

Used Car Market and Heterogeneous Environmental Standards, from Developed to Developing countries

From current observations and theoretical
analysis to a new model design

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1 INTRODUCTION

Between a worrying recurrence of pollution peaks, health alerts, and climatic disasters, our environment is deteriorating, in particular air quality. Formerly subject to localized pollution, essentially circumscribed to the first industrial basins, all the urbanized regions are today gangrened by air pollution. At the same time, the chemical composition of the atmosphere is changing fast and the ecosystems are undergoing transformations whose speed is unprecedented.

What are the causes? What does the future promise? Motorized transports are currently omnipresent, omnipotent. According to the European Commission, "Air pollution remains the main environmental factor linked to preventable premature illness and death in the European Union and it still has significant negative effects on a large part of the natural environment". The OECD announces that the urban air pollution should become by 2050 the main environmental cause of death in the world, in front of unsafe water and lack of sanitation.

For its part, the International Panel on Climate Change (IPCC) emphasizes that "global warming is unequivocal. Atmospheric (CO₂) concentrations have increased to unprecedented levels since 800,000 years. This increase is firstly explained by the use of fossil fuels. Human influence on the climate system is clearly established. To limit climate change, it will be necessary to significantly and sustainably reduce greenhouse gas emissions".

How is it that cars are constantly performing better, but that, collectively and globally, we fail to limit urban pollution and greenhouse gas emissions? What is the real contribution of cars to this degradation? How to explain the gap between the beneficial technical progress achieved on the theoretical level and the bad results observed in practice? Where would the complete renewal of car fleets take us if we equipped them with the latest technology? What measures should be taken at local, national and international levels to genuinely tackle the problem of air pollution by cars, those which would be capable of genuinely cleaning urban air and contributing in proportion to the stabilization of the climate?

Over the years, the automobile has been seen as a symbol of freedom, individualism, growth, and as the pillar of modern society. The automotive market is indeed one of the most important economic sectors by revenue. This market represents cars selling, manufacturing, development, and is correlated to many others such as energy markets (Brent, WTI, siderurgy), road building, maintenance, repair shops. Cars represent a significant budget for most of the households. We buy or lease cars and then we must face their costs of functioning: petrol, diesel, electricity, taxes, insurance, maintenance.

The automobile production process needs a huge quantity of energy, raw materials (metals, plastics, leather...) and capital (humans and machines). During its lifetime, a car can change owners and continues to consume and pollute. Both production and utilization are potential sources of earnings and growth but also sources of pollution.

In large urban areas, road transport has become the main source of pollution. There are more than 1.2 billion passenger cars in the world today. In 2019, more than 77 million passenger cars were made in a single year. In Western Europe, the number of cars increased by 130 percent in the past 40 years. There was a 100 percent increase in 20 years between 1980 and 2000. Now the rate of increase is lower, indicating that saturation is approaching, but trips are longer and more frequent. In developing economies, the rate of increase in the number of cars is often close to 10 percent annually, which means doubling every 7-8 years.

It seems that by prolonging the production and consumption of automobiles as well as the infrastructures, we are gradually settling in a smoky and warmed tunnel which leads to a dead-end, which should be the signal of a necessary and abrupt turn. Technical "depollution" devices exist and are being developed more and more by manufacturers. However, we can only note a very low or inexistent impact of these technologies. Indeed, the air quality in most of the cities in developed and developing countries (1) continues to deteriorate.

Facing the general difficulty in tackling these issues, it is necessary to try to better understand the automotive market and its interactions in the world. What about the research subject of this thesis? This thesis will point out the car environmental standards heterogeneity across the world and its catastrophic results on the pollution mostly explained by the used car market. Throughout developing countries, the demand for cars is being stimulated. Many old, second-hand and end-of-life cars are entering the market in low- and middle-income countries, causing serious consequences for public health and global warming. Economic growth has also inflated the demand for freight and transportation vehicles. In countries with economies in transition, the service life of a car is longer than its life in advanced economies. In national and global air pollution control and climate change mitigation strategies, people have neglected the constant flow of old, second-hand, and cheap vehicles from high-income countries to low-income countries in Africa, Asia, Latin America and the Caribbean. This has led to a large accumulation of used cars in the import market, and these used cars do not solve air pollution, climate and other environmental

(1) In this Thesis, the term "developed countries" refers to advanced economies and the term "developing countries" refers to in transition, less, and least developed economies.

impacts. These countries are becoming scrap sites for old cars from developed economies. Developed economies are able to cope with the ensuing problems of car switching in the domestic market, while poorer economies do not. Developing countries that do not have their own car manufacturing bases and strong environmental safeguards are most vulnerable to unregulated imports of used cars.

We will first draw the history of the automobile and its impacts on the environment. We will bring out the transport paradox. We will then analyse the car market in developed countries which is changing fast and do not necessarily take good directions. The developed countries are indeed more controlled by environmental standards but we will see that new cars are controversial. Advanced economies are also becoming exporters of used and polluting cars. In developing countries, in contrast, environmental norms are heterogeneous and unorganised resulting in polluting car imports. We will explain these facts with an empirical view and secondly weight down our words in a theoretical way. We will see that the open trade between developed and developing countries plays a major role in meeting the mobility needs of developing countries (welfare gains) but this international trade has disastrous environmental consequences. My research focuses on the global flow of used cars explained by heterogeneous environmental standards and the impact of these cars on local health with an emphasis on air quality. Vehicles that meet the emission standards for export markets, if used in combination with clean fuels, may reduce the negative impacts of road transportation but it is not often the case, especially if these cars are not well maintained. Both the export market and the import market play a role in promoting the circulation of used cars. The international community, international organizations, and industry groups have raised but not yet solved the problem of second-hand cars. Understanding and solving the impacts of second-hand car trade on local pollutants, health, and global air emissions should be a priority. We will see that this kind of trade should be more homogeneously controlled and restricted. We will finally present the different frameworks on individual carbon quotas and hence introduce a new model on national motor vehicle quotas. Increasing the motor vehicle usage price seems to be the only solution to stop the destructive cycle of automobiles. Exploring and analysing the automobile markets is an opportunity to take a step back from the current environmental situation, to understand its origin, to learn from it, and to imagine a favourable outcome in the near future.

2 THE DEVELOPMENT OF THE AUTOMOBILE AND ITS ENVIRONMENTAL CONSEQUENCES

2.1 The Origin of the Automobile and its Evolution in Figures

The first half of the 20th century was the boom period in the automotive market, driven by the growing extraction of "rock oil" which became "black gold" also called petroleum.

From the 1900s dozens of chassis manufacturers and bodybuilders appeared. They offered hundreds of different models of automobiles. In this very diverse offer, commercial battles were raging. The industrialization of manufacturing processes allowed the emergence of more common models, directing artisanal solutions to the fringe of the wealthiest customers. The 1901 Mercedes, designed by Wilhelm Maybach for Daimler Motoren Gesellschaft, is often considered as the first modern motorcar. The most widespread models were aimed at wealthy tourists, businessmen, doctors, and travel clerks. These automobiles were subject to constant technical improvements that confirm their ease of use and their future success. From 1906, American car production exceeded French production (French production was previously predominant).

Around 1910, current two-seater vehicles had an empty weight ranging from 800 to 1250kg, and four-seater models from 1300 to 2000kg. Their gearboxes generally have three or four gears and their engines have 4 cylinders. Their power varied from 10 to 50 horsepower (hp). At that time, cars consumed 7 to 20 litres of petrol per 100km.

Henry Ford owed his notoriety as a young automobile manufacturer to the fact that he held the speed record in 1904. He marketed in 1908 the first T model, particularly simple and robust in its design. The same year, William Durant founded General Motors. Ford became in October 1913 the first manufacturer building a car on a mobile assembly line respecting the Taylorism model: vehicles being assembled were produced in series. Ford employees performed reduced and unskilled tasks. They repeated a determined succession of assembly operations. The era of mass automotive production was born. Ford's competing manufacturers quickly adapted to this production method.

The car gradually replaced the function of the horse in the big Western cities. Before the First World War, Paris was the most congested city in the world. The automobile was becoming more and more affordable in terms of costs and was "considered" less polluting than the horse.

The First World War demonstrated the efficiency of the motorized car compared to its horse-drawn alternative. The emblematic emergency requisition of a thousand Parisian taxis and buses during "La Bataille de la Marne" in France is a very good example. After the First World War, the cars were more important in societies: In the United States, private cars became a structural element of large-scale urbanization organized around a vast road network. In Europe, where the urban organization was older, the territory was less affected by this new definition of spaces. In the 1920s, automobile production tripled, reaching almost 6 million vehicles per year by 1929. The crisis of 1929 had a major impact on this production, which lasted for about 3 years. The number of active automakers dropped from 253 in 1908 to 44 in 1929, of which Ford, General Motors, and Chrysler accounted for 80% of the industry's total output value. Chrysler was founded by Walter P. Chrysler from Maxwell in 1925. In response to the challenges of market saturation and technological stagnation, General Motors, under the leadership of Alfred P. Sloan, created the planned obsolescence process in the 1920s and 1930s, also named Sloanism. The objective was to put a new emphasis on styling, reflecting the annual model changes. New models, different makes, and prices for different niches in the market were offered each year. It made consumers dissatisfied, presumably to buy more expensive new models before the end of the life of their existing cars. Sloan's philosophy was "The company's main goal...is to make money, not just making cars."

The 1930s marked the beginning of gasoline taxes. This new restriction prompted manufacturers, mostly European to develop simpler, economic, and more basic cars for people, such as the 1939 Citroën TPV in France (the first 2CV) and the German Kraft durch Freude-Wagen in 1938 designed by Ferdinand Porsche, also called and commercialized later as the Volkswagen Beetle.

The 1930s also heralded the advent of automobile diesel engines. Mercedes and Citroen sold the first diesel-equipped cars in 1936, the Mercedes 260D and Citroën Rosalie 11cv MI.

The Second World War had a huge and positive impact on the development of the industrial processes and indirectly affected later the development of the automobile. To resume, in 1920, there were approximately 10 million vehicles worldwide, 31 million in 1930, and 70 million in 1950.

After the Second World War, Europe, Japan, and the United States were restarting the reconstruction of their infrastructure and the automotive industry. As a result, the total number of vehicles in circulation in the world increased from 70 million in 1950 to 150 million in 1962, and then to 300 million in 1973. Generally speaking, cars and road transport were internationalizing. The consumer society also contributed to the success of the automobile: The Glorious Thirty revived the rise of all sectors of the automobile industry, translated by an increase in choice, production, and the accession to the automobile, via the opening of the recourse to credit in the 1960s. The Volkswagen Beetle was the most impressive car success during that period since its production exceeded, in 1972, the record of models sold, held by the Ford T. In total, more than 21.5 million Volkswagen Beetle were produced around the world.

By the end of the 20th century, the total number of vehicles in circulation continued to grow at an annual rate of 3 to 4%, from 400 million in 1980 to 580 million in 1990, 750 million in 2000 and more than 1.2 billion in 2020.

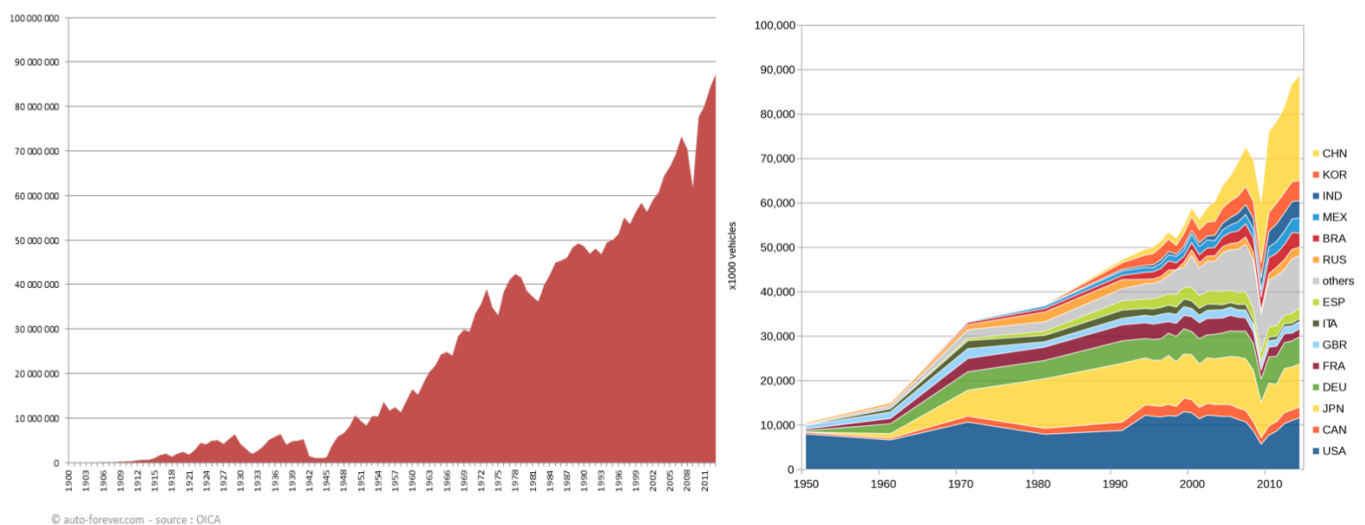


Figure 1: Motor vehicles' production since 1900 and by countries since 1950, source OICA

In Figure 1, we see some annual cyclical declines in automobile production. These reductions correspond to major crises, such as the depression of the 1930s, the Second World War, the first and second oil crises, and finally the

2009 crisis. Before the Second World War, in the best period, annual car production reached five to six million vehicles. After 1945, we witnessed a period of strong growth, which corresponds to the large-scale motorization of the population of developed countries.

From the end of the 1970s, the growth of annual automobile production began to slow down. In 20 years, its number increased from 42 million to 56 million, and from the late 1950s to the late 1970s, it increased from 12 million to 42 million.

Since 2000, a new period of strong growth has emerged. This is due to the large-scale motorization of the population of emerging countries. In 2009, China was the world's leading automotive market. Since the early 20th century, China has replaced the United States, which occupied this position.

2.2 Transportation Paradox

Transportation and environmental issues are contradictory: transportation can bring huge socio-economic benefits, but at the same time, transportation is affecting the environmental system. On the one hand, transportation activities support the increasing demand for mobility in passengers and freight transportation; on the other hand, transportation activities are related to environmental impacts.

The growth of passengers and freight mobility has developed the role of transportation as a source of pollutant emissions and its impacts on the environment. These effects are divided into three categories:

- Direct effects: Transportation activities have usually direct consequences that are clear and easy to understand. For instance, it is known that noise and carbon monoxide emissions have direct harmful effects.
- Indirect effects: Compared with direct impacts, the consequences are usually higher, but the relationships involved are often misunderstood and difficult to establish. For example, particles are mainly the result of incomplete combustion of internal combustion engines, which is indirectly related to respiratory and cardiovascular problems.
- Cumulative effects: The various effects that directly and indirectly affect ecosystems are often unpredictable. Climate change with complex causes and consequences is the cumulative effect of several natural activities and human factors, of which transportation plays a role.

Users usually do not fully bear the total cost of transportation activities, especially environmental damages. The lack of consideration of actual transportation costs can explain several environmental issues. Complex cost levels are involved, ranging from internal (mainly operations), compliance (compliance with regulations), contingent (risk of leakage, and other events) to external (borne by society). For example, according to Professor Rodrigue, specialized in transportation geography, external costs account for more than 30% of the estimated car ownership and operating costs on average. If environmental costs are not included in this assessment, the use of cars will, therefore, be subsidized by society, and the costs will accumulate as environmental pollution. Due to the steady increase in the number of vehicles, especially cars, it needs to be properly considered.

2.3 Transport and the Environment

The relationship between transportation and the environment is multidimensional. Some aspects are still unknown, and some discoveries may lead to changes in environmental policies. Historically, due to the mode of use and low mobility, transportation had almost no negative impact on the environment.

However, it was not until the 20th century that a comprehensive view of the connection between transportation and the environment emerged, especially with the transportation methods widespread such as cars and airplanes. At the same time, manufacturing and sales concepts (such as planned obsolescence) have inspired the design of models such as automobiles and products that can be continuously replaced. The 1960s and 1970s were crucial to achieving the negative impact of human activities on the environment and the need for regulations.

The environmental dimension of transportation is related to the causes, activities, outputs, and results of the transportation system. Building connections between environmental dimensions is a difficult task. In addition, transportation is embedded in the environmental cycle, especially in the carbon cycle, where carbon flows from one element of the biosphere (such as the atmosphere) to another element, where carbon can be accumulated (Permanently or temporarily) or continue to spread. For Professor Rodrigue, the relationship between transportation and the environment is also complicated by two factors:

- Contribution level: Transportation activities directly, indirectly, and cumulatively cause environmental problems among other man-made and natural causes. In some cases, they may be the dominant factor, while in others, their role is negligible and difficult to establish.
- Impact scale: Transportation activities have caused environmental problems at different geographic scales, from local (noise and carbon monoxide emissions) to global (climate change), without forgetting the problems of continents, countries, and regions (smoke and acid rain).

Therefore, the formulation of transportation and environmental policies must consider the level of contribution and geographical scope, otherwise, some policies may transfer the problem to other places and have unexpected consequences. An obvious example is the environmental policies of developed economies, which have encouraged some activities in developing economies with higher environmental externalities to be transferred elsewhere. This shifts the problem from one location to another.

2.4 Environmental Dimensions

Transportation activities, especially in urban areas, have a growing demand for passengers and freight mobility. However, the degree of motorization and traffic congestion caused by transportation activities continues to increase. As a result, the transportation sector is always more connected to environmental issues.

2.4.1 Air Quality

Land transportation plays an important role in people's lives. It is a means to promote connections with schools, universities, economic centers, shopping, workplaces, family visits, and excursions. Therefore, this sector seems to be an indispensable element in people's daily lives. However, it is not considered sustainable since it is a source of pollution in the form of gas and particulate emissions. These pollutants come from internal combustion engines, brakes, and tires. Even if the car fleet becomes fully electric, the dust created by the brakes (including pads, discs, and drums) and tires will still pollute the air in urban areas. Particles from brakes, tires, and road wear directly cause more than half of the particulate pollution in urban road transportation according to very recent chemical and immunologic researches achieved by Selley et al. (2020).

All these cumulative emissions affect air quality and damage human health. The most common emissions include carbon monoxide (CO), lead (Pb), nitrogen oxides (NO_x regrouping nitric oxide (NO) and nitrogen dioxide (NO₂)), benzene, silicon tetrafluoride (SF₆), volatile components (BTX), heavy metals (zinc, chromium, copper and cadmium) and particulate matter (ash, dust). Toxic air pollutants are associated with cancer, cardiovascular, respiratory, and nervous system diseases. Carbon monoxide (CO) inhalation reduces the level of oxygen in the human circulation system and can be extremely harmful or even fatal at certain concentrations. Nitrogen dioxide (NO₂) emitted from transport sources can reduce lung function, affect the respiratory immune defense system, and increase the risk of respiratory diseases. The emissions of sulfur dioxide (SO₂) and nitrogen oxides (NO_x) in the atmosphere form various acidic compounds that can cause acid rain when mixed into cloud water. The acid deposition will adversely affect the environment, reduce crop yields, and cause forest degradation. Goyal et al. (2006) confirmed the contribution of vehicles to urban air pollution and proved that in big cities, land transportation accounts for 70% of total CO emissions, 50% of hydrocarbon (HC), and 30-40% of NO_x, 30% of particulate matters (PM) and 10% of SO₂.

In many developing countries, urban air pollution is hence becoming a serious environmental problem, and many cities in the world are severely affected by this phenomenon. For Ozden et al. (2008) the main sources of air quality damage in developing countries include population growth, which leads to unplanned urbanization and industrialization.

Bickerstaff and Walker (1999) believe that air pollutants are an increasing environmental problem due to the existence of certain sources, including the increase in urban population, uncontrolled industrial activities, and emissions of pollutants from engines.

Gurjara et al. (2008) denounced the lack of air quality data and other information gaps in several developing countries, such as the lack of a comprehensive emission inventory.

Developed countries have already made some efforts and taken actions to obtain better air quality by formulating strategies involving many issues. These strategies include emission inventories, air quality regulations and standards, establishing air quality monitoring in cities and industrial sites, and switching to clean fuels (such as natural gas, hydrogen) and energies (such as electricity).

2.4.2 Climate Change

The greenhouse effect is a basic element that regulates the global climate and is a naturally occurring process that involves the partial retention of heat in the earth's atmosphere. These gases include carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and halocarbons. These gases have accumulated in the atmosphere long enough to achieve a uniform composition worldwide. Therefore, their concentrations are similar regardless of location. Since the Industrial Revolution, especially in the past 25 years, the amount of conventional greenhouse gases released into the atmosphere has greatly increased.

Activities in the transportation industry release millions of tons of greenhouse gases into the atmosphere each year, accounting for 25% to 30% of all greenhouse gas emissions. The extent to which these emissions are related to climate change is still currently under debate. Scientific researches are asking how much carbon the world can emit before the damages are irreversible. How long will it take to reduce fossil fuel emissions and reach the 2-degree target of the Paris Climate Agreement? When will the Point of No Return occur? As stated by Aenghenheyster et al. (2018), recent data and estimates are worrying and time is running out.

2.4.3 Biodiversity and Land Take

Transport also affects biodiversity. Demand for construction materials and the development of land transportation have led to deforestation. Many transportation routes require drainage, thus reducing wetland area and expelling aquatic plants. The need to maintain highway and road right of way or to stabilize slopes along transportation facilities has led to restrictions on the growth of certain plants, or changes in plants due to the introduction of new species. Many animals are on the verge of extinction due to changes in their natural habitats and transportation infrastructure that has shattered their habitats and reduced their scope. Traffic facilities have an impact on the urban landscape and lead to a massive loss of fertile land. Major transportation facilities may affect the quality of life by creating physical barriers, generating odors, reducing urban aesthetics, and affecting architectural heritage. The expansion of logistics activities is also an indirect factor for suburban land occupation.

Transportation activities have an impact on hydrological conditions and water quality. Fragments of micro-plastics, fuel, chemicals, and other harmful particles discarded from transport operations may contaminate the hydrological system. The environmental impact of transportation on soil quality especially involves soil erosion and soil pollution.

Environmental noise is a common result of transportation in urban areas. This is the cumulative result of all noise generated by vehicles (ranging from 80 to 100 dB for motor vehicles in service), which can impair the quality of life.

3 EMPIRICAL ANALYSIS: USED CAR MARKET FROM DEVELOPED TO DEVELOPING COUNTRIES

Most developed countries try to regulate this significant market by imposing new environmental regulations such as emissions control, low emission zones, carbon taxes, bonus/malus schemes. Since the 2000s, the three territories that lead the way in improving emissions standards are Europe, the United States, and Japan. They have significantly lowered the thresholds of pollutants obtained on the certification bench. Car manufacturers have to adapt and propose solutions. They develop new technology processes to limit car emissions. This sounds to be an opportunity for them to re-invent this market. The demand for standard internal combustion engines in developed countries is slightly decreasing for hybrid, electric, and low emissions vehicles. The International Energy Agency (IEA) explains that the global sales of electric vehicles (considering battery electric vehicle or a plug-in hybrid electric vehicle) exceeded 2.1 million in 2019, increasing the stock of electric vehicles to 7.2 million. Electric vehicles accounted for 2.6% of global car sales in 2019 and less than 1% of global car inventory.

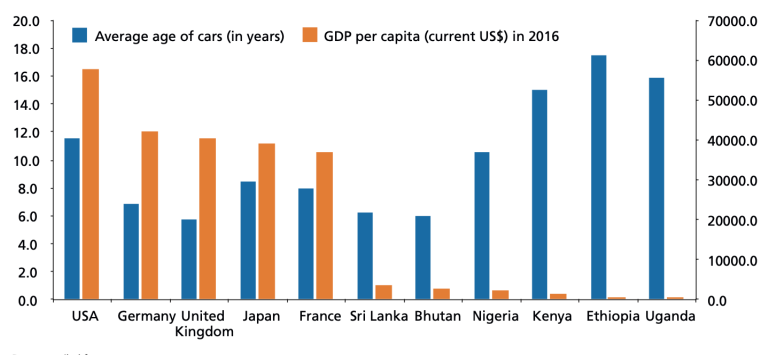


Figure 2: Relation between per capita GDP and average age of cars in rich and poor countries, source Centre for Science and Environment

These state regulations appear to be good in the first approach but after some researches, many side effects and difficulties appear. In Figure 2, we observe a correlation: the poorer (in terms of GDP per capita) a country is, the older and polluting is its car fleet. We explain this fact by the low purchasing power and the used car market in the developing and least developed countries.

At the beginning of this empirical part, we will focus our attention on the recent car market in developed countries to see if car production and consumption respond to "high environmental concerns". We will see that is not the case, in particular in terms of global motorization and size.

3.1 The Diesel Engines' Heyday

The demand and supply for "green" vehicles have increased in rich countries. There are important improvements in the electric and hybrid motorization since many studies showed that diesel engines were very dangerous for humans' health (particles, NO_x). Most of the consumers had still in mind a few years ago that diesel engines were the best compromise since they consume less and are reputed more solid. Why did consumers think so? An important communication campaign was done in the 1990s and the 2000s showing that diesel was the best alternative for efficiency (Diesel: the true (dirty) story (2017)). Environmental considerations played a strong role too. Developed economies focused their attention on this environmental aspect and CO_2 alone not thinking about fine particles nor NO_x emissions, resulting in health diseases. Hence, less CO_2 emitting diesel engines were less taxed and more promoted than petrol engines. Despite the bad reputation that diesel begins to have, diesel cars still represent 40 percent of the new fleet in Europe in 2019. These brand-new diesel vehicles are of course more efficient and pollute less in the "brochure" since they have to meet the environmental norms (Euro 6d in Europe). In the "brochure", what does it mean? The Diesel Gate scandal of 2015 is a very good answer. The car-maker Volkswagen (and there are many others) used software to cheat during emissions testing. The Turbocharged Direct Injection (TDI) diesel engines (EA189 engine) emitted up to 40 times more NO_x in real-world driving. Since 2015, according to the European Commission in May 2019 and researches of Eoin Bannon from Transport and Environment, only 10 million of the 43 million highly polluting diesel vehicles and trucks arrested in the Dieseldgate emissions scandal have been recalled. For consumers and public health in Central and Eastern Europe, the situation is even worse, where only 55% of Volkswagen Group cars have been recalled, compared with 83% in Western Europe.

Despite this scandal, if we check again actual emissions tests, the great majority of new diesel cars exceed the pollution standards with which they have been approved (in particular the NO_x norms). Bypassing the environmental rules is one of the negative consequences of this more regulated market. The hope of a better representativeness of automobile pollution is now focused on updating the approval procedures, with the publication of the "Worldwide Harmonized Light Vehicle Test Cycle", deemed more faithful to real driving conditions. This process should gradually be adopted by the various regulatory zones, and with the RTE "Real Driving Emissions" which is based on various tests in real conditions.

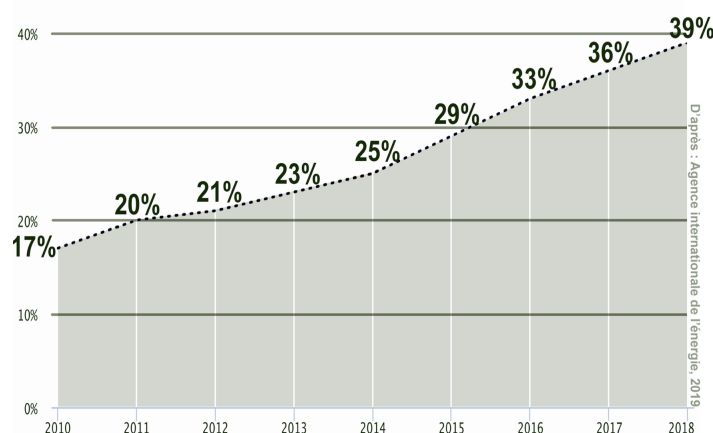
3.2 The SUVs' Paradox

Scientific researches (David Perlman (2015) from MIT) all agree that an efficient car must be light, have a low gravity center, a small aerodynamic penetration (C_x), and a small engine (examples: GM EV1, Volkswagen XL1). More efficient vehicles are needed to meet energy security and climate protection goals. New technological processes seem to be the keys. Improvements in material, energy, recycling, aerodynamic design, and drive train (engine and transmission) are the most relevant.

Do new cars meet those requirements? Checking the automobile's global trend characteristics, we can observe an average increase in weight, height, width, and power. Cars are becoming bigger (Laurent Castaignède (2018)). The safety devices (airbags, structural improvement of the frame) are ones of the response but not only. The financial market intervenes in this supply and demand transformation: by the attractivity of low-interest rates, many brand-new cars are now financed in credits or leasing. This phenomenon is also accentuated by the firms which provide company cars to their employees as benefits. In particular in Belgium, company vehicles account for approximately 20 percent of the national fleet. For the employer, the company car is an alternative to bypass the high taxation of a wage increase. It is hence easier to get a bigger and more powerful car for not so much money per month.

Comes in this context the sports utility vehicles (SUVs) paradox. According to the International Energy Agency (IEA) data, the rapidly growing market share of larger heavier models' SUVs, is driving up emissions. In Europe, the market share of SUVs was multiplied by more than four over the past 10 years from 8 percent in 2008 to 32 percent in 2018, while total SUV and truck sales in the US reached almost 70 percent in 2018.

Figure 3: Share of SUVs in annual sales worldwide, source International Energy Agency



For example, the 10 best-selling vehicles in the United-States in 2018 were mostly trucks and SUVs such as the Ford F-Series or the Dodge Ram. In Europe, in the 20 best-selling vehicles, there are 6 SUVs (Volkswagen Tiguan, Peugeot 3008...). The share of SUVs in annual sales worldwide is going up each year shown in Figure 3. It represented 17% in 2010 and reached 39% in 2019.

This trend is now common. In China, the SUV is regarded as a symbol of wealth and status. In India, sales are currently low, but as more and more people can afford SUVs, consumer preferences are changing. Similarly, in Africa, the rapid pace of urbanization and economic development means that demand for high-end and luxury cars is relatively strong. According to many analyses and the consultant Rapaille, psychology plays an important role in this increase. Most of the SUV drivers feel safer because of the height and the weight of their cars. There is also a very powerful notion that is the domination feeling.

The impact of its rise on global emissions is not surprising. In the past decade, the global SUV fleet's emissions have increased by nearly 0.55 Gt CO₂, reaching approximately 0.7 Gt CO₂. Therefore, SUVs are the second largest cause for the increase in global carbon dioxide emissions since 2010, after the power sector, but ahead of heavy industries (including steel, cement, aluminum) and trucks and aviation.

We are very far from the direction the automotive market should take to improve the sustainability of the environment. SUVs simply consume and pollute more (antagonistic situations). On average, SUVs consume a quarter more energy than mid-sized cars. As a result, the global fuel economy has deteriorated, partly because of the increased demand for SUVs since 2010. Do people need a 4-wheel drive to use perfect concrete roads?

SUVs do not meet low emissions and high-efficiency rules and those heavy vehicles are much harder to electrify than smaller cars. Consumers' individualism, lack of transparency, and irrationality influenced by lobbies practices are resulting in a very bad carbon footprint. Most of those SUVs are now driven in developed and rich countries but they will one day be second-hand and exported to developing countries.

3.3 The Recent Challenge of Environmental Regulations and Exports in Developed Countries

After having raised some environmental aberrations, we will indeed notice in the next subsection that developed countries create new environmental standards that are beneficial for them but not necessarily for the developing countries. We will hence concentrate our attention on the export market in this subsection.

As environmental regulations become stricter, more and more used cars are likely to retire early or be eliminated until they are exhausted in advanced markets before their useful economic life is exhausted. The consulting company Ricardo-AEA estimates based on the vehicle scrap rate that in 2015, in the European Union (EU), 94% of the cars have the second life, 87% of the cars have the third life, and about 27% of the cars have the fourth life.

Regular and expensive vehicle inspection tests motivate people to change vehicles faster. Higher disposable income leads consumers to decide to change vehicles more quickly. There are several plans to stop old and polluting vehicles in the city center, eliminate old diesel vehicles, or provide economic stimulus programs to replace old cars. These plans have caused a large number of used cars in high-income countries, and thus become overcrowded in developing countries.

Generally, in all advanced markets, legislative frameworks continue to emerge to scrap old vehicles and recycle end-of-life (ELV) vehicles. Once the vehicle is identified as an ELV, it is written off, which requires scrapping and recycling through appropriate domestic procedures. Currently, ELV recycling systems exist in the European Union,

Japan, South Korea, China, and Taiwan. The European Union, Japan, and South Korea have also adopted the principle of expanding producer responsibility, aiming to recycle used car parts, scrap metal, batteries, etc.

In the domestic market of high-income countries, the second-hand car trade provides a stronger impetus for not implementing certain scrap regulations for used cars. Exporting used cars is more profitable and more cost-effective than scrapping them.

It is often observed that exporting countries may find that exporting used cars is beneficial to them because it is more cost-effective than scrapping in the domestic market. Similarly, the cost-benefit of scrap procedures is often doubtful. Some studies have determined that providing cash for the used car program in the United States does not bring any major economic savings or environmental benefits. However, it is estimated that the recycling of materials from old cars can improve the overall economic resource efficiency.

Besides, scrapping procedures need to be properly designed to legally ensure that vehicles identified as scrapped are destroyed. Otherwise, the plan may lead to unintended consequences of encouraging second-hand car imports into the gray market. Rumors and media reports point to the illegal transport of scrapped vehicles from Germany and other EU countries to Africa and Eastern Europe. This is because the German plan for scrapped vehicles requires that scrapped vehicles be sent to the dump, but it is not legally required to provide evidence that the scrapped vehicles have been destroyed. This encourages illegal exports. In contrast, in the United States, the "cash-for-clunkers" program requires dealers to destroy old engines, and it also stipulates methods for destroying old engines.

According to Chandola and Chatto (2018) for the Centre for Science and Environment, a long vehicle transshipment supply chain has been added to re-export hubs in the Middle East and elsewhere, and these vehicles have been separated from advanced emission control systems in advanced markets. The information about this is very vague, so it is difficult to assess the status of the emission control system in imported vehicles. A large number of vehicles damaged by accidents or with manufacturing defects and recalled in advanced markets have also been exported. Even in South Asia, the gray market develops around porous borders, with a large number of used cars entering Nepal and Bangladesh through the border.

Let's center our study on Europe, the United States, and then Japan.

3.3.1 *Europe*

In Western Europe, new cars must comply with more stringent requirements: Euro 3 norms from 2000, then Euro 4 from 2005. As of the publication in 2007 of the Euro 5 standard, which very significantly reduces particulate matter emissions from 2009, many European countries were promoting the purchase of "clean" diesel vehicles through financial incentives. Since 2014, the new Euro 6 standard has further limited the number of particles emitted and sharply lowers the nitrogen oxide threshold for new diesel engines. Successive Euro emission standards have led to a significant reduction in the emissions of PM and other pollutants (such as HC and CO) in the exhaust gas.

Eastern European and non-EU countries globally follow "Euro standards" requirements, with time lags of a few years for their entry into force. For example, Russia imposed Euro 2 from 2006 and Euro 3 in 2009. Recurring concerns about the availability of low sulfur fuel in its refineries have led Russia to regularly postpone the application of the Euro 4 (from 2014) and Euro 5 standards.

However, since the adoption of the Euro standard in 1991, NO_x emissions, especially NO₂ emissions from road transport have not been reduced as expected, because emissions under "real-world" driving conditions are usually higher than those under type approval testing (especially diesel vehicles).

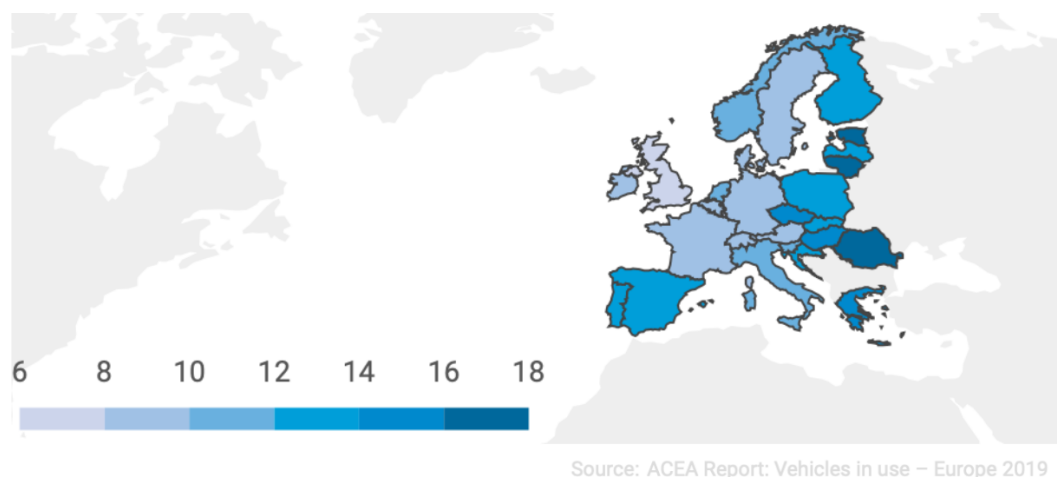


Figure 4: Passenger cars in use, by age in the European Union in 2019, source ACEA

The average passenger car in the EU is aging. According to the European Automobile Manufacturers Association (ACEA) and the European Environment Agency, the average age of passenger cars is 10.8 years (in 2018) and was 7.4 years in 2014. Indeed, many Member States reported that the share of “old” passenger cars (20 years old or older) in 2018 was still significant. The member states with the highest share are Poland (36.5%), Estonia (29.6%), Finland (25.2%), Romania (21.4%) and Malta (20.8%). Figure 4 shows this concentration of old cars in the Eastern part of Europe. In contrast, the “youngest” passenger cars (less than 2 years) with the highest share are Ireland (29.2%), Luxembourg (23.8%), Denmark (23.3%), and Belgium (23.1%) (Eurostat).

Given of the increasing number of urban bans and low-emission zones in Western Europe, drivers have been progressively abandoning diesel cars, and many of these dirty cars are now sold to Central and Eastern European member states. This means that air quality problems will be exported rather than solved, thus deepening the existing East-West gap in air quality in Europe.

The report “Dirty diesels heading East: Polish edition” written by Julia Poliscanova, Florent Grelier, and Jens Müller in 2018 for Transport and Environment illustrates the West to East used cars exports to Poland. The data show in this report that:

- In 2017, Poland imported more than 850,000 used cars, of which about 40% were polluting diesel.
- Nearly 75% of the diesel cars imported were produced before 2011.
- Diesels imported into Bulgaria in 2017 emit 12.5 times the current EU’s Euro 6 NO_x limit on average.

The second report “Dirty diesels heading East, New evidence on exports of 2nd hand dirty diesels in Bulgaria” written by Julia Poliscanova and Florent Grelier in 2018 for Transport and Environment illustrates the West to East used cars exports to Bulgaria. The data show in this second report that:

- In 2017, Bulgaria imported more than 100,000 second-hand cars from 28 EU countries. One third of which were heavily polluting diesel cars.
- More than half of the dirty diesel imported cars were more than 10 years, with no standard diesel particle filters, emitting dangerous carcinogenic fine particles.
- As for toxic nitrogen dioxide, at the heart of the diesel gate scandal, the dirty diesels imported into Bulgaria in 2017 emit 12 times the current EU NO_x limit on average.

The European Union also exports vehicles (we consider here Passenger Cars + Lorries < 5 t) to many developing countries outside the EU-28. The study of Dr.Ing. Mehlhart in 2017 showed that:

In 2014, 1,150,000 Extra-EU 28 used vehicles were exported.

Between 2013 and 2015, on average :

- 630,000 vehicles per year were exported to Africa (Benin, Nigeria, and Lybia was the top 3). €1,930 is the average price per vehicle exported.
- 296,000 vehicles per year were exported to Europe other than EU-28 (Serbia, Ukraine, and Bosnia Herzegovina was the top 3). €4,870 is the average price per vehicle exported.
- 214,000 vehicles per year were exported to Asia and Row (Georgia, Tajikistan and Kyrgyzstan was the top 3). €8,135 is the average price per vehicle exported.

3.3.2 United States of America

In the United States, California continues to play the leading role with LEV (Low-Emission Vehicles) standards. These measures are accompanied by the ZEV program (Zero Emission Vehicles). This is to encourage manufacturers

to design and market in California an increasing proportion of electric vehicles or vehicles equipped with the latest pollution control technology (U.S. Department of Energy). Several American manufacturers complained to the State of California in 2004 against this law which they considered too restrictive and its unjustified extension to the federal level. The State of California then suspended the program and proved in court in 2006, the responsibility of the 6 major American and Japanese automakers in multiple degradations of the environment, of the health of Californian citizens and for the excessive contribution of their vehicles to climate change. Finally, a 2008 amendment redefined the ZEV program to promote electric vehicles and alternative fuels. California is gradually dragging other states in its wake with its increasingly stringent LEV standards. At the federal level, Tier 2 standards are being gradually applied to 2004 to 2009 automobile models, then a new Tier 3 series from 2017, now harmonized with the California LEV III standards imposed from 2015, which require widespread low levels of nitrogen and particulate oxides.

David Coffin (2015) shows in his report that used cars represent an important part of U.S. passenger car exports. The huge foreign market for these export products seems to have supported sales of passenger cars in the United States and may reduce the price premium of new cars to American consumers. This shows that the current level of new car purchases in the United States can be at least partially attributable to foreign demand for second-hand American cars.

This market for the U.S. used car exports is different from the market for new car exports, especially in terms of quality. Second-hand passenger cars are often exported to developing countries since they offer competitive prices, luxury options, and match or exceed the quality of new and used local cars. From 2009 to 2020, the export volume of used cars in the United States is estimated to have increased by 51%, from 656,000 to nearly 990,000.

The Middle East, Africa, and Eastern Europe are the most common export destinations for second-hand passenger cars. The main markets for the US used car exports are mainly developing countries (if we exclude the United Arab Emirates in the first position) led in 2019 by Georgia, Nigeria, Ukraine, Libya, Mexico; the average unit price of exports to these countries was US\$7,800 (in 2019).

3.3.3 *Japan*

Two Japanese emission plans were implemented in the 1990s and early 2000s to reduce emissions from vehicles in use: the "Automotive NO_x and PM Law" and the "Tokyo Retrofit Program" respectively (Ministry of the Environment, Government of Japan).

In 1992, to deal with the NO_x pollution of existing fleets, the Japanese Ministry of the Environment (MOE) passed the "Motor Vehicle NO_x Law", which aims to eliminate the oldest and most polluting vehicles from the fleets in certain geographic regions. In 2001, the regulation was revised to include PM emission requirements and was renamed the "Automotive NO_x and PM Law."

The Tokyo region and several neighboring prefectures have adopted diesel emission regulations, which require the use of PM control devices (catalytic converters or particulate filters) to retrofit old diesel vehicles in use or replace them with newer clean models. The Tokyo modification requirements came into effect in October 2003.

In 2003, the Ministry of the Environment finally established a very strict 2005 emission standard for light and heavy vehicles. When it was implemented, the 2005 heavy-duty emission standard was the most stringent diesel emission regulation in the world. Beginning in 2009, these restrictions have been further tightened to the level between the US 2010 and Euro 5 standard requirements. The 2016 Japanese standard restrictions are comparable to the US 2010 and Euro 6 standards.

Engine and vehicle emission rigorous standards are now established under the authorization of the "Air Pollution Control Law", while the fuel efficiency target is passed under the "Law on the Rational Use of Energy" (Energy Conservation Law).

These regulations have significant consequences on the used car market, notably on exports. Despite the high transportation costs, it is still profitable to sell used cars to other countries due to the relatively low cost and the good condition of the purchased vehicles. The reasons for the feasibility of exporting include:

- Japan's strict motor vehicle inspections: The motor-vehicle inspection in Japan also called Shaken is very rigorous and expensive. Japan has very strict vehicle emission testing standards. Generally, a two-year inspection for a small or medium-sized passenger cars ranges from 100,000 yen (932 US Dollar) to 200,000 yen (1,832 US Dollar).
- Strict environmental protection regulations make Japanese car scrapping very expensive.
- High depreciation. It makes used cars less valuable in Japan in six years.

In Japan, used cars are mainly sold in car auctions by car owners and dealers. Exporters act as bidding agents for importers and use auto auctions as their main supply. More than 200 auto auction groups are operating, including JAA, JU Group, TAA, USS and ZIP. In addition to auto auctions, Japanese exports can also obtain vehicles from dealers and private sellers. In 2015, the export volume of used cars was 1,021,712, accounting for 21.8% of the total

number of cars exported by Japan (Atsumi (2018)). The most popular destinations for Japanese used cars (if we exclude the United Arab Emirates and New Zealand) are Myanmar, South Africa, Kenya, Mongolia, Bangladesh. This Japanese market responds to the RHD (Right Hand Drive) car demand.

3.4 Developing Countries' Car Market: A Global Overview

Let's continue this empirical part in developing countries, we will change our point of view from the export market to the import market. We will try to identify the bad environmental drifts of this market with a focus on car condition, maintenance, and modification. We will understand that a combustion engine car is not necessarily polluting when it is purchased new, but it becomes so if it is not maintained, controlled and monitored correctly.

In developing countries, the new car market is more low-cost oriented since the purchasing power in those countries is lower than in developed countries. The car manufacturers are adapting their supply and propose models that are only available in the emerging regions. For instance, the Peugeot 405 which is famous for its strong and highly polluting Diesel (D) and Turbo Diesel (TD) engines, was still one of the best sellers of the brand until 2017 with more than 260 000 cars sold in 2017. The production was stopped in 1997 in France while it continues those days in Azerbaijan. Another example can be the Renault Kwid which is sold only in Sri Lanka, South Africa, India, and Brazil. This model, designed in 2014, has been controversial with its crash-test result of poor quality (0 stars out of 5, crash-test Global NCAP 2016). The pollution and security are far from being the main preoccupations in those areas. This market is a financial windfall for car makers since most of the developing countries are becoming richer. Developing countries are reproducing and multiplying the problems that we made in the past in developed countries.

What about the used car market? As said before, developed countries try to limit automotive pollution and are slowly turning the fleet into a low emission one. There are indeed more and more environmental regulations and inspections for all types of vehicles. Those norms, controls, and restricted zone areas are becoming rigorous and allow fewer emissions. New regulations have been creating a new kind of market for poor and emerging countries. Old cars are pushed out of developed roads since they don't respect new norms anymore. That means drivers must buy more modern cars and sell their old ones if they want to circulate in restricted emissions urban areas such as in Brussels or Paris. What is the value of a car in a country where we are not allowed to drive it or which is not able to pass the inspection? The demand in developed countries for old cars is decreasing and the supply is increasing. Hence, their value is going down in developed countries. This is how the used car market in developing countries has been emerging and seems to be the substitute demand: In terms of vehicles, most developing countries are "technology takers", meaning that they import rather than manufacture vehicles. Most of the imports are used cars. For example, in Kenya in 2014, more than 99% of imported vehicles are used cars, while less than 0.5% are new cars (UN Environment collected data). Developed countries sell their used cars for a low price for exportation. The market is distorted by allowing dealers to buy the cars at scrap prices and export them to other countries where the pollution standards are non-existent or very limited compared to the EU, the USA or Japan: In general, most poor economies and emerging countries have very few policies on car intake and maintenance policies (including basic car emission standards) explained by developing regions in the next subsection. As soon as the used cars are in the new countries their values readjust. Developing countries need them to fulfill their booming mobility demands and freight. Hence, the ecological norms heterogeneity between developed and developing countries stir up those massive exports of dirty vehicles. Why dirty? Firstly, most of them have diesel engines and don't respect EURO-3 norms. Secondly, the fuels in emerging countries are often of lower quality. Thirdly, some mechanical modifications are very often implemented in poor countries, including :

- Particle filters disassembling,
- Catalytic converters removals also called and commercialized in every car shop as "Tube Afrique" in French. The installation of a "Tube Afrique" is therefore illegal and very harmful for air quality. Some "Tube Afrique" adopt a resemblance to catalytic converters, in order to be undetectable by the police forces, except in the event of an anti-pollution test, which happens very rarely. The catalytic converter is indeed compulsory and necessary to respect environmental standards for recent circulating cars. However, the average life span of a catalytic converter is about 100,000 miles or 160,000 kilometers. The catalytic converter may be one of the most overlooked components in modern vehicles. It is not cheap to replace the catalytic converter. For most vehicles, the average cost of a catalytic converter is between US\$400 and US\$2000, parts alone. This may be close to the value of a used car or even higher.

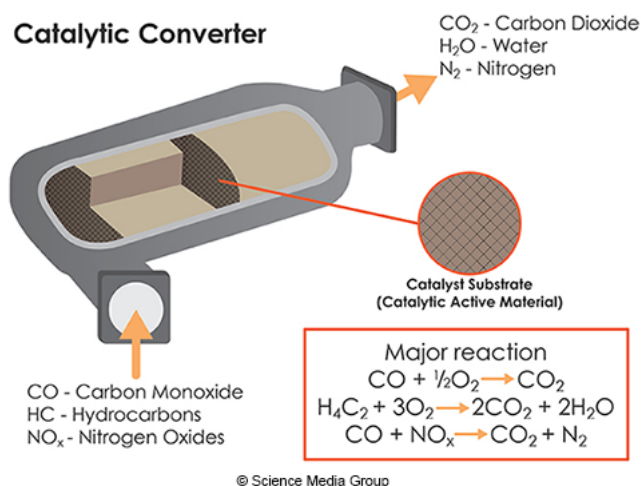


Figure 5: Catalytic Converter Functioning, source Utah Education Network Chemistry of Air Pollution

These kinds of devices are initially used to reduce toxic gases and pollutants in the exhaust gas of internal combustion engines into less toxic pollutants through catalytic redox reactions (oxidation and reduction reactions shown in Figure 5) but are expensive to replace, limit engine performances, and are often incompatible with bad quality fuel and dust air. It is important to note that even a very recent car with the catalytic converter removed becomes very dangerous for human health.

All these factors combined (bad emission standards, bad quality fuels, car modification, or negligence) are resulting in a significant expansion of pollution and health diseases.

Reducing carbon dioxide (CO₂) and non-carbon dioxide (NO_x and particulate matters) emissions from global fleets is a top priority for solving climate and air quality issues. By 2050, the number of global road vehicles will double, and most future car purchases will be in developing markets. However, although owning a car is an almost universal desire and second-hand cars offer opportunities to increase personal travel at a lower cost, not all second-hand cars have the same impact on the environment. Both newly imported and older vehicles with existing inventory (for example, vehicles earlier than the equivalent standard of Euro 4) emit disproportionate pollutants, and this does not change for the better with the age and significant mileage of these cars.

3.5 Used Car Imports from Developing Countries Side

This is a myth that only low-income and middle-income countries import used cars. In fact, in rich countries like Australia and New Zealand, automobile manufacturing has not taken off due to various local industrial and fiscal policies, and automobile imports dominate, including the import of used cars. However, the upper age limit in these countries/regions is very strict: only one year in Australia and subject to strict inspections and other requirements. These models can be used to develop protocols for managing the import of used cars. That is why we focus our analysis on the absence and limitation of environmental regulations in developing countries.

The current database on international imported vehicle trade does not distinguish between the flow of new vehicles and the flow of second-hand vehicles. Estimates of international trade in the used car trade are not easy to draw. Information is fragmented and discontinuous, most of which can be obtained from expert research, consultant reports, and limited official databases. This makes it difficult to assess the direction, composition, and volume of trade. Usually, data from different sources cannot be compared.

Let's center our continuation of the study on Africa, Asia, Latin America, and the Caribbean. We will understand that environmental standards in these regions are limited and heterogeneous.

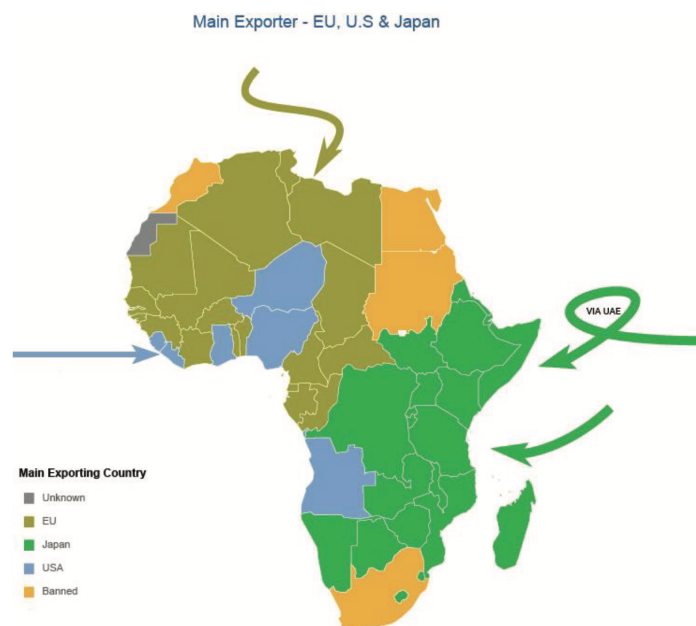
3.5.1 Africa

Although the motorization rate of African countries is the lowest in the world, the increase in car ownership is mainly driven by the import of used cars. Motorization in Africa is still in the early stages of growth. Estimates by the World Bank in 2014 show that the car ownership rate in Africa is far below the world average and high-income countries. In 2012, only countries with more than 50 cars per thousand people included South Africa, Botswana, Mauritius, and Namibia. As stated by the Fédération Internationale de l'Automobile (FIA) in 2020, out of 54 African countries, 25 countries do not have policies to control the import of used cars. Of the 27 companies that impose age restrictions on imported second-hand cars, only 14 have banned imports or have restrictions of 5 years or less. In

addition to these age restrictions, some countries also encourage the import of clean used cars, such as Seychelles, Nigeria, and Uganda.

Some countries/regions in Africa have set age restrictions on the import of used cars.

South Africa, Egypt, Sudan, and Morocco completely ban the import of used cars.



Source: Ariadne Baskin 2018, *Africa Used Vehicle Report*, Paper presented at the Africa Clean Mobility Week, Nairobi, 12–16 March 2018.

Figure 6: Direction of trade from developed countries to Africa, source UN Environment Programme

Countries such as Gambia, Ghana, Mali, Côte d'Ivoire, and Cape Verde have adopted punitive taxation measures for the import of used cars over a certain age. Some countries impose additional taxes, such as internal consumption tax in Algeria or environmental tax in Uganda. Some tax systems, however, encourage the import of old vehicles by imposing lower tax rates on them.

According to the United Nations Environment Programme, many second-hand cars shipped from Japan, the EU, and the USA to Africa have failed or are about to fail pollution tests in the country. But in many parts of Africa, such regulations are usually poorly implemented, and rampant corruption ensures that second-hand cars can slip under any control. The United Nations calls air pollution a "silent killer" in Africa, causing about 7 million deaths each year. The organization warned that car emissions are the main source of deteriorating air quality in prosperous cities.

According to United Nations data, more than 1.2 million second-hand cars were imported into Africa in 2017. Most of them are shipped to Nigeria and Kenya, the two largest economies in Africa.

3.5.2 Asia

Asia has the highest rate of motorization in the world, for the most part, driven by China, India, Indonesia, and the Philippines. As seen before, Japan is the world's largest exporter of used cars. Approximately 1 million second-hand cars are exported from Japan to other countries every year (ATSUMI (2018)). China has also begun to export used cars to other Asian countries, but there is no data yet. Similarly, India has also exported used cars to countries such as Nepal, but no quantifiable data has been found. Other used car exporters in the region are Thailand, Singapore, and South Korea. It is indeed more difficult to assess the trade in used cars in Asia. Anecdotal data from local officials and the market shows that a large number of second-hand cars are coming in from Japan, Singapore, and other Asian developed countries.

Bangladesh, Hong Kong, India, Malaysia, Nepal, Pakistan, the Philippines, Singapore, and Sri Lanka allow the import of used cars. However, some regulations are restricting the import of used cars in these regions, including compliance with applicability, emission standards, and vehicle manufacturing age. Those restrictions never exceed Euro 4 norms.

3.5.3 *Latin America and the Caribbean*

Imports of second-hand cars in Latin America and the Caribbean are mainly from Japan, the United States, Thailand, the United Kingdom, and Germany. Again in this area, UN Environment data demonstrate that there is no uniform vehicle standard.

In the South American sub-region, some countries have begun to adopt stricter vehicle emission standards. In 2017, all countries required the import of light vehicles with Euro 3 standards or more. Bolivia, Peru, and Paraguay are the only countries that allow the import of used cars. They impose age restrictions. Paraguay's age limit is 10 years old, while Peru's age limit is 5 years old. Argentina, Brazil, Chile, Colombia, Ecuador, Uruguay, and Venezuela ban the import of used cars.

In the Caribbean, most countries have age restrictions for used cars: 10 years old in Jamaica, 4 years old for gasoline and 3 years old for diesel in Trinidad and Tobago.

In the Central American sub-region, Belize, Costa Rica, Dominican Republic, Guatemala, Nicaragua, El Salvador, Honduras, Panama, and Mexico allow the import of used cars. The age limits in Panama and Mexico are 10 and 5 years old respectively. There is no age limit in other Central American countries, although Costa Rica proposes to limit the age to 12 years. Except for Mexico's 4 Euro and Costa Rica's 1 Euro light vehicle emission standards, no other countries have vehicle emission standards.

Hence, the developing countries in Africa, Asia, Latin America, and the Caribbean have very heterogeneous environmental standards and their mobility needs are booming. The used car capital from developed countries matches their wishes but it results in disastrous environmental consequences.

4 THEORETICAL ANALYSIS: INTERNATIONAL TRADE IN USED CARS

In this section, we will try to come with the same conclusions we found in the empirical part. We want to show theoretically that if used cars are forsaken in developed countries because of new environmental norms and other factors they will naturally end up in developing countries resulting in environmental degradation.

4.1 Literature

The research paper "International Trade in Used Cars and Problems of Economic Development" written by H.G. Grubel and published in 1980 explains a well-known phenomenon from the price theory, that is, compared with developed countries, the depreciation of cars in developing countries is slower and the age of scrapping is older. Professor Grubel develops in this article the fact that the renewal of free trade barriers for second-hand cars will bring considerable welfare benefits to developing countries through the capital gains implied by arbitrage and the positive externalities of the auto repair industry. An assessment of the negative external impact of increased automobile supply is made. The final part of this article considers what policies may be required to develop international trade in used cars on a large scale. Professor Grubel completely forgot to mention about the environmental consequences of this kind of trade. At this time (in the 1980s) the environment was not so considered in the analyzes.

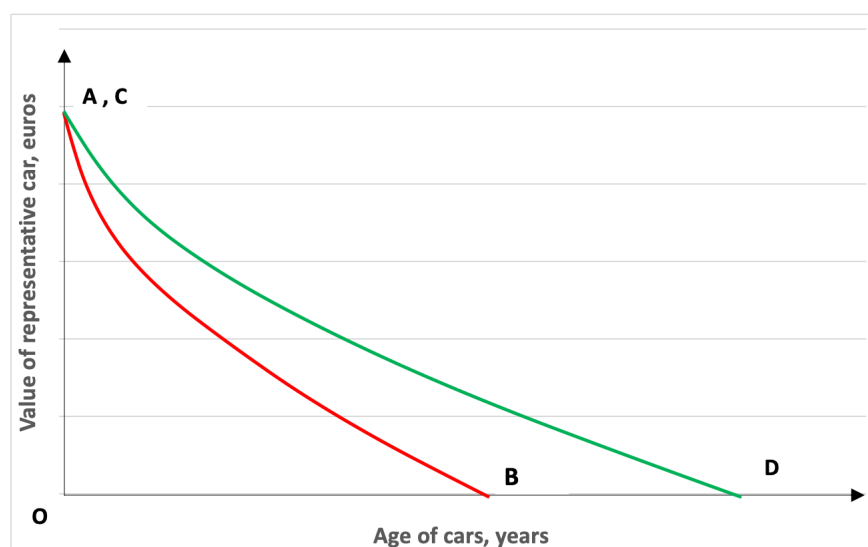
A second paper called, "International Trade in Used Vehicles: The Environmental Consequences of NAFTA (North American Free Trade Agreement)" written by L.W. Davis and Kahn M.E and published in 2010 was used. The vast majority of previous studies on trade and the environment have focused on how trade affects where goods are produced. However, trade also affects where goods are consumed. In this article, Professor Davis and Kahn describe a trade model with durable goods and non-homothetic preferences. In self-sufficient countries, second-hand goods are relatively cheap in high-income countries, and free trade has led to these goods being exported to low-income countries. Then, Professor Davis and Kahn use evidence from the North American Free Trade Agreement to assess the environmental consequences of this trading method. Since the removal of trade restrictions in 2005, more than 2.5 million used cars had been exported from the United States to Mexico between 2005 and 2010. By using a unique vehicle-level data set, he found that the vehicles traded are dirtier than those in the United States and cleaner than those in Mexico, so the trade leads to a reduction in the average vehicle emissions of the two countries. The increase in total greenhouse gas emissions is mainly due to the revival of vehicles that could otherwise be scrapped.

4.2 The Value of Used Automobiles

As we all know, all capital goods and durable consumer goods lose market value with age. For cars, there is a functional relationship between age and value, as shown by the AB and CD lines in Figure 7, where the value of the "representative" car is measured along the vertical axis, while the car's age is displayed along the horizontal axis.

The AB line in Figure 7 showed a well-known rapid depreciation rate in the first few years, followed by the average depreciation rate, and finally reached zero market value after B years. In this era, "representative" cars scrapped their parts as spare parts or the market value of scrapped sales, which is exactly equal to the cost of disassembling and selling parts.

Figure 7: Cars value through time in developed countries and developing countries



The term "representative" car needs some explanation. In the real world, depending on usage, maintenance, and other factors, cars manufactured in a particular year will depreciate at different rates. Car prices in each age category tend to be normally distributed, and the median value of the distribution is assumed to be the median of "representative" cars. When the "representative car" reaches zero market value after B years, half of the total number of cars is scrapped and half have still a positive market value. The concept of representative cars is very useful in analysis, and the lack of reality will not interfere with the validity of the main conclusions to be drawn below.

It is useful to distinguish these three reasons. First, there is a technical and style obsolescence. Outdated technology is due to the historically observed improvements in automobile power, comfort, and reliability, and technological progress to adapt to changes in fashion tastes evolution, and environmental norms. The second reason why cars lose value with age is that the expected maintenance costs will increase over time. The expected maintenance cost itself is a function of the likelihood of maintenance and repairs cost, both of which are functions of increasing age, simply because all automotive parts are susceptible to wear and face an eventual functional failure.

Over time, the third reason for the decline in the value of the automotive market is the increased risk of mechanical failure, and the effectiveness of mechanical failure is completely different from the cost of repairing the failure cause discussed in the previous paragraph. This phenomenon is caused by discomfort, danger, and time loss associated with car breakdowns. Therefore, an inoperable car may cause the appointment to be lost. Malfunctions can lead to traffic accidents.

Next, the analysis turns to determine the value of cars in developed and developing countries, focusing on the cause of the value loss just mentioned, and considering the AB line in Figure 7 representing the cars' age-value relationship in developed countries.

4.3 Difference in the Rate of Depreciation

In order to determine the basic determinants of the difference in the value of used cars between developed and developing countries, we first assumed that there is free trade in new cars and spare parts, but there is no trade in used cars at all. Under the further assumption that there are no transportation costs and that most of the cars are manufactured in developed countries, the cars' age value function in developing countries is represented by the green CD line in Figure 7 and the red AB line for developed countries in Figure 7. The CD line coincides with the AB line at the initial purchase price (the points A and C are the same), but then lies above the AB line over the entire range and reaches the zero value B-D years later than the AB line.

What explains the gap between the AB and CD lines? First of all, the most important point is that the labour cost of car maintenance in developing countries is relatively low since we assumed that the free trade of spare parts has the

same cost in the two countries types. A representative car that can be scrapped in developed countries after B years can be repaired and maintained at a lower cost so that its value at that age is still positive in developing countries. The labour maintenance cost is low. It explains the difference in the assumed values for all ages and when the value reaches zero.

The second factor that determines the difference in value is the low average income in developing countries and the income elasticity of demand for the "luxury" features of new car models. In other words, residents in developing countries are more inclined to get basic transportation services from cars and are reluctant to spend money on increasing power, comfort, elegant style, protection from pollution and other such luxury options. In a sense, old-fashioned cars have basic practicality and luxury, and their proportions are more suitable for developing countries than in developed countries.

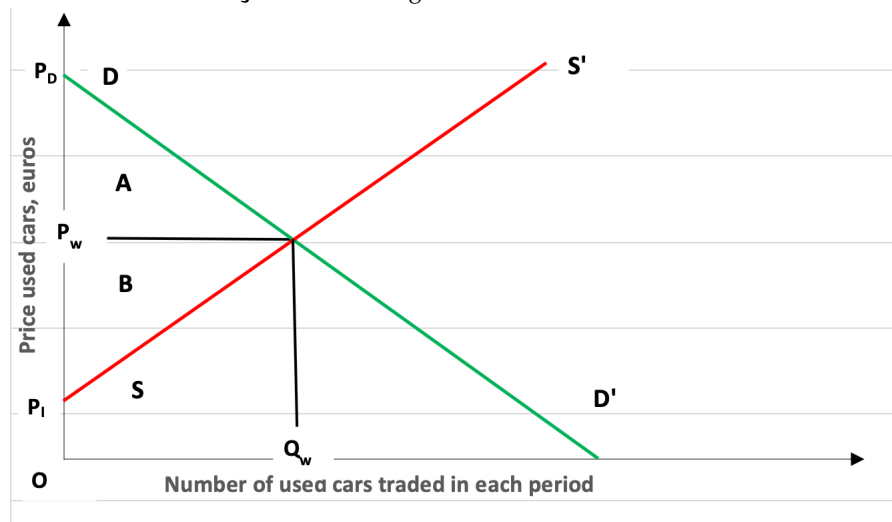
The third reason that the CD line is above the AB line in Figure 7 is due to the difference in the cost of suffering a car failure. Since the labor opportunity cost in developing countries and the average human capital value of drivers and occupants are often lower than in developed countries, the economic costs of negligence, waiting for repairs, and even death and injury are lower than in developed countries. Therefore in developing countries, compared with new cars, the possibility of failure and accidents of used cars increases, and the discount they bring to them is smaller than that of developed countries.

4.4 Model of Trade in Used Cars

4.4.1 Supply and Demand Analysis

Now go back to the condition originally assumed as the basis of Figure 7, namely that there is free trade in new cars and spare parts, while trade in second-hand cars is completely prohibited. Now let us consider what would happen if the used car trade was allowed and the transportation costs were negligible. Obviously, under the above assumptions, trade has led to the equalization of used car prices in developed and developing countries. After the initial inventory adjustment, only due to the replacement of worn-out vehicles and the increase in demand due to the increase in population and income, further trade was carried out.

Figure 8: Welfare gains from used car trade



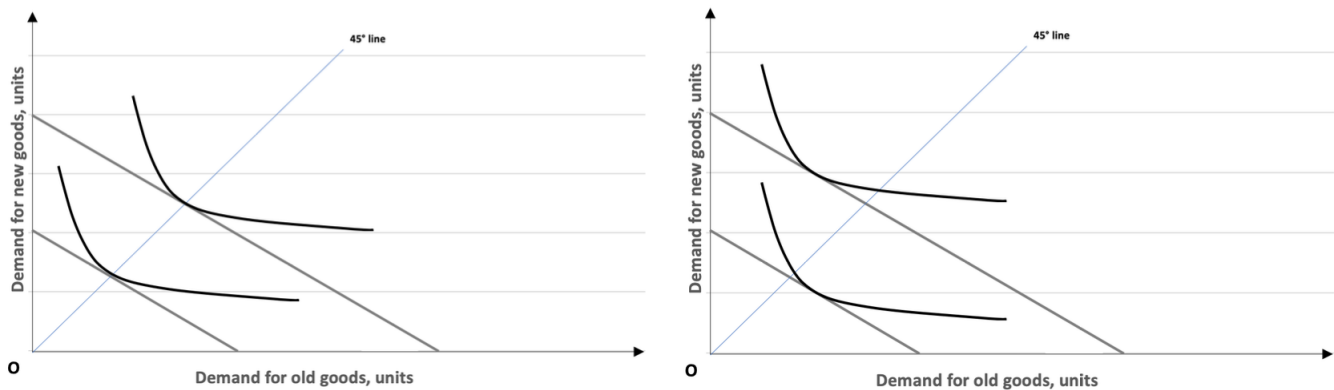
The impact of trade on used car prices and welfare is shown in Figure 8. The vertical axis describes the average price of used cars for all age groups, and the horizontal axis represents the volume of used car transactions in each time period. In the pre-transaction situation, the price in developing countries is P_D , which is higher than the price in developed countries P_1 due to the reasons given in the above analysis. The red line and the green line in Figure 8 correspond respectively to the supply curve for used cars in developed countries and the demand curve for used cars in developing countries. It can be seen that after the opening of trade, P_w is the equilibrium price, and the level of Q_w is the number of used cars traded in each period when the equilibrium is reached. Areas A and B in Figure 8 represent the welfare gains generated by free rather than not trade in used cars. Area A is equal to the consumer surplus enjoyed by buyers in developing countries, while area B is equal to the surplus enjoyed by sellers in developed countries. The Figure 8 presents an important point about the relative distribution of returns from the used car trade. This point is that the more elastic the supply curve is, the larger the area A relative to the area B is. In other words, if the demand for used cars in developing countries is small relative to the supply of used cars, then free trade will lead to an equilibrium price to be established that is very close to the prices in developed countries,

while developing countries enjoy the largest consumer surplus amount. In developing countries, the price of used cars will fall, while in developed countries, the price of used cars will rise. In developing countries, scrapping means that the age of cars will decline, while in developed countries, the age of scrapped cars will rise.

4.4.2 Non-Homothetic Preferences

Assuming that the preferences are non-homothetic, then the demand for high-quality products will increase in income. For constant prices, as income increases, the country consumes an increasing proportion of high-quality (new) goods. Figure 9 (right) shows that under relevant circumstances, the income expansion path is curved toward new products and away from old products.

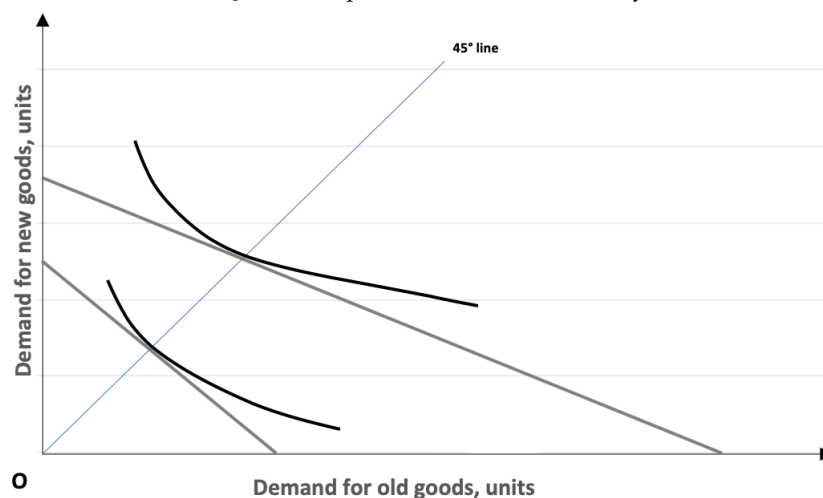
Figure 9: Homothetic (left) and Non-Homothetic (right) Preferences



The framework implicitly assumes a vertical model of quality. Durable goods are differentiated products described by vectors with different utility-bearing attributes. However, we assume that these attributes can be mapped into a single quality metric that is consistent across countries. This model provides an important starting point for describing trade patterns between rich and poor countries.

Consider the case where the life of durable goods is two periods. The goods are new in the first period and then old in the second period. If new goods are bought at a constant rate, the ratio of new and old goods will be fixed. In self-sufficient countries, second-hand goods are relatively cheap in high-income countries and relatively expensive in low-income countries. This can be seen graphically in Figure 10, where the fixed ratio of old and new commodities is represented by a 45-degree line.

Figure 10: Equilibrium Prices in Autarky



Due to non-homothetic preferences, a country consumes relatively more new goods as income increases. However, when the ratio of old and new commodities is fixed, relative prices must be changed to clear the market. In particular, as income increases, old products must become relatively cheap to maintain equal demand for both levels of quality.

When the market is opened for new commodity transactions, the prices of new commodities tend to be balanced, but the prices of old commodities continue to adjust to keep the two countries' demand for the two levels of quality equal. As durable goods age, their prices in high-income countries fall even faster. Also, when the second-hand goods trading market is opened, second-hand goods will be exported from high-income countries to low-income countries. Trade expanded until the price of second-hand goods reached the level shown in Figure 9 (right).

Both countries have benefited from trade. High-income countries have a high willingness to pay for quality and are therefore able to consume a large number of new products. As the quality of these goods declines, trade provides high-income countries with channels for selling their old goods. Low-income countries use a lot of old goods and buy old goods from high-income countries. The trade continues indefinitely since the goods of both countries are depreciating and need to be replaced.

4.4.3 *Environmental Externalities*

The used car trade has a significant impact on the environment. Trade provides rich countries with exports of low-quality durable goods. Since low-quality durable goods are usually high-emissions, they tend to reduce the average and total emissions of rich countries. In poor countries, trade increases the quantity of durable goods, but it may also improve inventory quality. Whether this change in composition is large enough to offset the scale effect depends on the characteristics of the initial inventory of durable goods and other factors. But we saw previously that the imported used cars must be recent, respect high environmental standards, be regularly and properly sustained to improve the inventory quality. All these conditions are often not respected. Also, due to the low scrap rate of vehicles in developing countries, these vehicles will continue to be used for many years.

The broad conclusion of the empirical and theoretical parts is that policymakers should carefully consider the impact of their policies on the trade in second-hand durable goods when conducting economic analysis of environmental policies. This is especially important for global pollutants such as CO₂ and NO_x, because increased emissions abroad can easily undermine domestic policies aimed at reducing emissions. As a result, when durable goods can be bought and sold, unilateral policies aimed at reducing greenhouse gas emissions may not yield total benefits.

5 FUTURE ENVIRONMENTAL ISSUES AND POLICIES

5.1 Actions to be done in the Short Run

5.1.1 *Harmonization Action on Age Caps*

When most importing countries are very weak in technically evaluating the driving and emission performance of each imported car, the most straightforward and feasible strategy is to use an upper age limit to eliminate vehicles that are polluting, unsafe and uneconomical. In many importing countries, it may not be possible to immediately ban used cars. However, the upper age limit will allow countries to eliminate the heavily polluting fleet. But exporting and importing countries will have to adopt proven standards to screen vehicles based on age, emissions and safety performance, accident history, damage and recalls. We saw, so far, that only four countries in Africa and three countries in South Asia have successfully completely banned the import of used cars. As many as 25 countries in Africa and most countries in South Asia have implemented age restrictions. But there are big differences in age limits, ranging from 3 to 15 years old. It needs to be unified to less than three to five years. The upper age limit varies, resulting in boundary leaks and the scope of re-exports.

Besides, a fiscal strategy that imposes higher tariffs on used cars must be designed to effectively reduce the import of used cars and polluting vehicles.

Countries will have to adjust their strategies. Coordinated action will help create bottom-up pressure in the international market and plug leaks.

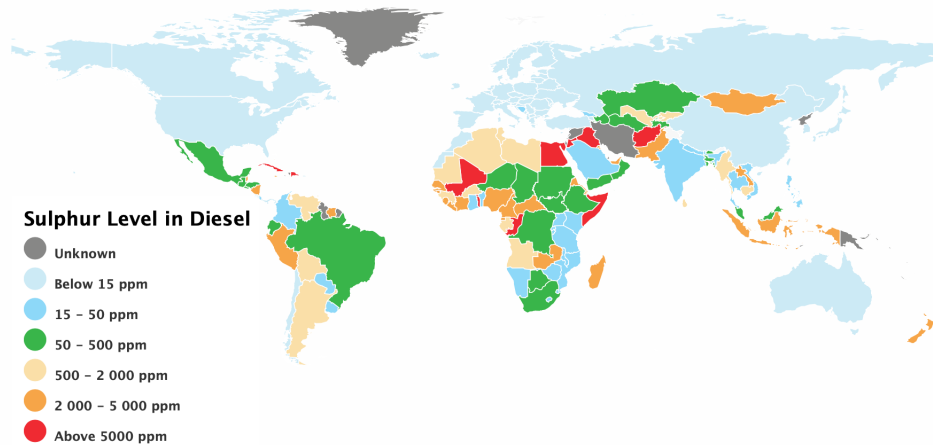
5.1.2 *Emission Standards and Fuel Quality Improvement*

There is a growing consensus among regulators and multilateral agencies such as the UNEP that for global vehicle trade, a level equivalent to Euro 4 should be the minimum uniform standard for import and export. By default, this will remove all vehicles older than Euro 4 from the export stream. This will also help stabilize prices for acceptable fleets in the international market, and will not weaken the regulatory actions of importing countries that are trying to establish age caps and minimum emission standards. Global exporters will have to comply with the age limit and emission standard requirements of international trade and must establish a unified approach multilaterally. If fuel quality and emission standards are not improved, importing countries will not be able to obtain cleaner, younger,

and more fuel-efficient vehicles from age restrictions. Currently, since most importing countries cannot obtain the required fuel, newer imported vehicles are deprived of improved and advanced emission control systems.

Figure 11: Sulphur Level in Diesel globally in 2019, source UN Environment Programme

Sulphur Level in Diesel Globally



11 countries in Africa have adopted clean fuels (low sulfur 50 ppm). These countries include Morocco, Mauritius, Kenya, Uganda, Tanzania, Rwanda, Burundi, Ghana, Mozambique, Malawi, and Zimbabwe. Morocco is the first country in Africa to use ultra-low sulfur (10 ppm) fuel, and Mauritius and East African countries have similar plans. Still, others are preparing for the transition. The fuel quality in Asia, Latin America, and the Caribbean is not uniform. Ensuring uniform fuel quality must be again a priority.

5.1.3 Vehicle Registration and Inspection

Import regulations will require a vehicle registration agreement and check the authentic documents about vehicle emissions and safety conditions to be obtained from dealers and sellers. It needs to record the date of manufacture, original emission standards, an export certification system, chassis details, fuel type, official emission status and safety inspections at the time of export and other relevant details according to a clear agreement.

Exporting countries must also maintain transparent and publicly available databases on vehicle emissions, safety, and inspection status. The entire dealer chain must be responsible and accountable in compliance with the agreement. Importing countries may be increasingly interested in linking imports to vehicle emissions and fuel economy. Countries need a clear supervision and surveillance system and dealer responsibility system. These systems should be further developed and replicated. Exporting countries have a role to play in meeting these challenges and creating transparent information for the supply chain.

At present, exporting countries have almost no incentive to adopt fool-proof, robust systems to intercept all scrapped vehicles, vehicles with impaired safety and emission performance, or vehicles affected by accidents to prevent them from entering the international market. Before exporting any vehicle, strict export rules need to be verified, inspected, certified, and coded in a transparent manner. It must be ensured that the vehicle and chassis identification numbers have not been tampered with. All scrapped vehicles, damaged vehicles, and vehicles with impaired emissions and safety functions must be prohibited from exporting.

There must be an online database for the importing country, the exporting country, distributors, and consumers. It is important to establish through multilateral procedures the basic documents that all exporters and importers must display during export, entry and registration. Anecdotal reports indicate that during the entire transshipment process, a large number of vehicles have been deprived of transit areas in the Middle East and elsewhere to eliminate advanced emission control systems that are not suitable for importing countries, which do not have appropriate emission control systems. There are also no clear regulations on how to monitor the supply chain.

5.2 Quota Implementation

The world in 2050 estimated by the United Nations: 9.8 billion people, 2 billion cars, and crowded megacities. Even with some form of electrification, two-thirds of the passenger cars will still be equipped with internal combustion engines. The population of developed regions is expected to remain unchanged, at 1.3 billion for the rest of the 21st century. All population growth is expected to come from less developed countries.

5.2.1 Literature

In such a context of interconnected markets, it seems legitimate to wonder about the voluntary activation of a Malthusian lever: The implementation of quotas on carbon and motorized transport means. This provision would guarantee a real progressive substitution of the polluting and energy-consuming fleet by more sober vehicles able to ensure overall sobriety in the medium run.

The literature is quite large for Personal Carbon Trading (PCT).

Current recommendations for PCT include:

- Tradable Energy Quotas (TEQs): Designed by environmental writer David Fleming, he published a paper on the subject in 1997. The Tyndall Centre for Climate Change Research in the UK has been studying the project since 2003. Recently, the Royal Society for Encouraging the Arts, Manufacturing, and Business (RSA) conducted research through its CarbonLimited project. The system has been the subject of a feasibility study funded by the British government in 2008, a report by a party parliamentary group in 2011, and a debate in the European Commission in 2018.
- Personal Carbon Allowance (PCA): Explained in the book "How We Save the Planet" written by Tina Fawcett and Mayer Hillman. The Institute of Environmental Change in Oxford, UK is working on PCA. The title "PCA" or "PCA Scheme" is often used to refer to any proposed form of personal carbon trading.
- End-User Emissions Trading: Preliminary proposal made by Suryapratim Roy and Edwin Woerdman in an article that analyzes the legal and policy nuances of individual emissions trading schemes, such as across the EU.

All these models above work quite similarly. Individuals under a Personal Carbon Trading system are most likely to keep their emission credits in an electronic card. They will then discard them when making carbon-related purchases (electricity, gasoline, heating fuel, oil). PCA may also require individuals to use points for public transportation. Tradable energy quotas will include all other sectors of society (for example, industry, government) into the scope of a single plan.

People who exceed their carbon credits (that is, those who want to use more emission credits than the allocated emissions) will be able to purchase more credits from other individuals who use fewer credits.

Proponents of individual carbon trading claim that this is a fair way to address climate change and peak oil. This system of quotas would ensure that the national economy lives within its agreed carbon budget. It would provide fair access to fuel and energy. They also believe that this will increase the "carbon literacy" of the public and encourage more localized economies.

Personal Carbon Trading has been criticized for its complexity and important implementation cost. So far, there are few reliable data on these issues. There are also concerns that personal "quota" and trading of quotas are politically unacceptable.

Researches in this field show that personal carbon trading will be a progressive policy tool to distribute money from the rich to the poor knowing that the rich consume more energy than the poor and therefore need to buy allowances from the poor. This is the opposite of a direct carbon tax, under which all low-income earners will be worse off before their income is redistributed.

But what is the link between the car market and carbon quotas? There is a strong relationship between the two: Under such a system, gasoline, petrol, LPG and, oil prices will considerably increase and could include the real environmental cost of car usage which today is much too neglected.

However, there are few studies on VQPs (Vehicle Quota Policies). VQP can largely draw inspiration from Personal Carbon Trading (PCT).

Economists generally believe that social welfare can be maximized by imposing marginal cost pricing. This approach may not always be feasible due to a lack of knowledge of marginal costs or the high cost of policy implementation. This phenomenon is easy to observe in China when the city government deals with traffic congestion. Road pricing in urban areas is rarely used. On the contrary, policies have been established to restrict vehicle ownership or vehicle utilization through a quota system. Although the policy may be at the extreme of various policy options, it is

already based on academic research. For instance, Daganzo (1995) stated mathematically that the best strategy for handling traffic congestion is a combination of road pricing and quota strategies.

5.2.2 *Reducing Car Usage and Ownership*

In emerging economies, vehicle demand management (policies and strategies aimed at limiting vehicle ownership and usage) focuses on restricting vehicle use and, to a lesser extent, strives to decrease vehicle ownership.

Let's look at some examples of cities in developing countries.

Car travel restrictions are receiving increasing attention in Latin America and China, but they initially set a precedent in Athens, Greece, which adopted the first-ever car restrictions in 1982. Mexico City further promoted the existing travel restrictions in 1989, and soon there were nine other cities in Latin America. The Mexico City model restricts travel within a designated geographic area (usually the central area of the city) to one or two days in a week based on the last digit of the vehicle license plate number. This strategy can manage traffic congestion and air pollution of motor vehicles.

Recently some Chinese cities like Beijing (2009), Nanchang (2010), Changchun (2010), Lanzhou (2010), Guiyang (2011), Hangzhou (2011), and Chengdu (2011) have deployed car use restriction policies to limit car congestion and air pollution.

The Vehicle Quota System (VQS), besides, limits the number of new vehicle registrations to control the growth of vehicle ownership at a "sustainable" rate through auctions or lotteries. This policy was first implemented in 1990 in Singapore in the form of a quota auction. This Singaporean system is named COE meaning "Certificate of Entitlement". Since then, Shanghai (1994), Beijing (2011), Guiyang (2011), and Guangzhou (2012) have adopted a vehicle quota system to limit the rapid growth of private vehicle ownership. Currently, the implementation of the vehicle quota system is limited to China and Singapore. Could we develop and export this model worldwide? In particular in developing countries where the motorization rate is uncontrolled and distorted by the used car market.

5.2.3 *Towards an Universal Quota System?*

The Universal Quota System, is this a completely Utopian proposition? Perhaps not, beyond the varied experiences of limiting the number of registrations in Singapore and several large Chinese cities, this has already been achieved on the scale of nations in another field: the land-use planning. Like the creation of the concept of land ownership and its management, which is opposed to the free installation of the inhabitants on unoccupied natural territories, the concept of "Certificate of Entitlement" could be established at the international scale and be defined as the "right to own a certain type of motorized vehicle". We will hence propose a new global model inspired by the "Certificate of Entitlement" in Singapore.

As the establishment of the land register or cadastre for land ownership, motorized transport means could be subject to a "numerus clausus" in every country. The hegemony of the individual car would then be managed on a national scale. While requiring attention to the social and international management of such a constraint, this measure would bring a revolution in the mindset of motorists, automobile manufacturers, and the states.

Before using a vehicle, the Land Transport Authority or the Transport Minister of each country would require potential vehicle owners to first hold a "Certificate of Entitlement". The number of available COEs would be controlled by a quota system called the Vehicle Quota System (VQS) and would be announced by the Land Transport Authority or the Transport Minister each year and reviewed during the year to make possible adjustments.

The number of COEs, provided each year to the public, would be regulated by the Vehicle Quota System (VQS), and would be calculated based on the following conditions:

- The actual number of vehicles on the road.
- The allowable increase in the number of vehicles, considering the evolution of traffic congestion, air quality, and carbon emissions.

What about the validity of the COE? For instance in Singapore, COE holders are allowed to own their vehicle for 10 years. After that, they must recycle, scrap, or export their vehicle or bid for another COE at the new current exchange rate if they want to keep their vehicle. Remember that COE in Singapore can be obtained only through an auction process dividing into categories: the more powerful and polluting a vehicle is, the less COEs in that category there are. And so, the more expensive the COE in that category is. The paper "Assessing Motor Vehicle Quota Policies in China" written by Lin et al. suggests the implementation of a mix of auction and lottery processes. Auctions have indeed the highest ability to match precious resources with individuals who cherish these resources the most, and lotteries meet society's expectations of fairness.

The motor vehicle sector would thus include a series of tiered vehicle categories, from small vehicles that are very economical to large vehicles that consume more energy. In order to avoid certain forms of crowding effects with other types of motorized transport, no transport means consuming fuel or electricity would be spared. Each country would be allocated quotas for each category of transportation. The number of quotas would change annually, in order to allow developing countries to slowly grow their motorized fleets in a measured and consensual way to ensure their growth. In return, the developed countries would gradually see their quotas stagnate or fall.

The possession of such a right would not be compulsory to use a vehicle: The vehicle rental companies with rights could be very widespread, as today with the rental of accommodations.

The valuation of such rights, like land ownership, would reshape the full cost of vehicles, and current economic models. The inevitable increase in price to motorized mobility, due to the additional costs of the "Certificate of Entitlement" and its annual tax, paid directly by the driver or included in rental prices, would encourage the pooling of resources and the optimization of filling rate. The use of bicycles or other weakly motorized "soft" modes would become more obvious. This would allow leverage for the relocation of activities and the reduction of futile trips, in favor of much shorter circuits. It is important to specify that the revenues generated by the "Certificate of Entitlement" and the annual road taxes would have to be invested in the national ecological transition and the improvement of public and less polluting transport means.

It should be noted that some social biases would appear. This model of quotas could easily constitute a new source of segregation and speculation. And a potentially new form of precariousness would emerge. These would be people whose mobility would be limited to walking, cycling, and public transport and who would be isolated by an inappropriate location. Financial and social measures will have to be implemented to limit these risks.

The global cap on these different fleets would transform the car manufacturers' business model into renewal and reuse markets. Auto manufacturers would be more focused on defending their "renewal market shares", abandoning their general focus on a perpetual increase in their sales volumes. They would then become key players in the "real sustainable development" transforming them from the effective status of climate change contributors to true ambassadors of emission reductions. They would allow a real and general substitution of the existing fleet by more economical and cleaner transport means.

6 CONCLUSION

In the developed world, driving new vehicles and creating strict environmental standards sound to be the best sustainable solution. Is it the case? We have seen that the market is full of paradoxes and is above all animated by individualism and profit mechanisms. Lots of new cars are still far from the definition of an efficient car. Most of them have a combustion engine and are too big, too powerful, and polluting. Recent emissions norms are bypassed by car manufacturers. We have also explained that if a car is not regularly and properly sustained (in particular the catalytic converter) it will emit disproportionate amounts of pollutants.

The developing countries are following the developed model with a wealth lag. The old and polluting cars' capital from the developed side has been sold to emerging regions since they need to fulfill their mobility need (welfare gains). This trade is accentuated by environmental regulations that are way too heterogeneous in these parts of the world. There is, however, a huge difference between the two areas: The demography. The world population is expected to reach 9.7 billion in 2050 and all the population growth will come from less developed countries.

The result is that pollution, traffic congestion, and all its consequences are continuously expanding. The model must change if we want a more viable world. The transition should be made by multilateral cooperation on environmental standards, more transparency and data on emissions, and a serious improvement of collective public transport and individual shared transport solutions. It is important to increase the car usage price by its environmental cost by implementing road pricing and quota policies. The changes in mind and behavior are needed to break with car monopoly and oil dependency.

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