own pollution (Zhou). Thus, developing countries face a contradictory predicament whereby they are simultaneously advised to limit greenhouse emissions but also forced to engage in polluting activities. Instead of stipulating that poorer nations limit greenhouse emissions and implement more sources of renewable energy, the governments of wealthy countries should prioritize lowering their own emissions. In 2015, anthropologist Jason Hickel stated that between 1850 and 2015, the Global North was directly responsible for emitting 92% of global carbon emissions (Hickel). As such, placing a carbon tax on developing economies is futile and will only be detrimental to their fragile economies. Figure 3 on the next page illustrates the disproportionate amount of carbon dioxide emitted by the Global North.

Figure 3: Proportion of Carbon Dioxide Emitted by the Global North and Global South (1850-2015)



Source: Hickel, "Quantifying national responsibility for climate breakdown: an equality-based attribution approach for carbon dioxide emissions in excess of the planetary boundary."

Section 4: Comparison of U.S. and Chinese EV Methodologies

4.1 Overview of the Current State of the Chinese and U.S. Rivalry

One of the critical goals of this paper is to exemplify how the EV revolution affects and is affected by continuous geopolitical tensions between world superpowers, which shows how this topic directly relates to globalization. At the center of this narrative is the intense EV rivalry between two juggernauts of the industry, China and the United States, who have already been in such a complicated bilateral relationship in the last several decades. Sweeping tariffs from both countries, compounded with accusations of China interfering in U.S. elections and stealing American intellectual property, have increased tensions recently ("U.S.-China Relations").

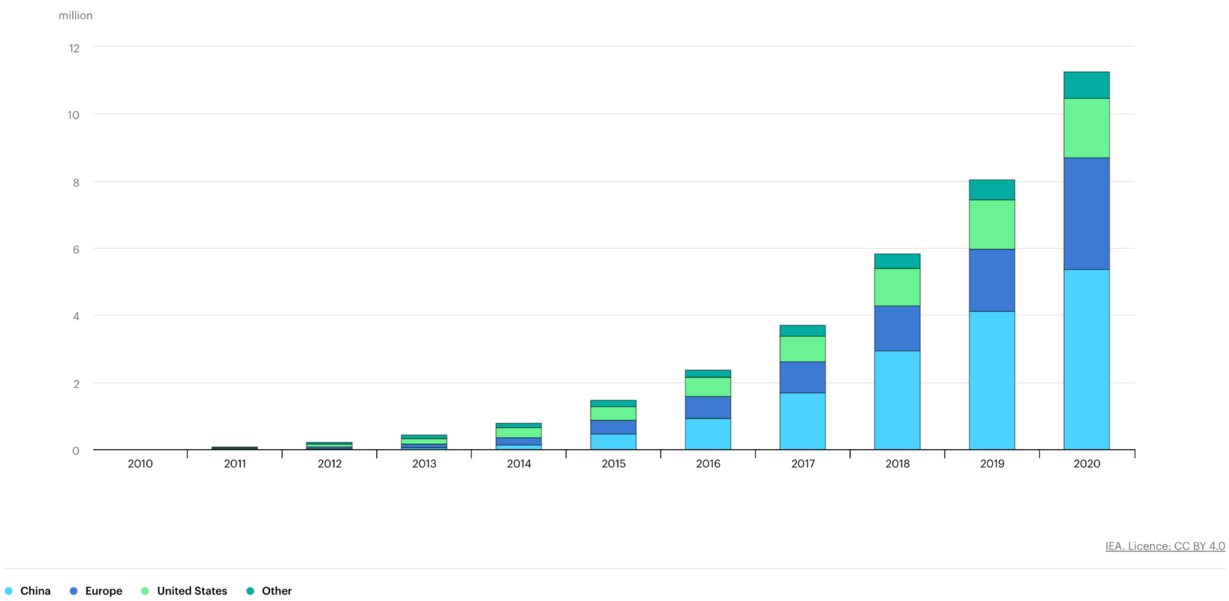
Nevertheless, China and the U.S. have also cooperated on efforts to mitigate climate change, as evidenced by their signing of a joint statement, the Glasgow Declaration, at a United Nations climate conference in November 2021 ("U.S.-China Relations"). As two of the world's largest carbon emitting countries, the onus was upon them to create actionable methods to "encourage decarbonization and electrification of end-use sectors" and "accelerate the transition to a global net zero economy" ("U.S.-China Joint Glasgow Declaration"). One predominant facet of their strategy to reduce greenhouse gas emissions and promote electrification as outlined in the Declaration is EV production, which does not entail cooperation but instead involves heated competition.[5]

4.2 Comparison of Chinese and U.S. EV Progress

China currently possesses an overwhelming advantage over the United States in key metrics such as total EV sales, number of charging stations and acquisition of rare earth minerals, among others. Bloomberg reported that in the span of a single month (October 2022), approximately 722,000 of such vehicles were sold in the country (McKerracher). To put this number in perspective, roughly three million EVs were sold in China in 2020, which was already twice the amount of EVs sold Stateside that year (Lee). One possible factor for China's success is the diversification of its EVs, which includes the likes of electric buses, postal vehicles, trucks and other heavy-duty vehicles. In 2020, China possessed more than half a million registered electric buses, accounting for 98% of all electric buses worldwide (Lee). Currently, the country has more than 575,000 electric buses and 28,000 electric trucks (Lee).

[5]One exception is China permitting Tesla to set up a gigafactory in Shanghai established as a wholly foreign-owned enterprise, a first for China in auto-production ("Tesla Becomes China's First Auto-Manufacturing WFOE").

Figure 4: Global electric vehicle stock by region, 2010-2020



Source: International Energy Agency, "Global EV Outlook 2021."

China's EV market has also flourished due to the presence of inexpensive electric cars. The BAIC EU-Series (US$18,430), the BYD Yuan (US$11,200), the SAIC Baojun E-Series (US$7,697) and the Wuling Hongguang Mini EV (US$14,040) are just a few examples of some of the most popular EVs among Chinese consumers (Graham et al.).[6] In stark contrast is the U.S. market, where the most popular car models are priced significantly higher, such as the Tesla Model Y (US$60,000), Tesla Model 3 (US$46,990), Ford Mustang Mach-E (US$43,895) and Chevrolet Bolt EV (US$27,200) (Graham et al.).

China already boasts comprehensive electric transportation infrastructure with more than 66,000 charging stations, though most of them are concentrated in wealthy provinces such as Zhejiang, Jiangsu and Guangdong and megalopolises such as Beijing and Shanghai (Lee). In addition, the country has approximately 1.947 million EV charging piles and 716 battery

[6]These are the base prices after government incentives.

swapping stations (Lee). The sheer number of charging facilities in China means drivers are less concerned about vehicle range. Moreover, the Chinese Ministry of Transport seeks to implement additional stations on highways and stretches of road leading to rural areas (Manthey).

Conversely, the United States employs only 46,000 charging stations (Loveday). The major issue is that of these stations, only about 6,000 are "DC Fast Charging" (charging at upwards of 150 kilowatts) while the rest are "Level 2" (charging at only 50 kilowatts) (Loveday). Notwithstanding Tesla owners, who can charge their EVs at any one of 1,300 Supercharger stations nationwide, other EV owners are often relegated to charging at Level 2 stations, which is not ideal for long road trips (Loveday). Powering 26 million EVs by 2030 in the United States necessitates at least 2.4 million charging stations, ultimately costing approximately US$28 billion (Lee). However, whether the Biden Administration can build enough facilities, especially DC Fast Charging stations to meet this goal, is still in question. Although President Biden called for US$15 billion to be spent towards building 500,000 stations, Congress only allowed for 250,000 to be built (Lee). In order to increase the number of fast charging stations nationwide drastically, the U.S. government will need to consider the viability of deploying additional power resources, in declining priority: renewable power (solar, wind, hydro), nuclear power, and possibly gas-fired but not coal-fired power. "Nuclear reactors are responsible for over half of all carbon-free energy produced in the U.S., and nuclear energy pairs well with renewables, like wind and solar, to create a cleaner grid" (Durham). Successful implementation of these resources will enhance decarbonization.

4.3 Comparison of Chinese and U.S. EV Legislation and Goals

In terms of ambition and scope, Chinese EV policies differ tremendously from U.S. legislation. In order to reach its objective of carbon neutrality by 2060, China aims to have "70% of passenger vehicles electrified in 2025 and 100% in 2035" as outlined in their New Energy Automobile Industry Plan (2021-2035) (Lee). In order to achieve this, China established a comprehensive consumer subsidy program beginning in 2009. Depending on the model purchased, some subsidies covered 40 to 60 percent of the cost (La Shier). Additionally, China recently extended a 2014 purchase tax exemption for EVs that will last until December 2023 (Kharpal). To showcase their support of clean energy, local Chinese governments such as Shenzhen and Beijing also subsidized EVs (La Shier). Unfortunately, in 2015, after several manufacturers swindled the Central government of US$158 million by falsely reporting their sales numbers to receive more subsidies, the latter enforced a limitation of local subsidies (La Shier). Chinese EV legislation has also allowed the country to amass widespread control over the markets for rare earth metals and battery inputs (Graham et al.). China's commanding influence over the EV industry must also be analyzed with the context of its geopolitical relationship with the United States as well as other nations involved in EV production, such as Germany, South Korea and Vietnam. One author suggests that China's underlying primary motivation is not to advance its environmental goals but rather protect itself in the case the U.S. government imposes more severe economic sanctions (Lee).

The U.S. government's overarching goal is for "electric vehicles to make up 50% of all vehicles sold in the United States by 2030" (The White House). As stated by the Biden Administration, the enactment of the Bipartisan Infrastructure Law will allow more than US$7.5 billion to be allocated towards financing over half a million EV chargers nationwide, and at least

US$7 billion will be spent towards domestic EV manufacturing (The White House). Further, the Inflation Reduction Act (IRA) grants Americans a tax credit of US$7,500 for a new EV or $4,000 for a used EV (Scott). This incentivizes all citizens, especially those in lower-income brackets, to make the switch to cleaner energy. Prior to this law's enactment, two major companies, Tesla and General Motors, did not qualify for consumer subsidies because they met a 200,000 unit-per-manufacturer sales cap, which will be removed in 2023 (Scott). Two additional proposed benefits of the IRA include providing "credits to help manufacturers retool existing facilities and build new manufacturing in the United States, and grants to deploy zero emission heavy-duty vehicles" (The White House).

The Biden Administration emphasized that a large part of their current success has been predicated on "historic private sector investments" (The White House). During Biden's presidency, major automotive companies such as Ford and Hyundai have all announced multibillion dollar investments in new manufacturing facilities (The White House). Support for the transition to EVs has also been reflected at the state level, as California, Washington and New York recently passed mandates to ban ICE vehicles by 2035 (Karnowski). California's emissions regulations are connected to environmental legislation in a total of 17 states; an additional 15 have yet to decide whether to phase out ICE vehicles themselves (Karnowski). Excluding states such as Colorado and Pennsylvania, the California ban could set a precedent for numerous other states to follow suit.

Of critical importance is examining the potential shortcomings of the Biden Administration's EV policies. Firstly, due to the IRA's alignment with U.S. local content laws, its tax credit proposal may violate several measures outlined in the General Agreement on Tariffs and Trade and the Agreement on Subsidies and Countervailing Measures:

> The first criterion of a violation is that domestic and imported products be treated as "like products." The second criterion is the enforcement of a law that would affect the internal sale, purchase, distribution, and use of the imported product. Third is that the imported product is afforded less favorable treatment than the domestic product (Reinsch).

Pursuant to the IRA and associated local content requirements, EVs that are not assembled in North America are ineligible for tax credits (Scott). Moreover, EVs may only contain raw materials from either the United States or "from nations with which the US has a free trade agreement" (Scott). Because these requirements are so stringent, it is thus very unlikely for vehicles to obtain the full tax credit. Even if the U.S. and China are competing against each other in the EV race, they are still trading partners. Numerous battery manufacturers rely on China's expertise of refining minerals (Reinsch). In any event, demanding the use of American materials and inputs in EVs will prove to be a financial obstacle as production costs may increase (Lee). These concerns were unaddressed in White House statements vis-à-vis the IRA (Lee).

The key takeaway is that the IRA appears to undermine World Trade Organization (WTO) policy and "underscores an emerging tension at the nexus of trade and climate, which is the inherently conflicting nature of protectionist trade measures and the need to accelerate the green transition" (Reinsch). This poses as an ironic situation because in the past, the United States has considered filing complaints to the WTO about China's misconduct. For example, the Obama administration alleged that the Chinese central government solicited the assistance of foreign automakers to "share their PEV[7] technology" with local manufacturers (Graham et al.). These allegations were later dropped.

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[7]The acronym "PEV" stands for "Plug-in Electric Vehicle" (Graham et al.).

Secondly, experts have also criticized the U.S. government for focusing too much on private sector R&D. “U.S. firms will continue to lose ground in the competition with Chinese companies if Washington continues to rely so heavily on private sector research and development,” asserted Jennifer Harris, a Roosevelt Institute fellow (Lee). Because China directly subsidizes EV manufacturers, she argues that the U.S.’ overdependence on pursuing lucrative business opportunities with conglomerates is inadequate to counter China’s growing dominance in the industry (Lee).

Thirdly, manufacturers of auto parts nationwide and especially in the Midwest fear that the EV revolution will drive them out of their jobs. Automation and offshoring have already decreased the demand for workers in the automotive industry. The pivot away from ICE vehicle production presupposes reducing the number of employees in assembly lines because EVs contain much fewer moving parts, thus less labor is required to manufacture them. Companies will also have to consider the viability of establishing training programs to equip employees with the specialized skills and technical knowledge needed to make EVs (Waters et al.).

Section 5: Conclusion

In an ideal world, a successful transition to an EV-dominated automotive industry would require a results-driven, multi-pronged approach by Global North countries, Chinese SOEs, car manufacturing companies and commodity trading corporations. This would entail addressing the harsh working conditions of laborers in Global South countries, ensuring the sourcing of raw materials and manufacturing does not exacerbate climate debt, assessing the feasibility of implementing additional sources of renewable power and electrical infrastructure and improving the affordability of EVs. Whether these ambitious goals are achieved in the next decade is debatable. While the proliferation of these vehicles will eventually decrease greenhouse gas emissions in the long run, it is paramount that fundamental challenges as outlined throughout this essay are adequately resolved first.

Although this paper discusses at length the sourcing of critical components and commodities for EV production, an ongoing trend is the globalization of production and distribution worldwide by the likes of Tesla, which has already established gigafactories in China and Germany (Root). Despite only producing vehicles in-country, China's incumbent EV players such as NIO and XPeng have made inroads to distribute its cars in Norway and the rest of Europe (Gibbs). Another example is Vietnam's VinFast which has established sales distribution networks in the United States (Shahan). Although this paper did not explore the deficiencies with respect to other leading EV production players from Germany, South Korea and Vietnam, the same discussions outlined above could also be superimposed upon an analysis of these incumbent and rising players on such problematic issues as EV battery production, climate debt and WTO-compliant subsidization of domestic EV producers. As this paper has shown, the growth of the EV industry is inextricably linked to globalization.

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