# POLITECNICO DI TORINO

Master's degree in Engineering and Management

**Department of Management Engineering and Production**

## Master's degree thesis

**FDI flows in the automotive sector: an econometric analysis of the location choices of Toyota and Volkswagen**

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# 1  Abstract

The purpose of this paper is to analyse the innovation process that is taking place within the automotive industry, trying to understand what role car manufacturers are playing and by what means they are facing the problem.

The main objective is to investigate the automotive market at all, and specifically the behaviour of the main actors Toyota and Volkswagen and by what determinants they are influenced through their strategical decisions for investments abroad.

The annual reports of Volkswagen and Toyota were analysed in order to identify the market and business strategies, the strengths of the car manufacturers, their level of internationalisation, the supply chain, and the level of verticalization of the company; in addition, special attention was paid to M&A, and new plant constructions.

With the help of the statistical software Stata [1] and the collection of a huge database of data from European and global institutions, it was possible to merge the data of the individual car manufacturers with the data on investments and the qualitative data on the destination of the investments. In this way, it was possible to see how strongly each investment was linked to location variables, to associate variables to individual strategies of the car manufacturers and to analyse how location determinants interact with firm-specific strategies.

The aim of this work was also to connect the destinations of investments to the market strategies of the car manufacturers, supporting the thesis that certain market strategies are strongly related to the performance of the destinations of investments, and also to the history of a country and the elements that have fortified its economy over time.

## 2   Introduction

In order to understand the technological changes that are taking place in the automotive industry and to understand the drivers that are moving the car manufacturers, it is helpful to dig into the meaning of the word innovation.

According to Scherer (1967), innovation is the machine by which the industry evolves; competition is the engine of the machine.

Dutton and Thomas [2] argue that innovation can be incremental or radical: incremental if innovative product performance is introduced slowly, radical if there is a drastic change and replacement of the old product with the new one.

Anderson and Tushman [3], on the other hand, categorised innovation as competence enhancing and competence destroying depending on whether it takes place in support of or in opposition to existing technology. Finally, Christensen [4] argues that an innovation is sustainable if it does not lead to changes in market equilibrium, and disruptive if it upsets supply and demand curves.

However it is defined, the innovation process is certainly something that goes hand in hand with research, which is the reason why the largest multinationals invest billions, annually, in R&D; but what are the drivers for R&D?

Recently, some studies have tried to answer this question through the use of regression analysis with pooled regression models, panel models with fixed effects (FE), and random effects (RE): the results have shown a relationship between the firm investing and some data in its statement of operation such as net sales, net income, and total assets [5]

The automotive sector is facing a fundamental shift in powertrain technologies due to restrictions from international institutions. For example, the EU has committed to a 20% reduction in $CO_2$ emission levels by 2020 compared to 1990 levels: by 2025, manufacturers must reduce emissions by 15% for both cars and vans, compared to 2021 levels. By 2030, they will have to achieve a reduction of 37.5% for cars and 31% for vans. The regulation

also includes a mechanism to encourage the uptake of zero- and low-emission vehicles in a technology-neutral way [6].

These restrictions have triggered experimentation with alternative powertrains that are not based on internal combustion: these are hybrid engines, full battery electrics, hydrogen, fuel cells, and other types.

Certainly the dominant design is the ICE engine (Internal Combustion Engine), which is still undergoing constant research and modifications to increase its efficiency in terms of fuel consumption and performance: in 2019 the Skyactiv-X engine by Mazda came onto the market; it is a petrol engine whose combustion takes place through compression of the air-fuel mixture controlled by a spark plug; it practically combines the operating principles of the Otto cycle engine and the diesel cycle engine; the results of this engine are 20% lower fuel consumption and torque increased by 10% to 30% [7]. Of course, alternative powertrains are also developing, and as in all innovative processes, the road to the finish line is very winding and full of pitfalls.

## 2.1  Literature Review

The purpose of the literature review was to identify the background where the analysis is born, which is a background that does not include the recent shocks in supply and demand due to any phenomenon that occurred in 2020 as the main objective is to approach things in a general  perspective (for this reason 2020 data have not longer been considered).

The first to make a theory on location choices was Johann Heinrich von Thünen, in 1826, in the model *The Isolated State* where he showed that the profit of agricultural production is achieved in concentric zones, with zones devoted to one product and zones preferred for another one. Thünen argued that farmers surrounding the market will produce products that have the highest market value because transport costs are lower. Alfred Weber in 1909 endorsed this theory in his book *Theory of the Location of Industries*, 1929, where he optimised a utility function derived from the profit of a product that is at the apex of a triangle when the two raw materials are at two different vertices away from the final product; the profit function is maximised when the raw materials are as close as possible

to the final product.  A further contribution was made by William Alonso [8] who suggested a model according to which the profit function of a land (land use type) depends strongly on its location, and therefore a land can be exploited or not according to the place where it is located.

## 2.2   FDI

The presence of FDI occurs when there is a minimum threshold of participation of the foreign investor in the share capital of the company. According to the Bank of Italy, FDI are considered a vehicle for the international transfer of technological, organisational, and managerial knowledge.

 An important element to identify the presence of a FDI is the ownership by the foreign investor of at least 10% of the ordinary shares of the investee company. According to this definition of FDI, subsidiary companies, i.e., those companies in which the foreign investor holds more than 50% of the share capital, associated companies, i.e., those companies in which the foreign investor holds between 10% and 50% of the share capital, or so-called branches, which are establishments, offices, or joint ventures between a foreign investor and third parties, can be FDI companies.

Another manifestation of FDI are greenfield investments, i.e., those where capital is contributed from abroad ex novo, creating new production units in the receiving country [9].

Actually, the theories describing the decision factors within a foreign investment are different: the industry and product life cycle theory, which is based on the product life cycle model of Abernathy and Utterback (1978); the imperfect market theories elaborated by Stephen Hymer and Charles Kindleberger; the internationalisation theory, developed in its first version in 1976 by P. J. Buckley and M. Casson and further developed by Caves and Teece, in 1971 and 1986 respectively; the eclectic paradigm [10], which emphasises the role of localisation factors and the role of attractiveness factors as driving factors with respect to the country of origin and the expansion of firms beyond their national borders. [11]

For all FDI, the size of the receiving market is of crucial importance as it is the main factor in attracting investment. The choice to delocalise and produce locally instead of exporting the finished products could depend on transport costs and related factors such as taxes and bureaucratic restrictions, e.g., Italy could pay for its ranking in the EQI index measuring the quality of services in advertising, ahead only of Bulgaria and Romania. In particular, transport costs could be influenced by infrastructure endowment and incentives towards the improvement of public facilities. Other elements that could influence the presence of foreign investment in a country is the presence of a high level of services, research, and innovation, or the cost of production factors such as raw materials and machinery [11].

More generally, the factors influencing foreign direct investment can be real and material, national and region-specific [12]; region-specific factors define the potential market which is often one of the most important drivers for the choice of location, as is the case in Italy [13].

The process of economic globalisation is the expression of the international fragmentation of the production value chain and the presence of FDI is strongly linked to the international transfer of technological and organisational knowledge which therefore represents a spillover for the countries that attract them.

Basically, an investment decision is concerned with two macro-objectives: gaining market share and benefiting from a territory's expertise. However, it is not excluded that both may occur simultaneously [14].

## 2.3   Analysis of FDI flows in the automotive

Thanks to the database provided, it was possible to analyse FDI flows over a given period, for the most explanatory states.

Figure 2.1.1 shows which were the most preferred destinations for FDI in the automotive sector and how preferences have changed over time.
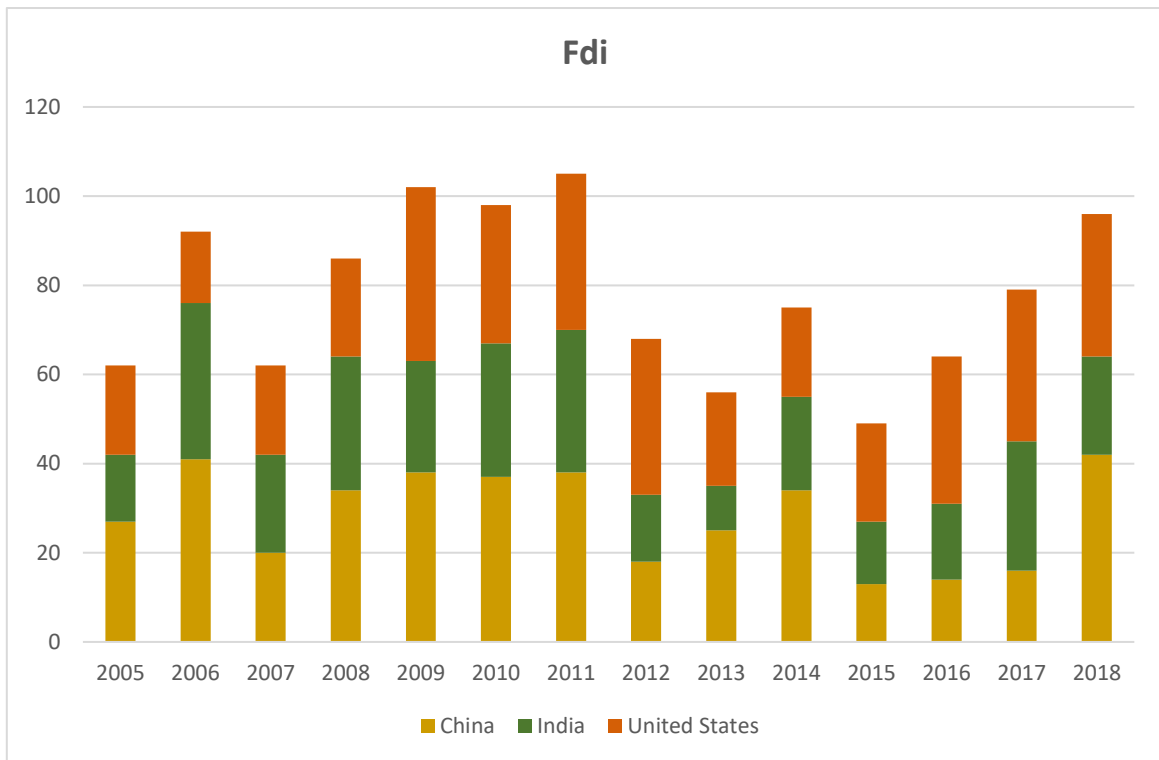
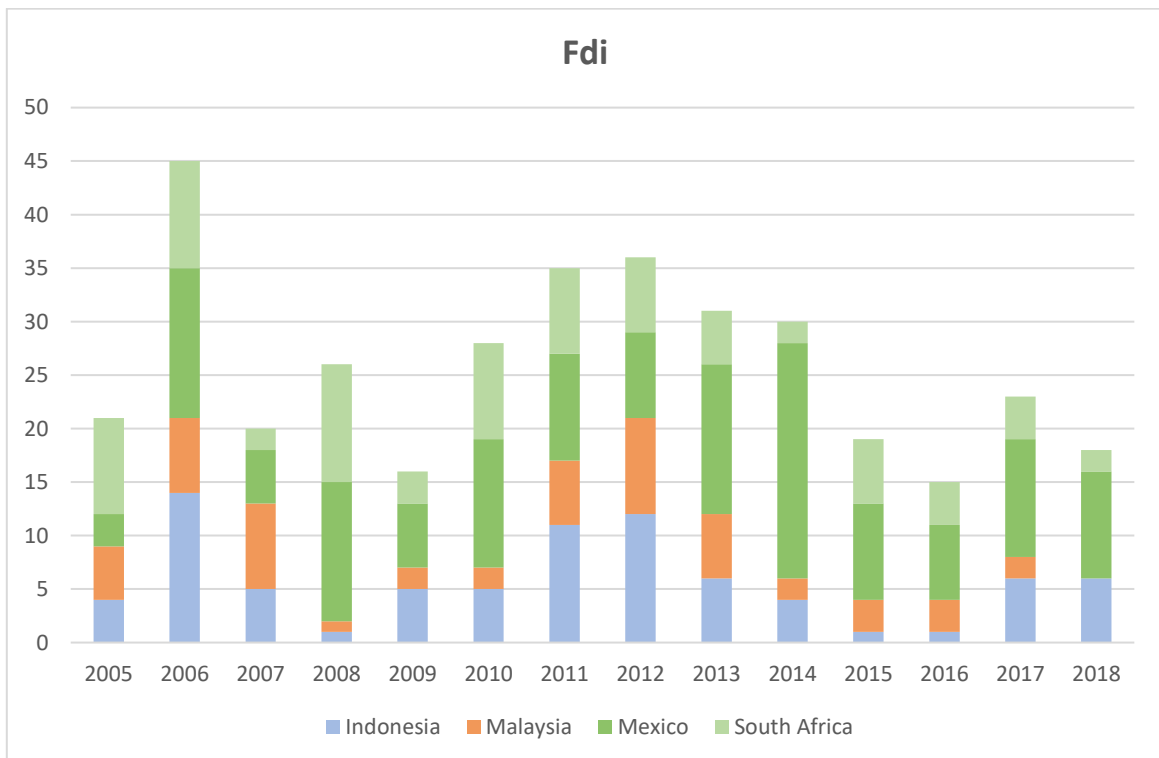Figure 2.1.1, source: FDI database



Figure 2.1.2, source: FDI database

Figure 2.1.2 shows how investments have been distributed in some destinations among developing countries with Mexico standing out the most.

In the figure 2.1.3 Italy is compared to other European powers, at a clear disadvantage. While Spain and Germany receive the most foreign direct investment Italy is the European power that receives the least FDI, even though its history in the automotive industry is one of the most remarkable.
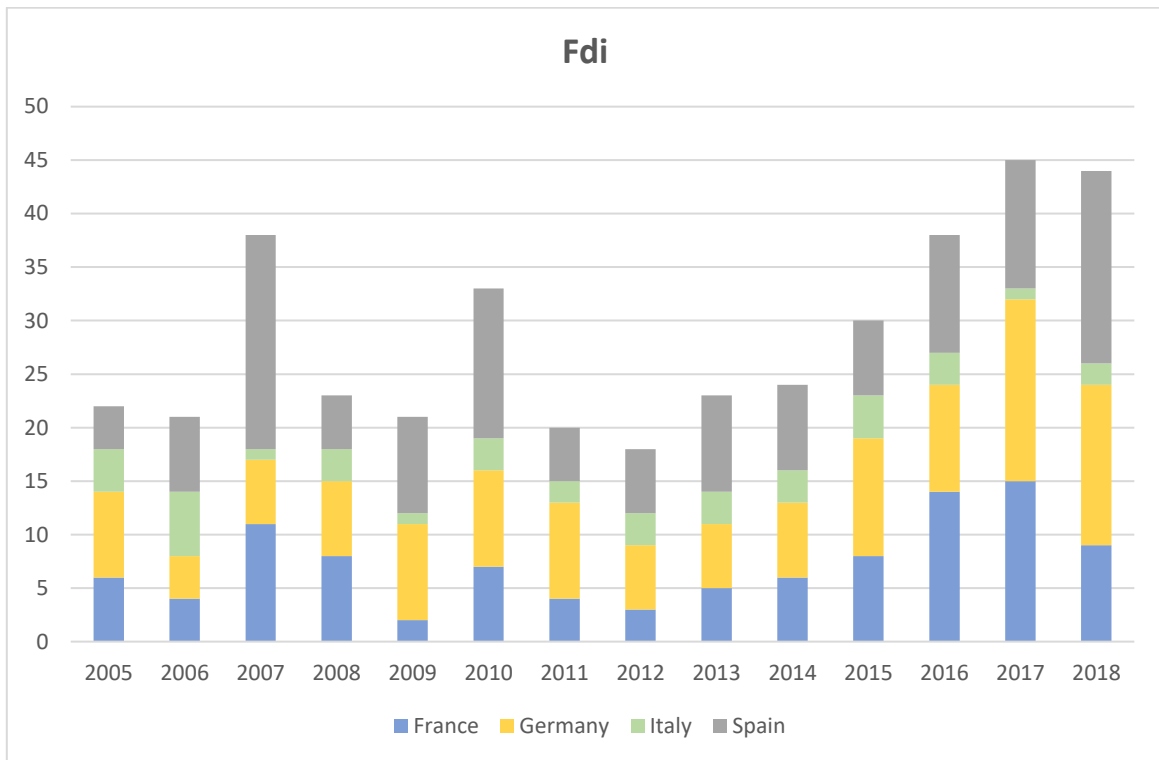


Figure 2.1.3, source: FDI database

Staying with the Italian situation, it was interesting to analyse how the car manufacturer FCA distributed its investments abroad; the figure 2.1.4 shows the destinations where substantial investments were made: in recent years, FCA preferred the USA rather than Asian countries or Italy.

FCA's foreign investment policies and mergers with other carmakers have led it in recent years to increase market share in the countries where it has invested and boost sales. [15]
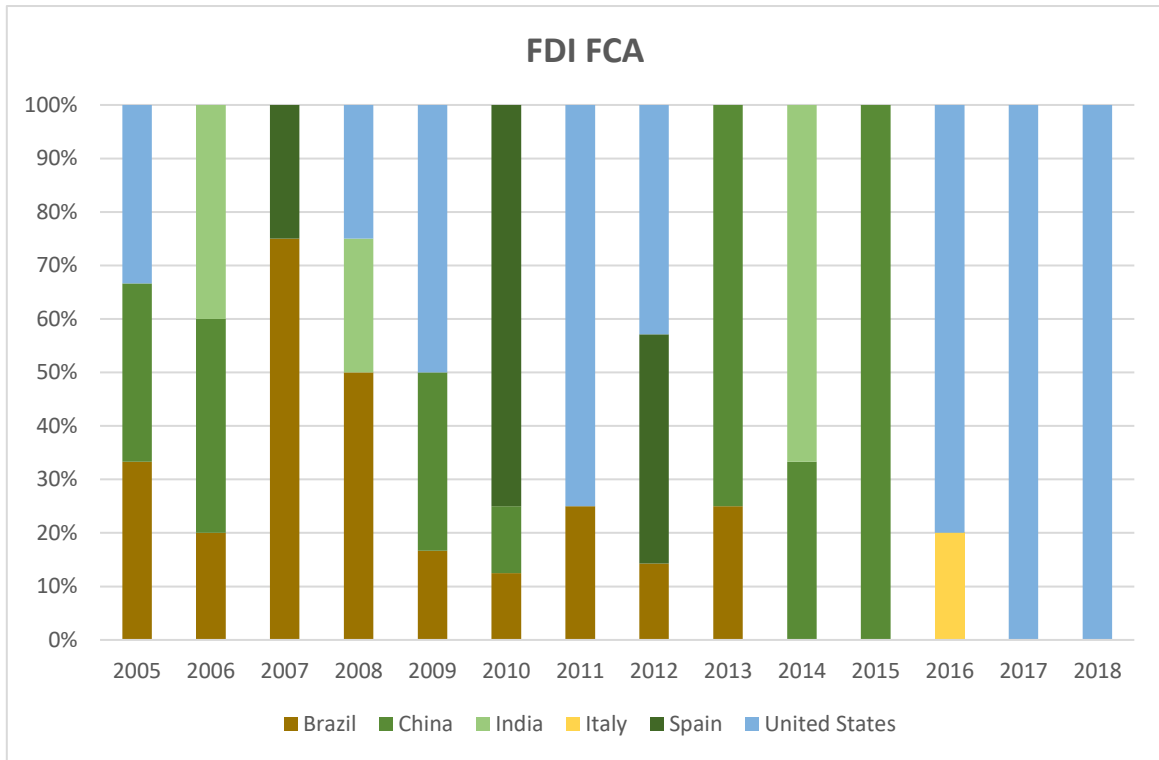
Figure 2.1.4, source: FDI database

Although Italy has not collected much FDI in recent decades, the slice of the Italian market and the quality of suppliers has attracted a number of manufacturers, mainly Daimler AG, Volkswagen, and GM: the former has invested in the Car2Go company, which became SHARENOW later: SHARE NOW is one of the five services offered by the mobility joint venture formed by BMW Group and Daimler AG, officially presented in Berlin on 22 February 2019 [16]; Volkswagen and GM have invested in mechanical components, the former for the Lamborghini brand, the latter in the Powertrain centre linked to the Turin Polytechnic (Punch Group, today).

Table 2.1.2, source: FDI database

| ParentCompany | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AVL Group | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Actia Group | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Alcoa | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Anhui Jianghuai Automobile (JAC) | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Avis Budget Group (Cendant) | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Bayerische Motoren Werke (BMW) | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Beijing Automotive Industry Holding | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| Bertrandt | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Brose | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| China South Industries Group (CSG) | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| Chongqing Lifan Industry | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Ciclad | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Daimler AG | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 5 |
| Dana Holding Corporation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| Denso | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Diesel Technic | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Eaton | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Europa Rent a Car (Goldcar) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 5 |
| FCA US (Chrysler Group) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Fiat Chrysler Automobiles (Fiat) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| Fuji Heavy Industries (FHI) | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| GKN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 |
| General Motors (GM) | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Grammer Industries | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Hyundai Motor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| IHI Corporation | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| ITT Corporation | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| JC Auto | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Karsan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Key Safety Systems | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Mahindra Group | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| Mitsuba | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Mubea | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Nanjing Automobile Group | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Nissan | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Paragon | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Porsche SE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Renault | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Robert Bosch | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Rochling Group (Roechling Group) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Seakeeper | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Start Technologies Europe | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Tesla Motors | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Volkswagen | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 7 |
| Wartsila (Waertsilae)(Wartsila) | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Zhejiang Hozon New Energy Automobile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Total | 6 | 11 | 8 | 6 | 2 | 5 | 4 | 4 | 3 | 5 | 5 | 4 | 6 | 5 | 74 |

It was also interesting to see which car manufacturers invest in Italy and for what reasons. Needless to say, the south is only represented by a small percentage and some regions are even excluded from the list, such as Calabria and Sicily.

Table 2.1.2, source: FDI database

| DestinationState | Freq. | Percent | Cum. |
|---|---|---|---|
| Abruzzo | 1 | 1.35 | 1.35 |
| Basilicata | 2 | 2.70 | 4.05 |
| Campania | 1 | 1.35 | 5.41 |
| Emilia-Romagna | 9 | 12.16 | 17.57 |
| Friuli-Venezia Giulia | 1 | 1.35 | 18.92 |
| Lazio | 6 | 8.11 | 27.03 |
| Liguria | 1 | 1.35 | 28.38 |
| Lombardia | 8 | 10.81 | 39.19 |
| Marche | 1 | 1.35 | 40.54 |
| Not Specified | 11 | 14.86 | 55.41 |
| Piemonte | 19 | 25.68 | 81.08 |
| Puglia | 1 | 1.35 | 82.43 |
| Toscana | 4 | 5.41 | 87.84 |
| Trentino-Alto Adige | 6 | 8.11 | 95.95 |
| Veneto | 3 | 4.05 | 100.00 |
| Total | 74 | 100.00 | |

## 2.4 Trends

Trends in the automotive industry have followed one another [17]: in the first half of 20th century the verticalization of the operations was a consequence of the end-to-end mass production of the first automobiles; from 00s to 10s the tendency was to horizontalize operations thanks to the worldwide phenomenon of globalisation; today the trend seems to be, again, to integrate operations, especially the more specialised ones, in order to increase quality; first amongst all Tesla, which in 2013 decided to set up a Gigafactory to produce its batteries. There are different approaches to enter the market: greenfield investments is one of this. Others are licensing (e.g., from 1997 to 2005 most of the Porsche Cayman and Boxter were produced by the Finnish company Velmet or some Fiat diesel engines which were produced by Suzuki), franchising, business alliances (e.g., TPCA between Toyota and PSA which produced the Citroen C1, Toyota Aygo and Peugeot 107 in 2005), joint ventures, outsourcing, cross-ownership (Renault and Nissan), mergers and

acquisitions (e.g., VW acquired SEAT in 1968 and Skoda in 1991 [18]). Some mergers do not go well, such as the one attempted between Mercedes and Chrysler in 2007; some acquisitions may also fail, such as that of BMW against Rover in 1994. Other ways of establishing a company in a foreign market are subsidiaries [18] .

Automotive sector is in constant transformation firstly because digitalisation and electrification but also what the car represents is changing in customers' mindset: car it is no longer seen as a necessity in cities, for example, where means of transport are efficient and technological innovation has enabled the spread of phenomena relating to sharing and sustainability. This obviously worries manufacturers, who are trying to approach the market with innovative strategies, not always succeeding and often running the risk of being laggard in the market. As supported by McKinsey report [17], the total number of employs in the automotive industry is very large: 8 million in Europe, more than 12 million in  the US and more than 5 million in Japan. For instance, a very large part of the literature analysed talks about the relationship between car manufacturers and suppliers as this part of the B2B industry represents one of the key nodes in the value chain, as Porter states [19]. Analysing the largest (by sales) OEMs comprising 80 per cent of global sales is a way to understand what the evolutions in the market could be, the challenges and opportunities, the benefits that OEMs can reap from innovations in this field, and what are the segment implications in the market. The key components of future growth are *complexity*, *cost structure* (as there will be more sharing platforms and more modular systems), *diverging markets* considering Brazil, Russia, India, and China as the markets with the most substantial growth, *digital demands* due to the increasing demand for connectivity by users, *shifting industry landscape* due to the change in powertrain preferences. Another important problem is hot to overcome the costs of $CO_2$ restrictions, since *sustainability* is another key factor to understand the current trend in the market [17].

Another important factor is how much an asset is specific, which is asset specificity. The proportional relationship between performance and specialisation of the supplier, in particular between human specialization and product life cycle and low inventory cost. In

such terms, Jeffrey H. Dyer's study show the benefits of proximity between plants and the high level of human specialization towards module production [20]. The Resource Based View approach suggests that strategic decision-making consists in understanding which resources become core competences, which are set of skills that distinguish a firm in the marketplace fundamental for its competitiveness [21]. Having many capabilities helps the firm as well as having specific assets. Therefore, the value chain is increasingly characterised by interfirm specialisation fed by transaction specific investments to communicate with other firms; the aim is to obtain quasi rents and competitive advantage and to counter-opportunism. The specificity of the assets concerns site, physical and human resources. Site assets specificity means proximity, physical assets specificity means where to direct investments, human refers to know-how.

In relation to quality, Jeffrey H. Dyer has demonstrated that it increases in relation to a low number of suppliers, with increasing feedback and reliability of data, collaboration between customer and supplier and with human interfirm specialization. The Japanese industry achieves higher integrity because suppliers are more willing to make custom parts [22], but this means investments in customized tools e.g., dies, jigs, etc... . Clearly, the trend of clustering activities changed with globalization, being decentralization of both production and R&D source of competitiveness and market capitalization. It was anticipated by Malmberg and Maskell [23] and later by Bathelt [24] that global information exchange can take place efficiently through pipelines even over long distances. Indeed, one of the main obstacles to decentralization is tacit knowledge that only partially is solved by clustering [25].

The automotive industry is not identifiable to operate neither globally nor locally as each company might decide to compete in a niche or providing standardization [26]. From the production point of view, the tendency is to integrate locally for technical and political reasons, but at the same time suppliers must have a global presence in order to work with economies of scale. In general, there is a concentration of investment in regions with low operating costs which currently are the U.S. South and Mexico in North America, Spain and Eastern Europe in Europe and South East Asia and China in Asia. A worldwide example of

adherence to outsourcing theories is that of GM and Ford who in 1990 created respectively Delphi and Visteon, which became leading automotive suppliers; conversely Nissan and Renault in 1998 consolidated their relationships with suppliers. The big manufacturers that started to produce in one location demanded that suppliers either move with them or have an established sales network in that location. In this way, the profits of a few suppliers increased at the expense of the locals. In addition, many American suppliers went bankrupt in the 21st century because there were too many of them and because they used to design their own parts and pass the costs on to the car manufacturer; Japanese manufacturers, on the other hand, co-designed with suppliers and created long-lasting trust-based relationships [27].

## 2.5 Determinants

Location choices might depend on many factors. Influencing these choices are certainly microeconomic factors such as demand (described by the needs-problems scenario of a population thereof sales is an appropriate indicator) and supply, and macroeconomic factors such as availability of raw materials, governmental arrangements, inflation, exchange rate and investment volatility . For example, from 2006 to 2008, the weakness of the dollar against the euro led some companies to migrate to the USA, which is one of the reasons why VW opened a production plant in Chattanooga in Tennessee. It was a case of greenfield investment which is a way to enter the market together with

Certainly, decentralising control to increase quality and reduce costs is a strategy for resolving the gap between product standardisation and differentiation, resulting in the strategy of outpacing. With the electrification of powertrains, the concept of the low-cost car will be re-evaluated, since it is very costly to produce batteries oneself, especially for carmakers with a long history and from which customers expect certain outputs (in this regard, too, Mercedes, GM and BMW have decided to share the costs of a hybrid powertrain.

The electrification and autonomous driving are two of the most successful trends of the 21st century, so some location choice factors could be influenced by electricity production determinants, such as the percentage of electricity consumed and produced in a country.

## 3   Volkswagen and Toyota in the international scene

The analysis of the leaders Volkswagen and Toyota started by studying their annual reports.

The annual report is a report containing the results achieved by a company, and the alignment of these results with the strategies that have been set in the past and future. For example, in the case of a car manufacturer, the annual report contains at the beginning a description of all holdings, joint ventures and groups of the company, then the market strategies, new products, new production centres, key success factors of the company, main resources and competencies, key points, weaknesses and finally the economic-financial values such as income statement, balance sheet or free cash flow. Despite the fact that some of these data are necessary for shareholder clearance operations (since almost all the major automotive groups are public limited companies), many market analyses and performance studies are based on non-objective grounds, which is why it takes a very critical eye to read the information and to be able to discern those that are intended to make a fuss from those that actually give indications about the  welfare of a company.

A very important thing that happens in annual reports is "Analysis Of The Past To Prevent The Future" [28]: in fact, through the study of the annual reports of Volkswagen and Toyota it was possible to clarify their business strategies, to see how they have changed in the past and what direction they will take in the future by linking the strategies with the destinations.

### 3.1   Toyota in the earliest 21$^{st}$ century

Following the monozokuri philosophy, Toyota inherits a Customer First oriented policy, genchi genibutsu roots (on-site, hands-on experience), and approach to enhancing added value for all stakeholders [18].

Toyota's strategy in the early years of the 21st century has been to strengthen its position in the market by innovating in the areas of operations (development, purchasing, production and sales), to achieve growth in the USA and Europe, and to improve the leasing sector to allow customers to buy cars temporarily and sell them at the end of the leasing period. In this respect, Toyota is showing a certain farsightedness and is certainly anticipating market trends, as is already happening with engine forecasts. Leasing activities are subject to residual value risk; residual value risk arises when the lessee of a vehicle does not exercise the option to purchase it at the end of the lease period. In recent years, Toyota has seen a decline in purchases following the leasing period, a sort of profit on this activity; this trend could lead to Toyota losing earnings if it is unable to sell the vehicles returned to it after leasing on the second-hand market. The increased risk associated with the non-return of leased vehicles and the contingency for this eventuality will undoubtedly increase as the volatility of the market where the leasing is taking place, or where the cars are being resold, increases. For this reason, Toyota maintains an overall risk management strategy to mitigate its exposure to fluctuations in interest rates and currency exchange rates [29].

Toyota's short-term objectives in 2005 are to increase sales of the luxury Lexus brand in Japan from 50,000 to 60,000, to establish a new brand in Japan, and to increase the sales of the Lexus brand in Japan.

The following years have seen a development of vehicle hybridisation and advancement of localisation strategies; in 2006, overseas branches of the Global Production Centre were established in the United States, the United Kingdom, and Thailand. This marked a transition from the previous phase, in which Japanese trainers taught overseas personnel, to a new phase in which local trainers pass on their skills to local personnel, as well as personnel from other countries, to promote the spread of technical skills on a global basis [29].

In 2008 Toyota continued to talk about plant sustainability and cost reduction during the product development phases, even prior to blueprints: the strategy is to consider

individual "components" as well as multiple component "systems" striving to reduce the number of components by integrating components and systems with similar functions and reviewing the functions and placement of systems, such as engine and safety systems. Moreover, Toyota also reduced the number of components and the amount of material used without reducing product quality by reviewing production processes that have until now been standard [29]. Toyota asserts to give priority, in the near future, to improving the profitability of compact cars and cars manufactured overseas keeping on promoting cost reduction activities to further increase its cost competitiveness. The strategy of keeping low the costs together with the strategy of modernizing new plants are the cause of the very low number of new plants born in this period.

Toyota in 2005 launches a project called Innovation International Multipurpose Vehicle (IMV) which allows it to respond flexibly and promptly to various demand changes by constructing a global production and supply chain system.

IMV vehicles started to be assembled in Thailand, South Africa, and Argentina with parts from specialised centres around the world. Assembly takes place through a new line of robotic assemblers and stamping lines. IMV project continues introducing the "global link production system" to enable flexible responses to global demand shifts. The foundation of Toyota's link production lies in the relationship between mother plants and new overseas plants. Simply put, plants with low operating rates will take on part of the production of plants with high operating rates with the aim to raise production capacity utilization and production capacity by establishing a mutually supportive global system based on monitoring demand trends and the operating status of plants in regions worldwide [29].

The advantage of the 'global link production system' project is to allow Toyota to concentrate on its flagship models (Corolla, Camry, Yaris and IMV series) and to create new models by interconnecting them. This project also ties in well with the company's business origins, where the Japanese centres were the mother plants that dispensed quality and information to the other international centres: in 1985 Toyota had created a flexible and

innovative welding line for vehicle bodies, FBL (Flexible Body Line), which radically reduced jig replacement work arising from model changeovers and allowed the mixed production of four or five models; the line was implemented for the first time outside Japan at Toyota Motor Manufacturing Kentucky, in 1988 [29].

In September 2007, a Toyota fuel cell hybrid vehicle covers a distance of 50 km (from Osaka to Tokyo) without needing to refuel, using air conditioning. In 2008, Japan certifies the first plug-in Toyota car and allows it to travel on public land. These figures are a symptom of how proactive and avant-garde Toyota has been in the field of new engine technologies, from hybrid to hydrogen. It has to be said that most of Toyota's R&D funds have gone into the study of these two technologies, which is why pure electric has been put on the back burner until today's statements by CEO Aiko Toyoda, who argues strongly that the car industry's current business model risks collapsing if the sector switches to electric vehicles too quickly [29].

## 3.2 Volkswagen in the earliest 21st century

Volkswagen immediately showed itself to be more proactive than Toyota in internationalising, less avant-garde in exploiting new frontiers and more traditionalist in its choice of what the market considered to be emerging countries. For this reason, as early as 2005, it began to invest heavily in India and Russia and set up joint ventures in China (Volkswagen FAW Engine (Dalian) Company Ltd. on April 13, 2005). Volkswagen made M&A a must in its strategies: in 2007 it acquired shares in MAN and Scania, which became part of the Volkswagen AG group. In the same year, VW CEO Martin Winterkorn unveiled a strategy in his annual report that he said would enable the company to compete for the world market leadership in sales within a decade. VW wants to sell 11 million vehicles (it sells 6 million, 300,000 in America, where Toyota sells 2.5 million; "The United States is our most serious Achilles' heel" says Winterkorn), which means doubling 2017 sales (VW sells 1 million vehicles in South America, Toyota 400,000) and increasing the pre-tax profit margin from 5.6% to 10%. Toyota, which was already the market leader in 2007, already had these numbers in 2007, when its profit margin was 9.3%. The aim was also to increase customer satisfaction, improve quality and implement measures to protect the environment by

making products more sustainable. Similarly, the Audi subsidiary has been motivated for years by the slogan "Beyond BMW" to overtake its Bavarian competitor [30].

Achieving certain goals can mean many things: one of the decisions taken by VW was to develop vehicles on only three platforms. At that time, the group has a total of 61 plants worldwide, which are set to increase dramatically. In 2011, production began at the plant in Chattanooga, Tennessee, while the plant in South America, Brazil, was deconsolidated. In 2012 Porsche was completely acquired by Volkswagen, while relations in Northern Europe were consolidated through a JV with the Group's Norwegian importer. In 2013, a plant was opened in the Chinese city of Foshan, capable of producing 300,000 vehicles a year, while another plant is planned to be built in Yizheng: the aim is to produce up to 3 million vehicles in the ASEAN regions, where, for example, flagship models for the European market, such as the Passat, are also beginning to be assembled in Malaysia, with the partner company DRB-HICOM [30].

China was becoming Volkswagen's largest sales market and it was able to ride the wave of China's economic boom, but China was not Volkswagen's only goal: in 2014 Audi built a new plant in San José Chiapa, Mexico, while Ducati and MAN TRUCKS became part of the Volkswagen Group and a new partnership was signed with Chinese giant SAIC to build a plant in Urumqi, western China [30].

Since 2014, plants have been built in Poland, for the Volkswagen Commercial brand and a new Audi production in Brazil and a new JV with FAW and only at the end of 2015 Volkswagen approached the world of leasing, when it acquired all the shares of Guangzhou Zhiwei Car Leasing Co. Ltd; in 2017 Volkswagen agreed on a new joint venture for e-mobility in China with the Chinese car manufacturer Anhui Jianghuai Automobile (JAC): the two partners each have a 50% interest in the new company, which plans to develop, produce and sell electric vehicles. The agreement includes the construction of a further factory and a research and development centre for this purpose. The partnership also comprises the development and production of components for New Energy Vehicles (NEV) as well as the enhancement of vehicle connectivity and automotive services [30].

## 3.3 Market Strategy

Toyota has become famous for its production method, TPS Toyota Production System, which is based on a JIT (Just In Time) approach and the Jidoka principle (ensuring quality at every stage of production) through an integrated supplier network, lean production method, high quality standards, development of new technologies. The Japanese Kaizen theory based on the individuality of the employee who must constantly improve the quality of the product comes from Japanese culture.

From the statistics, it is clear that Toyota appears to be more co-conservative than VW as most of its employees are not foreigners and it acquires (little) mainly on the territory as well as selling less than VW outside its borders. VW's production is also higher than Toyota's outside its borders (66.4% vs. 48.2% in 2007).

VW's decentralisation began in 1952 with the creation of a sales company in Canada, and years later the subsidiary Volkswagen do Brazil was founded (in 2007 it had 48 production facilities in 19 states and sold in 150 states). Toyota in 1957 founded a sales company in the USA (in 2007 it has 74 production facilities in 27 states and sells in 170 states) and over time has become even more decentralised than VW.

Both Volkswagen and Toyota produce where the cost of wages is the lowest (for Europe in Bratislava and Kolin respectively) and where the market is growing extremely fast. VW first entered the American production market in 2008 with the intention of launching fuel-saving cars, against all market trends.

As far as research centres are concerned, VW's ones are all in Europe; exceptions are the ERL centres in California and the Asian research centres in China. Toyota, on the other hand, follows the logic of decentralisation for its R&D centres as well as its production sites, having scattered several of them around the world in order to have access to local information networks. For example, the Toyota Corolla (Auris), the world's best-selling car in history (in its various versions) was produced in 16 different countries in 2007, while 400,000 VW New Beetles for the European market were all produced at the Puebla plant in Mexico. There is no doubt that VW's initial difficulty in international investment lay in the

centralisation of its development centres, which did not allow it to understand American culture. "There is no question that VW has failed to understand what American customers want" says Catherine Madden, analyst with the market research firm Global Insight [18]. Another factor that undoubtedly initially held back VW's international expansion was an excessive focus on technological and material quality, which did not always meet the need for cheap products in emerging markets; in this regard, some of the cheapest cars in the world, such as the Tata Nano, contain quality mechanical components, Bosch, of not excessively advanced technology, to meet the price constraints expressed by the Indian market.

Since the 1980s, FDI have become common and widely used in almost all industries. The aim has been to combine market growth with low-cost, adequately skilled labour in the largest countries in the developing world such as China, India, and Brazil [17]. In the first half of 2020, Toyota and VW are respectively in first and second place for the number of vehicles sold in the world, with a market share of 12.4 and 11.3 % [16]. By delving into some of the official annual and other documents issued by the companies, some characteristic features of the strategies that these two car manufacturers have undertaken in the years 2005 to 2020 have emerged, which have led them to be the two leading car manufacturers worldwide. Both car manufacturers are facing the problems of the new millennium which are problems of the last decade that are growing policies on consumption and therefore cost pressures, markets that are diverging with some growing faster than others, digitalisation, and electrification [3]: since 2005 Toyota appears to be more forward-looking than VW as the first hybrid technologies are developed and released in the market; referring to the diffusion of innovation by Everett Rogers, VW is only at the apex of the curve in an early majority, if not laggard condition since its first hybrid car was marketed in 2010 [17] while Toyota is an innovator since its first hybrid car was marketed in 1997.

Broadly speaking, the production trend of the two car manufacturers follows the market trend; specifically, VW's car production in Europe is gradually increasing, while Toyota's production has only been growing since 2013. In terms of vehicle production in North America, the trend was similar until 2014, while since 2017 vehicle production has been

increasing for VW and decreasing for Toyota, indicating that the balance of location is changing.

In the table 3.3.1 is possible no see all the data regarding production for both manufacturers and later how the production is split in the main regions.

Table 3.3.1, source: Annual reports

| Volkswagen AG (production) | | | | Toyota Motor Corporation (production) | | | |
|---|---|---|---|---|---|---|---|
| **2006** | 5,684,603 | **2013** | 9,379,229 | **2006** | 7,711,000 | **2013** | 8,698,000 |
| **2007** | 6,267,891 | **2014** | 9,894,891 | **2007** | 8,180,000 | **2014** | 9,016,000 |
| **2008** | 6,437,414 | **2015** | 9,872,424 | **2008** | 8,539,000 | **2015** | 8,928,000 |
| **2009** | 6,067,208 | **2016** | 10,126,281 | **2009** | 7,051,000 | **2016** | 8,578,000 |
| **2010** | 7,341,065 | **2017** | 10,058,005 | **2010** | 6,809,000 | **2017** | 8,973,000 |
| **2011** | 8,525,573 | **2018** | 11,000,000 | **2011** | 7,169,000 | **2018** | 8,962,000 |
| **2012** | 8,952,401 | **2019** | 10,800,00 | **2012** | 7,435,000 | **2019** | 8,982,000 |
| Volkswagen AG (sales) | | | | Toyota Motor Corporation (sales) | | | |
| **2006** | 5,732,000 | **2013** | 9,729,000 | **2006** | 7,711,000 | **2013** | 8,698,000 |
| **2007** | 6,192,000 | **2014** | 10,217,000 | **2007** | 8,180,000 | **2014** | 9,016,000 |
| **2008** | 6,272,000 | **2015** | 10,010,000 | **2008** | 8,539,000 | **2015** | 8,928,000 |
| **2009** | 6,310,000 | **2016** | 10,391,000 | **2009** | 7,051,000 | **2016** | 8,578,000 |
| **2010** | 7,278,000 | **2017** | 10,776,000 | **2010** | 6,809,000 | **2017** | 8,973,000 |
| **2011** | 8,361,000 | **2018** | 10,809,000 | **2011** | 7,169,000 | **2018** | 8,962,000 |
| **2012** | 9,344,000 | **2019** | 10,957,000 | **2012** | 7,435,000 | **2019** | 8,982,000 |
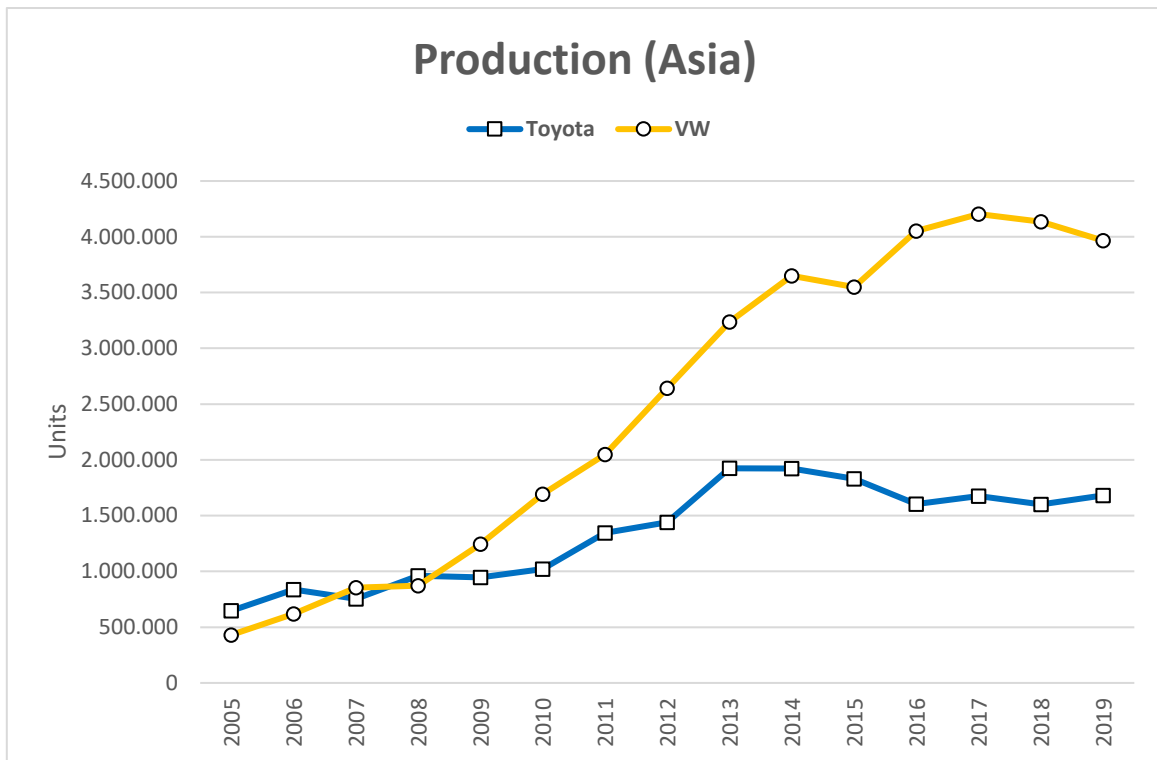
Figure 3.3.1, source: Annual reports

According to the trend in vehicle production in Asia (excluding production in Toyota's original homeland of Japan), vehicle production for Toyota in Asia has been decreasing and then stable since 2012, against market trends [31]. From the graph of production in Asia, it can be seen that there is a point at which Volkswagen's vehicle production exceeds that of Toyota (from which line production in the home country is excluded); this data is consistent with Volkswagen's market strategies and the numerous openings of new plants in China by Volkswagen.
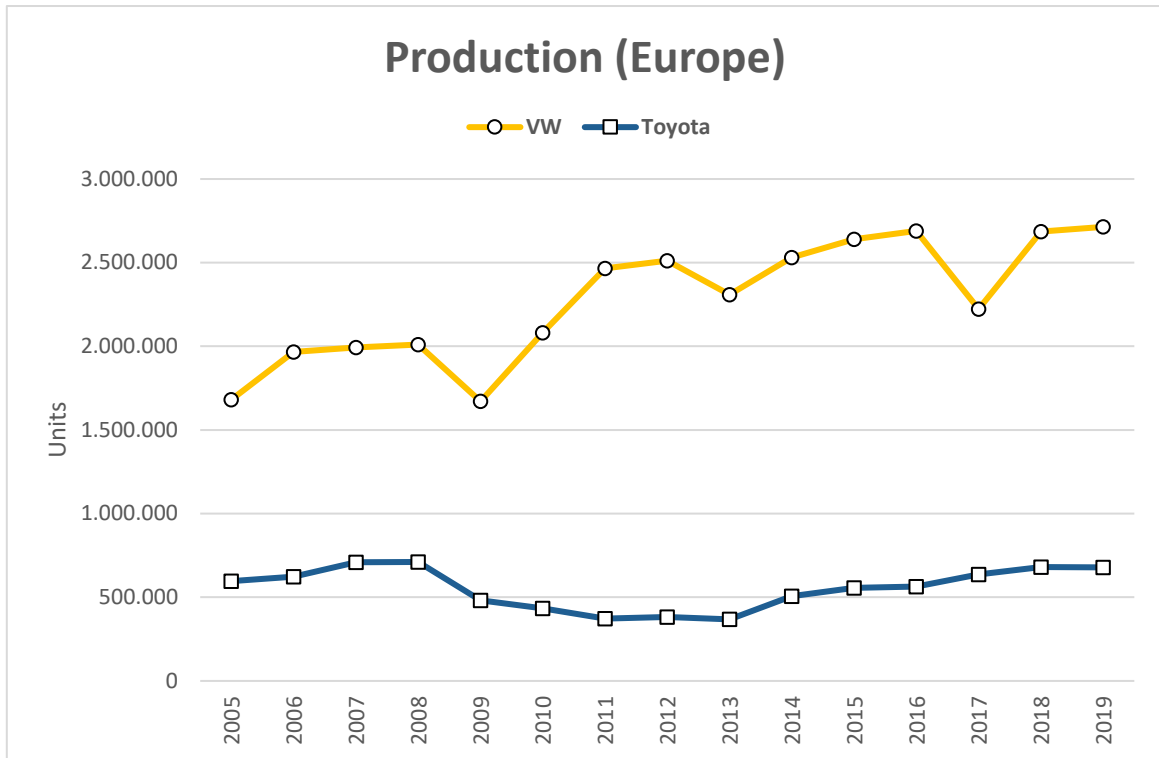
Figure 3.3.2, source: Annual reports

Production in Europe was also considered without the production of vehicles in Germany by Volkswagen. Here it can be seen that at the beginning there is a tendency for Toyota to increase its production while that of Volkswagen is even decreasing in 2009. After this peak, however, Volkswagen's production begins to increase as a result of investments in eastern Europe and Northern Europe, while Toyota's production remains more or less stable.
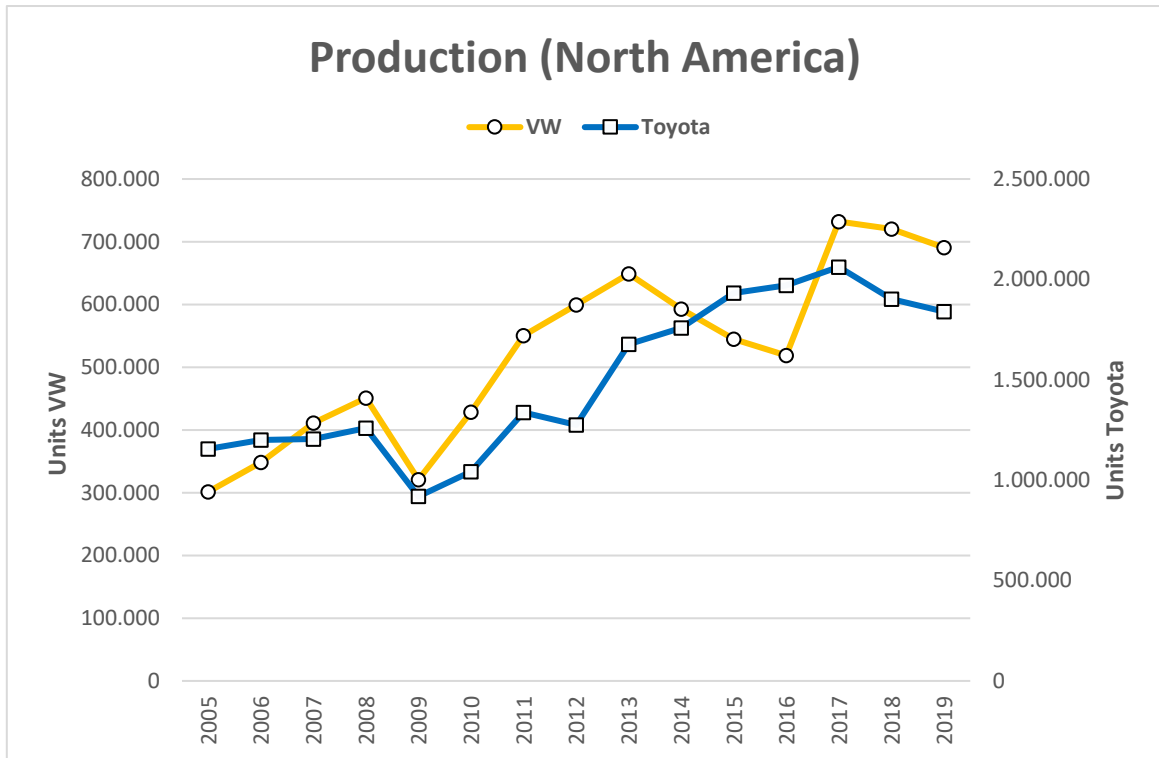
Figure 3.3.3, source: Annual reports

In terms of production in North America, Volkswagen overtook Toyota in 2006, then the production trends were both increasing until 2013 when Volkswagen closed plants in South America and Central America; Toyota overtook Volkswagen in 2014 and was in turn overtaken in 2017 when Volkswagen decided to re-invest in Mexico.

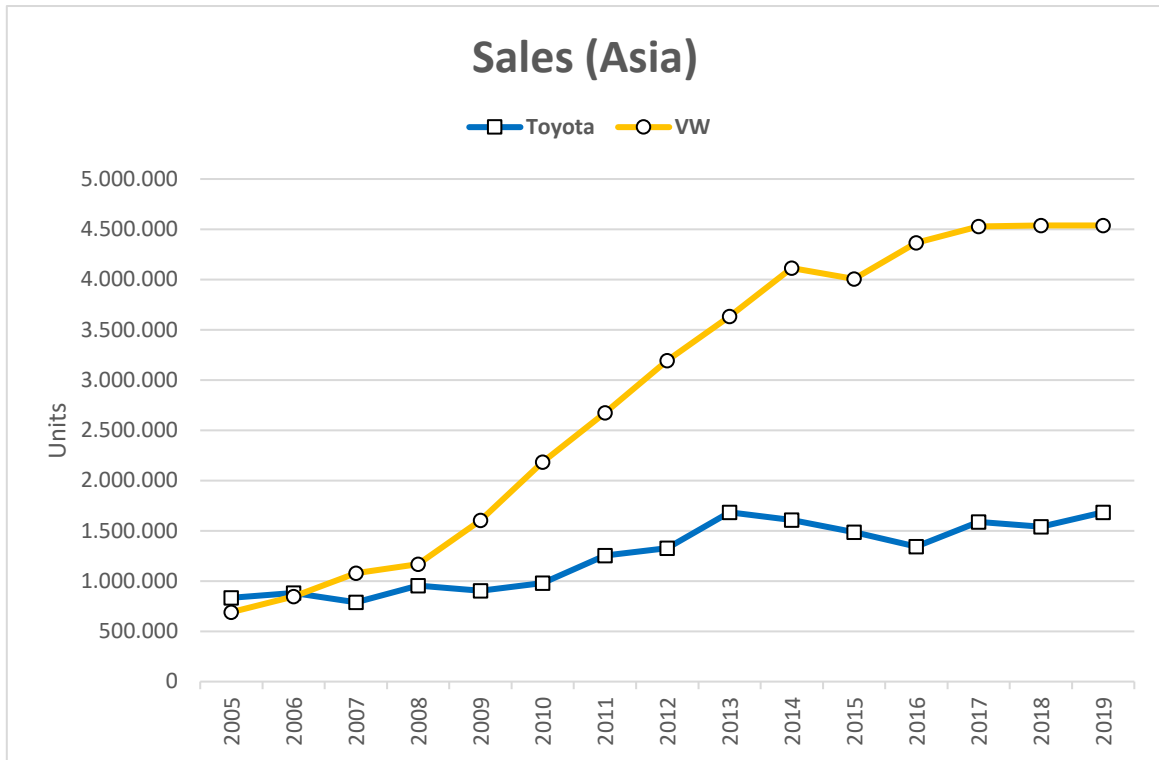Sales performance, on the other hand, follows the market trend in North America and Asia.

Figure 3.3.4, source: Annual reports

Volkswagen is increasing its sales of vehicles in Asia very rapidly, as it had been doing for production. Only at one point does Volkswagen's curve have some uncertainty, and that is in connection with the Diesel-gate that overwhelmed Volkswagen in 2015; as of today, the curve is rising again. Sales in Europe (excluding Germany for Volkswagen) met in 2008 when Toyota's cost-reduction policies prevented it from growing even more at the same rate as Volkswagen would have done consistently until 2019.
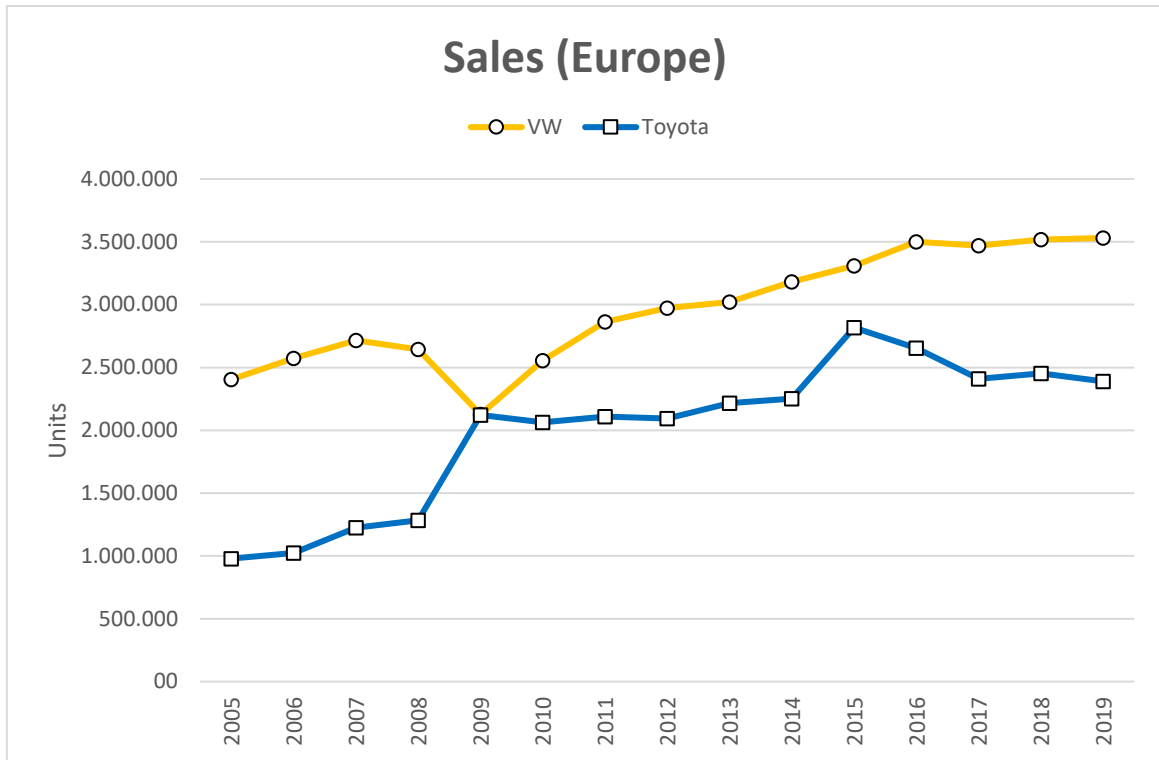
Figure 3.3.5, source: Annual reports

Toyota's sales in North America fell sharply from 2008 to 2012 due to its cost reduction policy and the adoption of innovative powertrains that did not allow it to exploit the most popular ones. Volkswagen's sales, on the other hand, grew from 500,000 to 1 million.
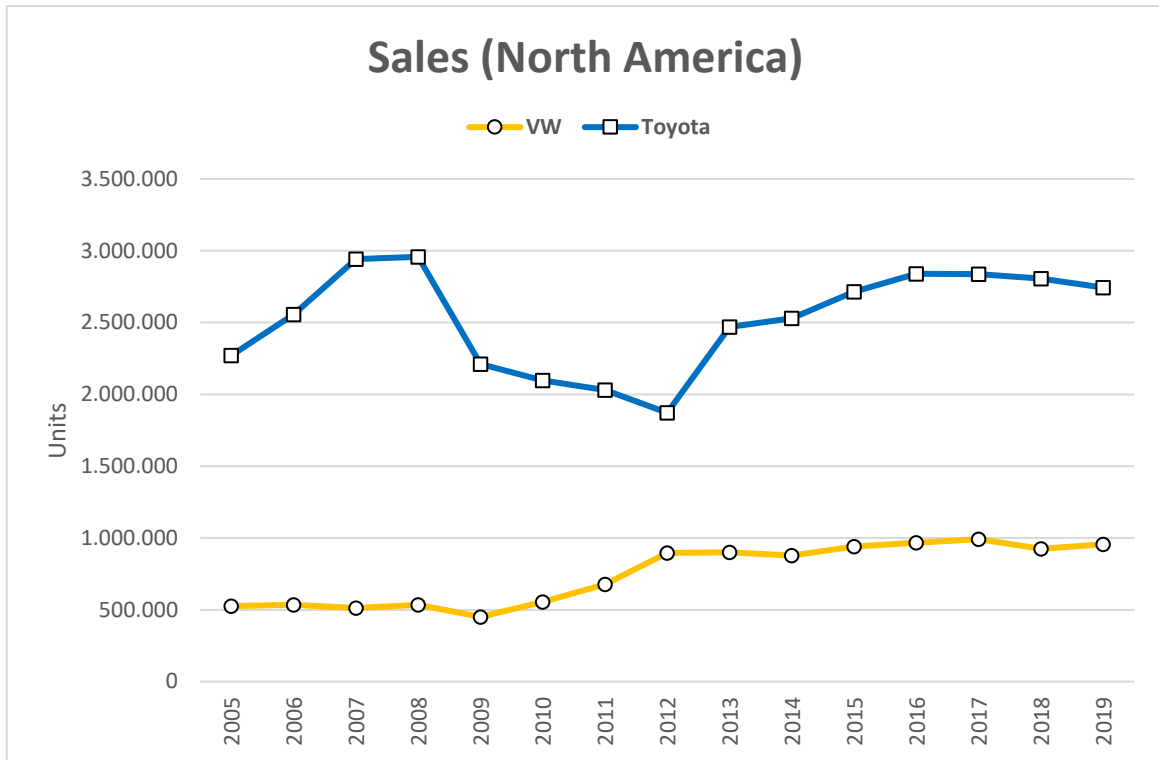
Figure 3.3.6, source: Annual reports

The R&D graph is very illustrative as it clearly shows the strategic differences in the research budgets of the two car manufacturers.
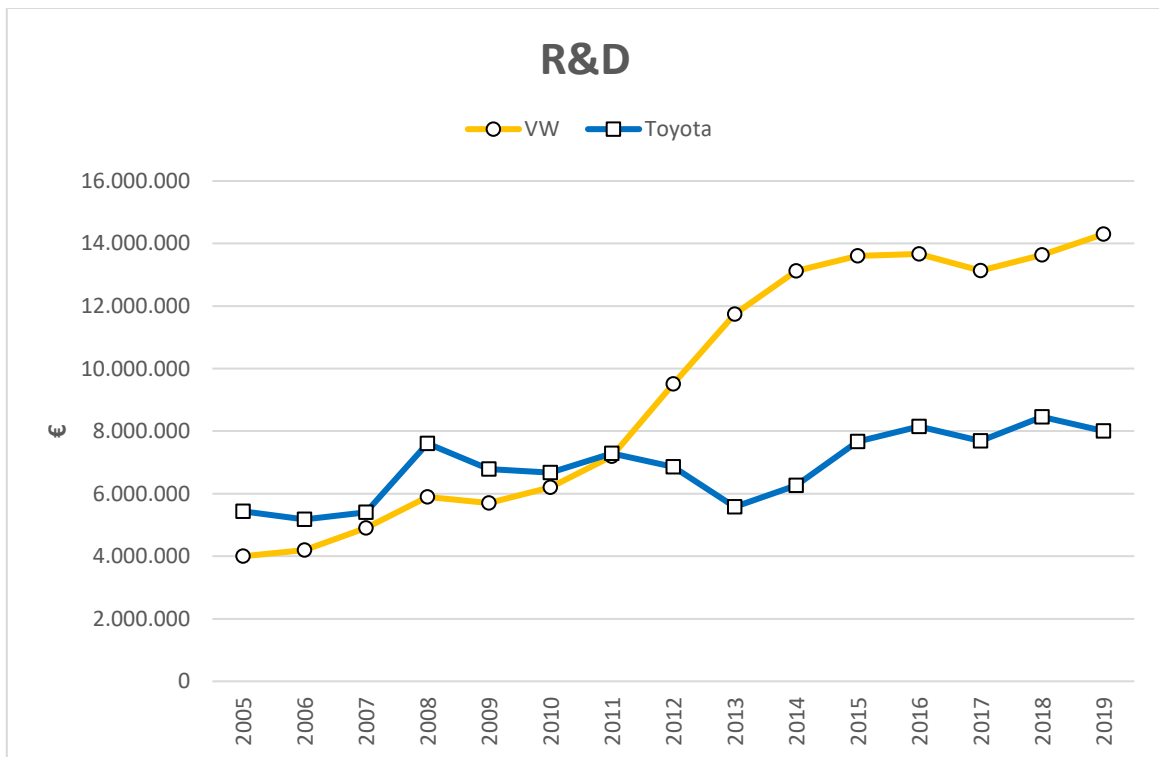


Figure 3.3.7, source: Annual reports

Figure 3.3.8 shows the percentage of foreign sales in relation to the total sales of Toyota and Volkswagen; both trends are increasing, a sign of the strong internationalisation of both brands.
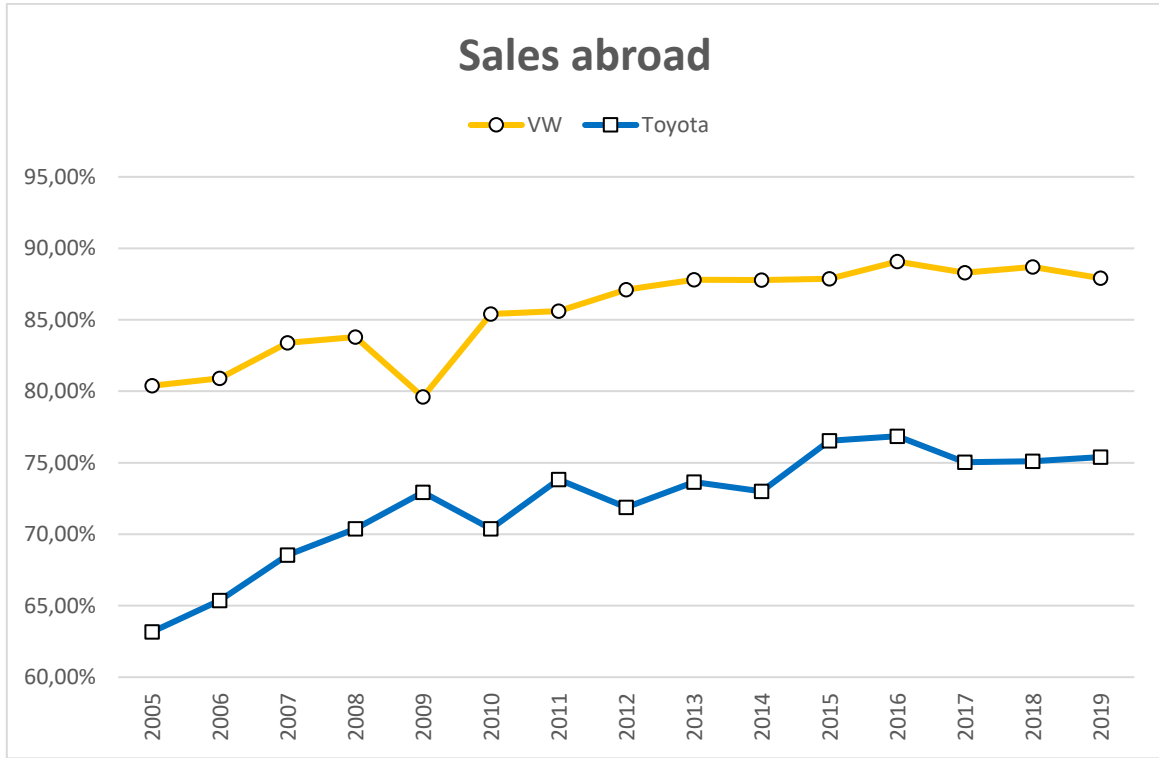


Figure 3.3.8, source: Annual reports

Figure 3.3.9 shows the trend in recruitment outside the home country: VW's curve is rising faster than Toyota's, and this is certainly due to the larger number of plants that were opened from 2005 to 2019 by the Wolfsburg household.
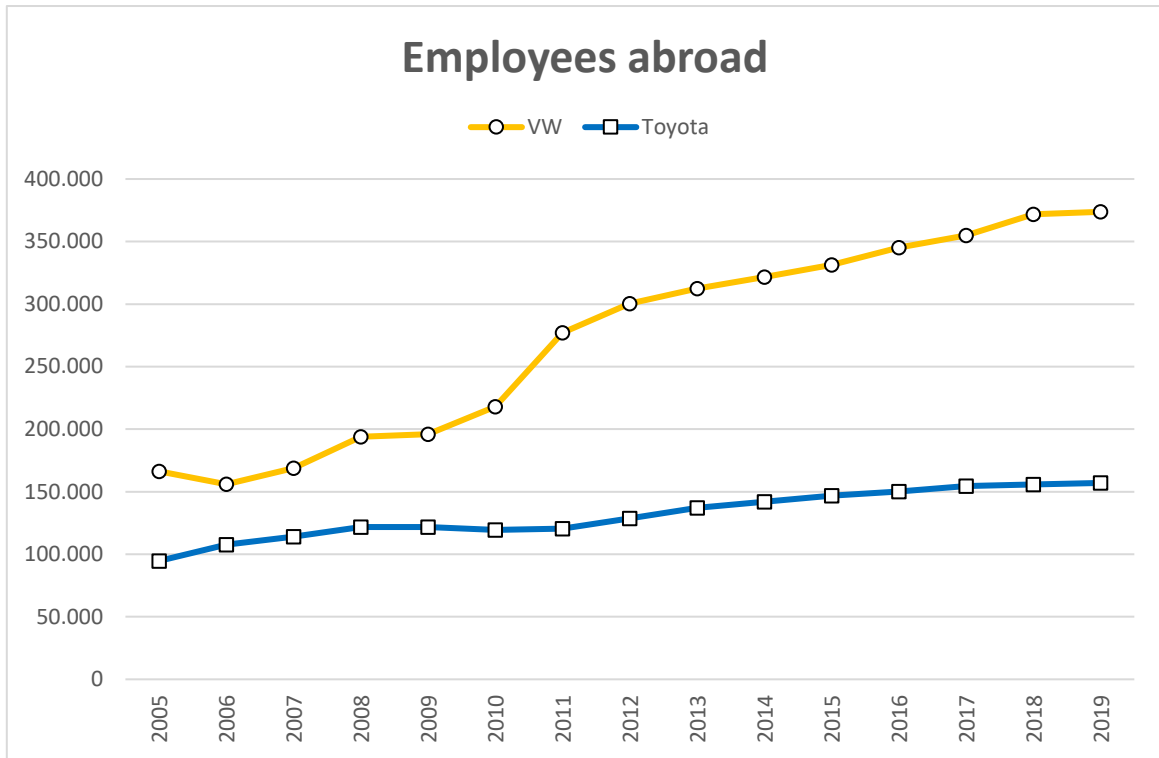
Figure 3.3.9, source: Annual reports

Figure 3.3.10 shows how much of the total production was done abroad, while figure zzz shows the trend in sales of engines with cutting-edge technologies: this graph shows how much Toyota has been working and investing in hybrid technologies for decades now, paving the way for itself in the years to come, should the hybrid prove to be one of the scenarios preferred by consumers. This obviously entails Toyota taking a big risk, which will be repaid when its hybrid and plug-in hybrid powertrains become dominant designs.
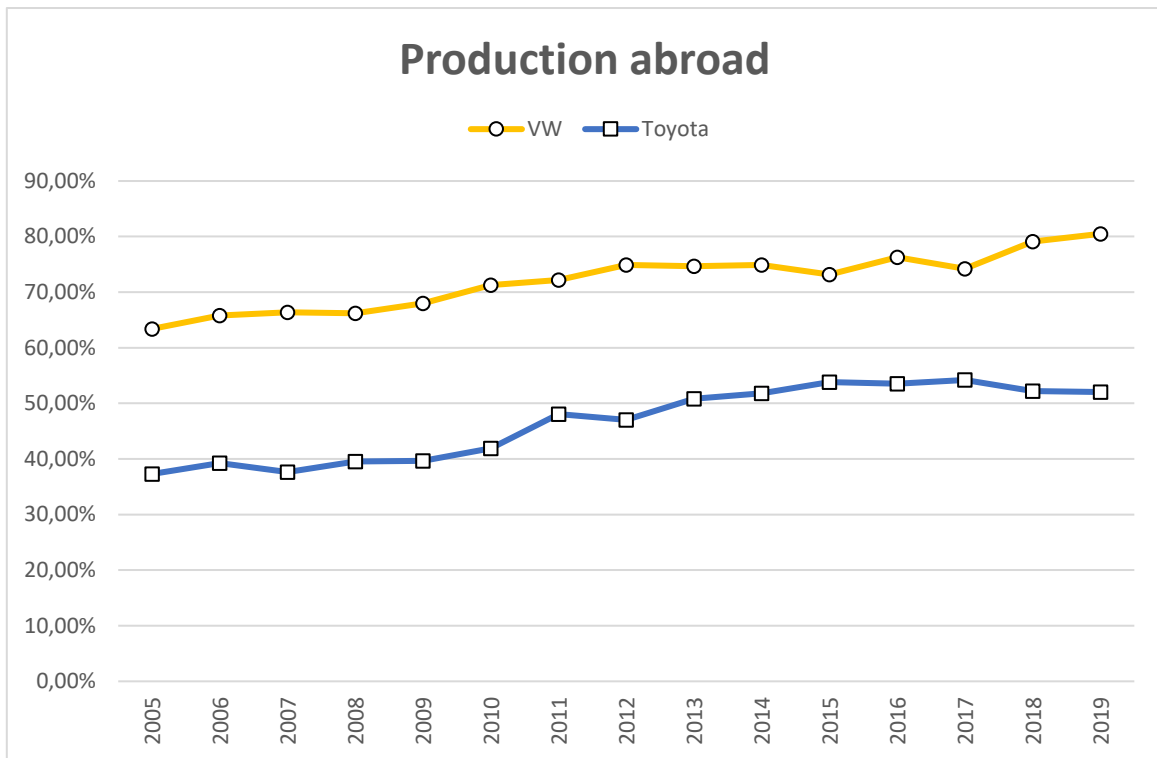
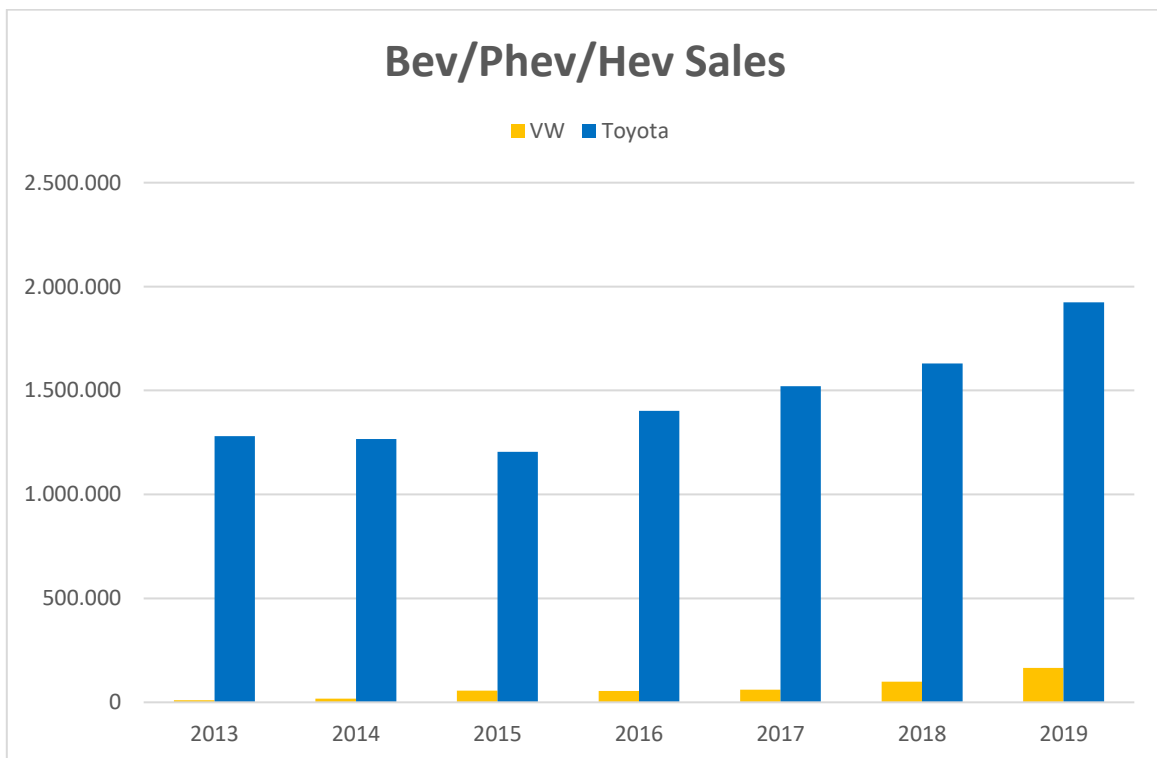Figure 3.3.10, source: Annual reports



Figure 3.3.11, source: Annual reports

The trend in R&D expenses has seen VW invest a greater amount of funds since 2011, the result of Toyota's savings strategy, which in its Annual Reports mentions and emphasises

the importance of the cost reduction component, which is becoming more and more incisive from year to year.
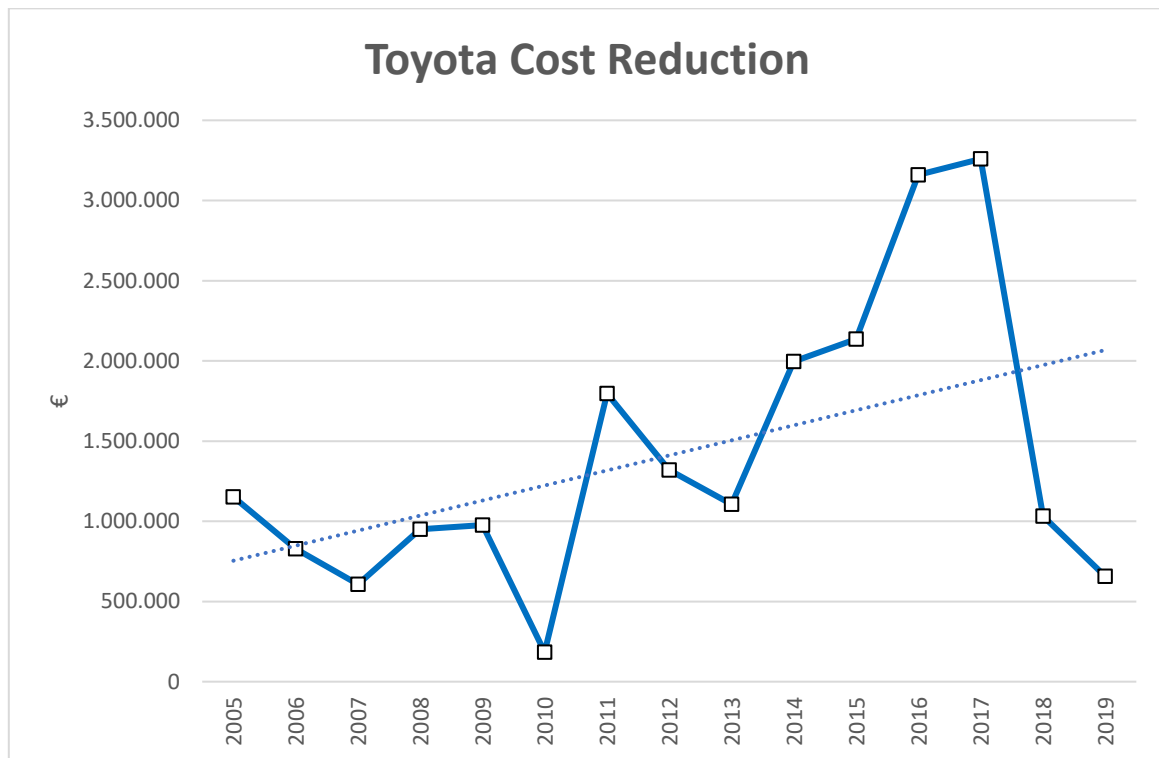


Figure 3.3.12, source: Annual reports

In the figure 3.3.13 and 3.3.14 are highlighted the mail countries where the FDI of both manufacturers are the highest in percentage.

The localisation choices of Toyota and VW can be deduced from the amount of investment in geographical destinations: for VW, an exponential increase in investment in China has been noted since 2005, particularly high for subsidiaries, accompanied by a substantially high investment in Eastern Europe, specifically in Slovakia, as well as an ever-present component of investment in the US. Toyota invested mainly in China and North America as well as its subsidiaries.

Figure 3.3.13, source: FDI database
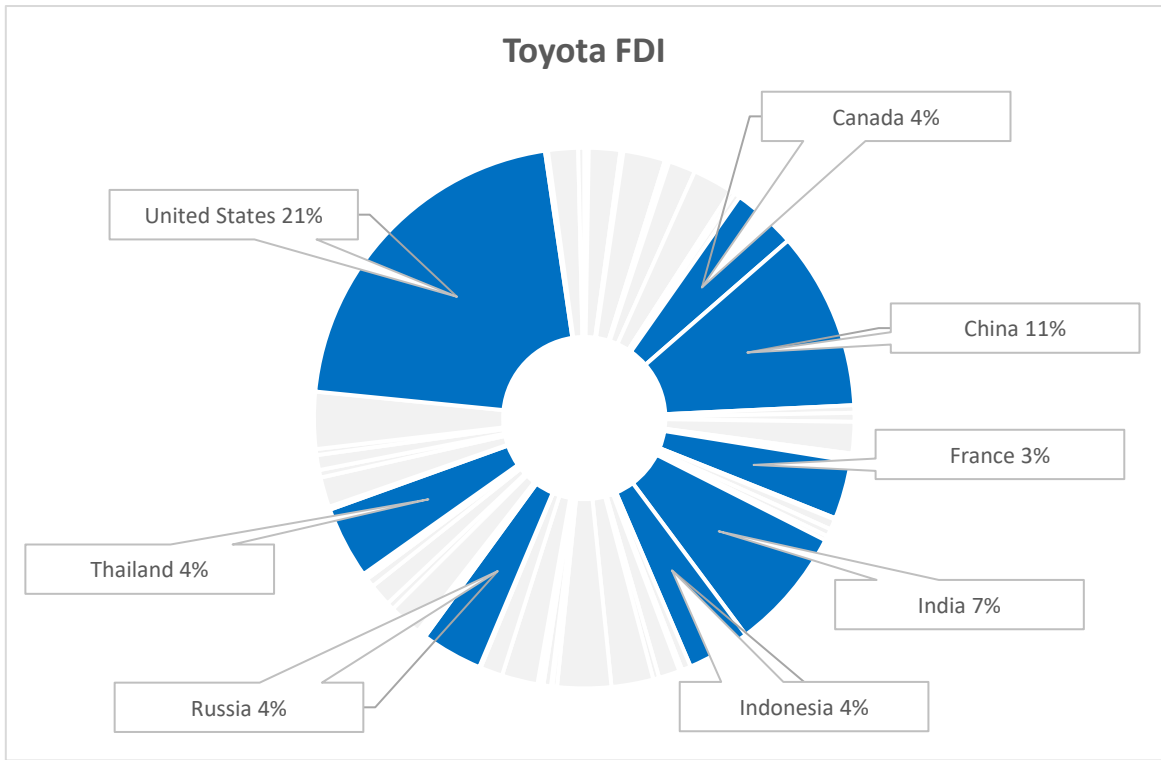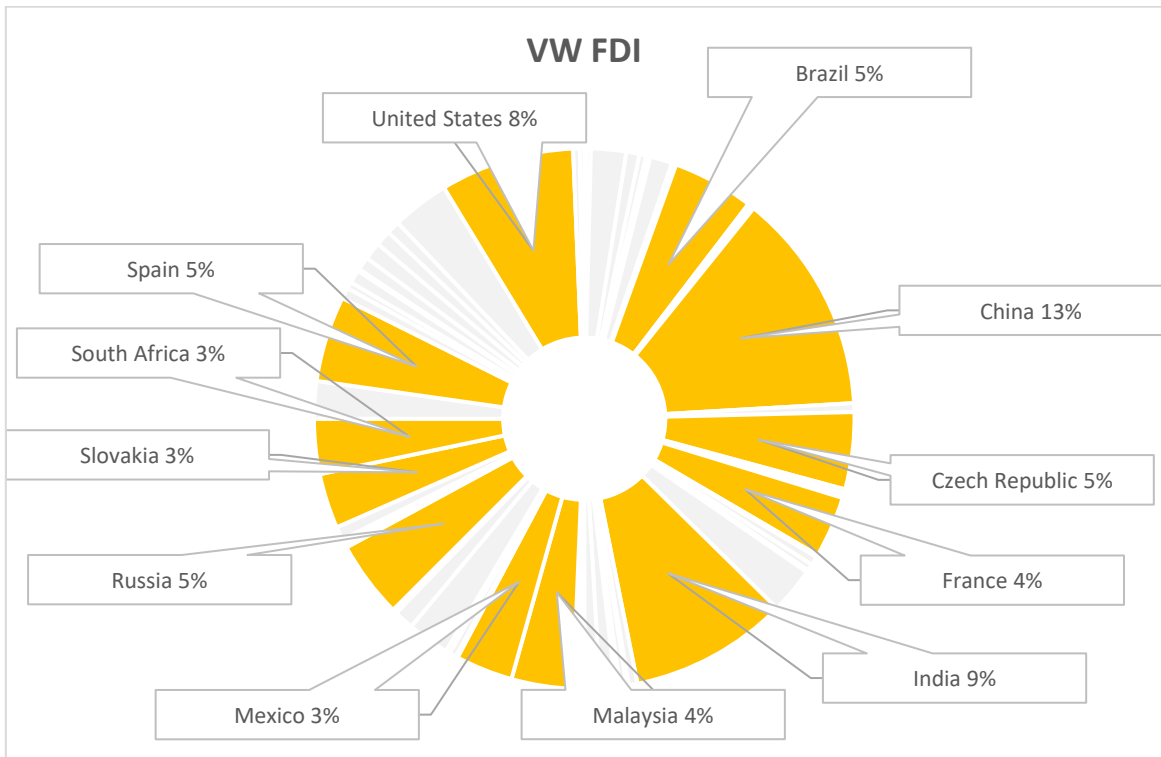


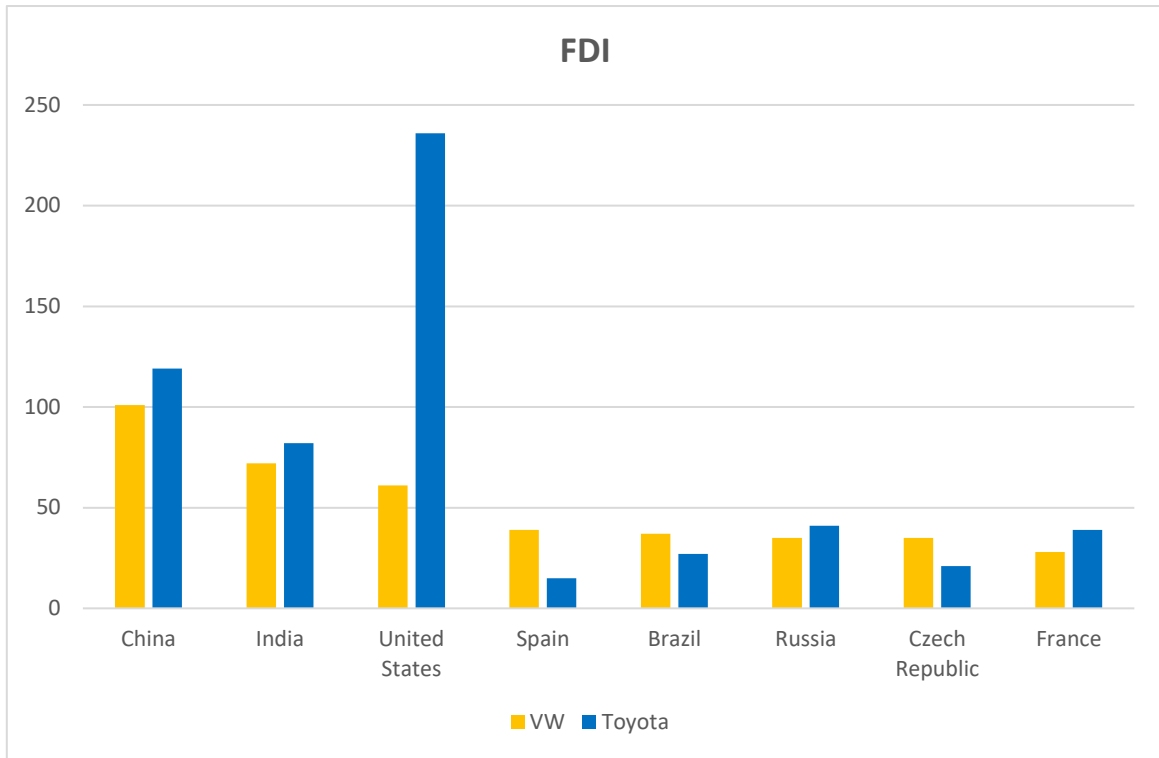Figure 3.3.14, source: FDI database

Figure 3.3.15, source: FDI database

With regard to the number of plants, Toyota's is clearly less fluctuating than VW's and this is reflected in the analysis of the Annual Reports; VW has grown exponentially in recent years and this has led to a large number of plant openings especially in Asia, where VW has increased its sales.
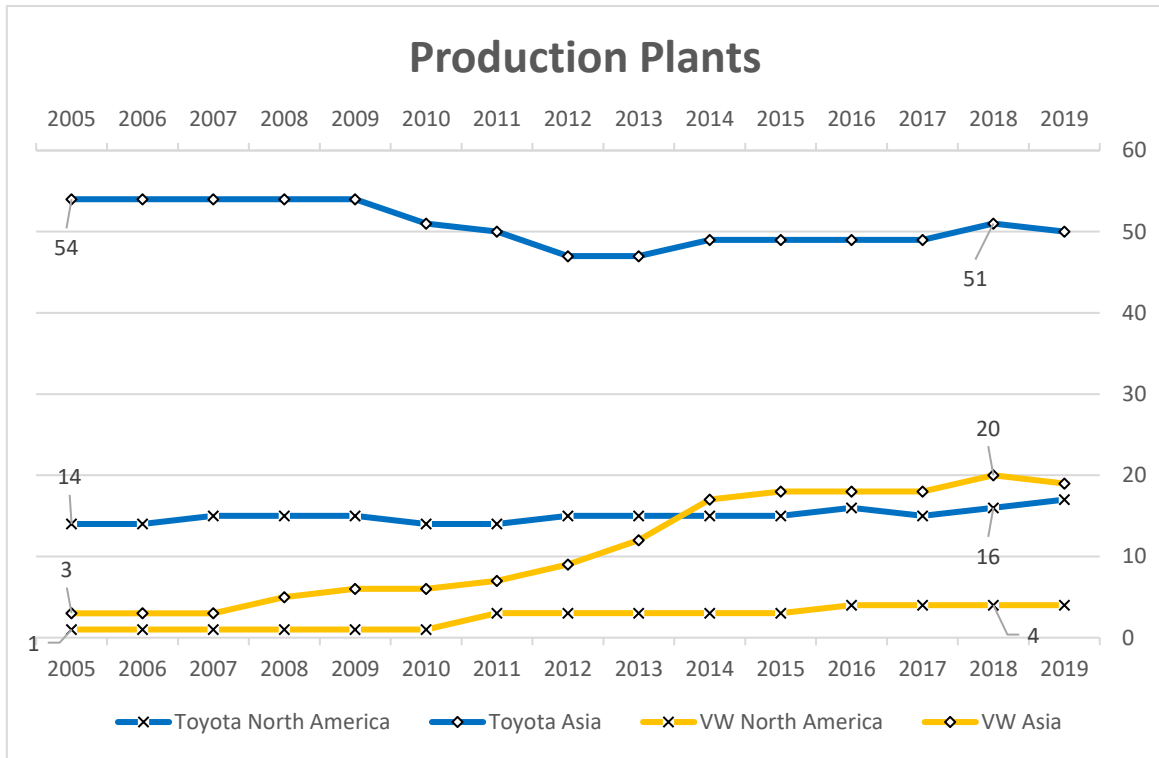
Figure 3.3.16, source: Annual reports

## 4   Econometric model and Results

The literature on FDI location choice uses discrete choice models such as the conditional logit to relate a dummy variable "Choice" that is worth 1 when the investment is successful in that region, 0 otherwise. The conditional logit works with the assumption of independence of irrelevant alternatives (IIA) and with assumptions of homogeneous effects of parameters on the decision maker's choices (McFadden). In our case, the variable "Choice" was combined with the set of variables constituting the model. The total number of choices under consideration is equal to the number of investments N (which depends on the number of car manufacturers considered in the model) times the number of potential locations J. The decision-maker is the investing company f which is called to make a set of decisions n.

## 4.1 Database

### 4.1.1 UNCTAD

UNCTAD is a permanent intergovernmental body established by the United Nations General Assembly in 1964. It is part of the UN Secretariat and of the United Nations Development Group [32].

### 4.1.2 WGI

Worldwide Governance Indicators (WGI) is a set of indicators reporting aggregate and individual governance indicators for over 200 countries and territories [33]

### 4.1.3 CEPII

The CEPII is the leading French centre for research and expertise on the world economy whose work aims to contributing to the policy making process through analysis in international trade, migrations, macroeconomics, and finance [34].

### 4.1.4 PWT

Penn World Table is a set of data developed by scholars of University of California and the University of Groningen containing a database with information on relative levels of income, output, input, and productivity, covering 182 countries between 1950 and 2017 [35]

## 4.2 Variables

This study analyses the choice of 1863 investments in the time period between 2005 and 2019. The variables that have been considered are specified below. For several reasons, the econometric technique of deltalog [11] has been preferred to mitigate the problems due to the presence of heteroskedasticity, i.e. (when the variance of a random variable varies across sample observations different sample observations [36]). So, each variable is transformed with the logarithm at time t-1, where t is the year in which the investment takes place; the difference between one period and the next has been made because one of the objectives is the reasoning about the effect of changes in a variable rather than its absolute values( [13]).

The coefficients can be considered as elasticities when the variables are transformed with the logarithm (Train 2009).

*ln_dist* was extracted from the CEPII database and describes the distance between the most populous capitals between one destination and another. In the case of interest, it describes the distance between the most populous city from where the investment starts and the one where it arrives

*count_sector* : this variable was extracted from the FDI database and is a counter of how many times the company has been located in a destination with an investment in the same sector.

*euro* is a dummy created specifically to indicate whether the investment falls within the Eurozone.

*count_bilateral*: this variable was extracted from the WDI database, it is a counter of how many times the company has invested in a given country.

*ln_elec_consump_from_renew* is a variable extracted from the WDI database that describes the consumption of a destination in terms of energy from renewable sources

*ln_elec_prod_from_renew* is a variable extracted from the WDI database describing the production of a destination in terms of energy from renewable sources

*ln_fuel_exports* is a variable extracted from the WDI database describing fuel exports

*ln_fuel_imports* is a variable extracted from the WDI database, describing fuel imports

*ln_stocks_traded* is a variable extracted from the WDI database, describing how many stocks are traded in a location

*ln_trademark_appl* is a variable extracted from the WDI database, describing how many trademark applications have been signed in a location

*ln_tax_on_international_trade* is a variable from the WDI database describing the taxes on international trade imposed by a location

*ln_real_interest_rate* is a variable from the WDI database describing the interest rate on currency exchanges in a location

*ln_gdp_growth* is a variable from the WDI database describing GDP growth in a location

*ln_daily_work_hours* is a PWT database variable describing the weekly working hours of the workers in a location

## 4.3   Descriptive Analysis

Using the most basic Stata commands, it was possible to describe the database obtained after selecting the predefined set of variables. Table xxx shows the times when the two car manufacturers chose the destinations on the left: the most popular states, as was previously pointed out, are China, India, and the United States. In China, the number of VW investments is slightly higher than Toyota's one; in India it is about the same. This result shows that VW is investing slightly more in Asia than Toyota. By contrast, Toyota's investments in the United States are significantly higher. Moreover, Toyota's tendency to locate itself in the emerging Asian countries stands out, while VW tends to colonise the eastern European market.

Table 4.3.1, source: own calculations

| iso_dest | Toyota | Volkswagen |
|----------|--------|------------|
| ARE | 6 | 6 |
| ARG | 27 | 14 |
| AUS | 31 | 5 |
| BEL | 22 | 9 |
| BRA | 32 | 36 |
| CAN | 44 | 2 |
| CHN | 92 | 82 |
| CZE | 24 | 31 |
| ESP | 20 | 33 |
| FRA | 35 | 24 |
| GBR | 45 | 24 |
| GHA | 7 | 4 |
| HUN | 0 | 20 |
| IDN | 46 | 4 |
| IND | 91 | 65 |
| KEN | 20 | 1 |
| KOR | 7 | 14 |
| MEX | 39 | 23 |
| MYS | 31 | 26 |
| PHL | 27 | 0 |
| POL | 18 | 18 |
| RUS | 41 | 28 |
| SVK | 0 | 25 |
| THA | 48 | 6 |
| TUR | 23 | 8 |
| UGA | 12 | 0 |
| USA | 264 | 57 |
| VNM | 15 | 2 |
| ZAF | 19 | 24 |

Thanks to the command *summarize* it can be seen that the total number of investments the number of investments analysed is 1.863; despite this, for many investments it is not possible to have all the variables available, so each variable will be restricted to a smaller number of investments. During the analysis, the variables with as many investments as possible have been selected, so that the number of observations involved in the conditional logit and the mixed logit could be as high as possible.

The variables for which the highest number of investments is available are those in the databases with the fewest missing, which are those in the CEPII database, on the geographical distances of the leases, and the counters extrapolated from the count of the variables within the FDI file.

In the same table it is possible to view the average, minimum and maximum value of each variable which, being transformed with a logarithm function, are not easy to interpret.

Furthermore, knowing that the mean of a dummy variable describes the number of positives, it can be stated that, about 20% of the investments are in the Eurozone; this result is not surprising as most of the investments are located in Asia and America.

Table 4.3.2, source: own calculations

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Renew_consum | 1,320 | 2.622041 | .8678322 | 0 | 4.569837 |
| Renew_prod_ | 1,305 | 1.367555 | .8050504 | 0 | 3.84446 |
| Fuel_export | 1,665 | 2.206293 | .9116164 | .0000355 | 4.61371 |
| Fuel_import | 1,662 | 2.644096 | .6104138 | .251465 | 4.199781 |
| Euro | 1,863 | .2050456 | .4038434 | 0 | 1 |
| Stocks_trade | 1,499 | 3.840095 | 1.33597 | .0207644 | 6.573911 |
| Patents | 1,608 | 9.182761 | 2.662047 | .6931472 | 12.65413 |
| Taxes | 1,287 | 1.414711 | .9065753 | -.0328438 | 3.693485 |
| Gdp | 1,689 | 27.88955 | 1.790703 | 22.75575 | 30.65286 |
| Int_rate | 1,173 | 1.392209 | .9317488 | -4.82994 | 3.820679 |
| Work_hours | 1,490 | 7.562364 | .1245312 | 7.217955 | 7.806513 |
| Dist | 1,863 | 8.646013 | .9172138 | 5.162062 | 9.828258 |
| Count_sector | 1,863 | 6.046162 | 7.589567 | 0 | 33 |
| Count_bilate | 1,863 | 6.804616 | 8.981987 | 0 | 37 |

By calculating the average Euro investment for Toyota and Volkswagen separately, it can be seen that Volkswagen invests more in Europe (31.48%) than Toyota (14.38%).

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Euro | 667 | .3148426 | .4648017 | 0 | 1 |

Figure 4.3.1, Euro investments by VW source: own calculations

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Euro | 1,196 | .1438127 | .3510465 | 0 | 1 |

Figure 4.3.2, Euro investments by Toyota, source: own calculations

Then, it was possible to find the correlation coefficients between the variables, taking care that those between two variables were not too high: this occurs on a few occasions when the relationship between the two variables is obvious, e.g., in the case between Gdp and Stocks_trade it is obvious that the increase in a country's Gdp is due to economic progress from which the stock market cannot be excluded  [37].

Table 4.3.3, source: own calculations

| | Renew_consum | Renew_prod_ | Fuel_export | Fuel_import | Stocks_trade | Patents | Taxes | Gdp | Int_rate | Work_hours | Dist | Count_sector | Count_bilate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Renew_consum | 1 | | | | | | | | | | | | |
| Renew_prod_ | 0.2425 | 1 | | | | | | | | | | | |
| Fuel_export | -0.1373 | -0.0733 | 1 | | | | | | | | | | |
| Fuel_import | 0.0006 | 0.1234 | -0.2121 | 1 | | | | | | | | | |
| Stocks_trade | -0.5297 | -0.054 | 0.0991 | 0.2121 | 1 | | | | | | | | |
| Patents | -0.3034 | 0.0917 | 0.1179 | 0.2071 | 0.7024 | 1 | | | | | | | |
| Taxes | 0.4015 | -0.1276 | -0.1189 | -0.0341 | -0.1838 | 0.1307 | 1 | | | | | | |
| Gdp | -0.363 | 0.1402 | 0.2013 | 0.1161 | 0.742 | 0.8207 | -0.1029 | 1 | | | | | |
| Int_rate | 0.3357 | 0.0708 | 0.0309 | 0.0052 | -0.2836 | -0.1199 | 0.1023 | -0.1519 | 1 | | | | |
| Work_hours | 0.0531 | -0.3127 | -0.0963 | 0.0604 | -0.0905 | 0.1424 | 0.5008 | -0.1824 | 0.0073 | 1 | | | |
| Dist | 0.3242 | 0.0845 | 0.1585 | -0.1183 | -0.1757 | 0.0359 | 0.0587 | -0.1434 | 0.19 | 0.1254 | 1 | | |
| Count_sector | -0.0617 | -0.0121 | 0.1034 | 0.0637 | 0.3722 | 0.4575 | 0.0575 | 0.5239 | -0.0959 | 0.0969 | 0.0371 | 1 | |
| Count_bilate | -0.0692 | 0.0383 | 0.1132 | 0.0781 | 0.3927 | 0.492 | 0.0522 | 0.5603 | -0.1044 | 0.0659 | 0.0679 | 0.69 | 1 |

## 4.4  Conditional Logit

Thanks to the conditional logit model, it was possible to identify the relationship coefficients between the dependent variables and the set of independent variables: it is interesting to note that the level of investment is negatively correlated with population density and GDP per capita, a sign that investments are probably oriented towards countries where GDP per capita decreases and population density decreases, while they are oriented towards places where car sales are higher.

In the table 4.4.1 is possible to see the different coefficients of the conditional logit model for both VW and Toyota, on depending on the different variables selected

Table 4.4.1, source: own calculations

|  | (1) | (2) | (3) |
|---|---|---|---|
| Renew_consum | 0.643*** | 0.571*** | 0.540*** |
| Renew_prod_ | 0.398*** | 0.662*** | 0.494*** |
| Fuel_export | 0.353*** | 0.523*** | 0.425*** |
| Fuel_import | -0.381*** | -0.506*** | -0.479*** |
| Euro | 1.953*** | 0.821 | 0.602 |
| Stocks_trade | 0.325*** | 0.502*** | 0.432*** |
| Patents | 0.217*** | 0.133 | 0.0983 |
| Gdp | 0.665*** | 0.706*** | 0.533*** |
| Int_rate | -0.00657 | -0.0126 | 0.0147 |
| Work_hours | 6.253*** | 7.591*** | 6.637*** |
| Taxes |  | -0.0131 | -0.00200 |
| Dist |  |  | 0.0446 |
| Count_sector |  |  | 0.00498 |
| Count_bilate |  |  | 0.0394*** |
| Observations | 25545 | 17959 | 17959 |

Standard errors in parentheses
$^{*} p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$

The table 4.4.2 shows how the investment distributions of the two car manufacturers are spread across the continents.

Table 4.4.2, source: own calculations

| Mainland | Freq. | Percent | Cum. |
|---|---|---|---|
| africa | 33 | 5.30 | 5.30 |
| asia | 206 | 33.07 | 38.36 |
| eu | 245 | 39.33 | 77.69 |
| north_america | 82 | 13.16 | 90.85 |
| oceania | 5 | 0.80 | 91.65 |
| south_america | 52 | 8.35 | 100.00 |
| Total | 623 | 100.00 | |

Table 4.4.3, source: own calculations

| Mainland | Freq. | Percent | Cum. |
|---|---|---|---|
| africa | 79 | 7.41 | 7.41 |
| asia | 361 | 33.86 | 41.28 |
| eu | 205 | 19.23 | 60.51 |
| north_america | 328 | 30.77 | 91.28 |
| oceania | 31 | 2.91 | 94.18 |
| south_america | 62 | 5.82 | 100.00 |
| Total | 1,066 | 100.00 | |

## 4.5 Mixed Logit

The aim of the mixed logit model is to capture the heterogeneity in the effects of the set of variables on the investment choices of decision makers [38]. In particular, the analysis regards the determinants of the choice of a certain destination distinguishing the effects that have a significant mean from those that have a significant variance losing the IIA hypothesis typical of the conditional logit [37].

Table 4.5.1, source: own calculations

| | (1) Mean | SD | (2) Mean | SD | (3) Mean | SD | (4) Mean | SD |
|---|---|---|---|---|---|---|---|---|
| Dist | -0.0543 | | -0.0417 | | -0.0518 | | -0.0285 | |
| Count_sector | -0.00158 | | 0.00296 | | 0.00997 | | 0.00544 | |
| Count_bilate | 0.0332*** | | 0.0276*** | | 0.0134 | | 0.00938 | |
| Euro | 1.586** | | 1.484** | | 1.998*** | | 1.942*** | |
| Renew_consum | 0.807*** | -0.0120 | 0.798*** | -0.0177 | 0.808*** | -0.000963 | 0.848*** | -0.0193 |
| Renew_prod_ | 0.586*** | 0.777*** | 1.233*** | 0.685*** | 4.725*** | 0.550** | 0.139 | 0.701*** |
| Fuel_export | 0.692*** | -0.0174 | 0.692*** | -0.0149 | 0.737*** | -0.00549 | 0.757*** | -0.0159 |
| Fuel_import | -0.598*** | 0.0197 | -0.651*** | 0.0117 | -0.682*** | -0.000786 | -0.653*** | 0.0133 |
| Stocks_trade | 0.560*** | 0.0202 | 0.588*** | 0.0224 | 0.596*** | 0.00699 | 0.603*** | 0.0251 |
| Patents | 0.372** | -0.207 | 0.461** | -0.301** | 0.483** | 0.211 | 0.491*** | -0.278* |
| Taxes | -0.0980 | -0.121 | -0.0819 | -0.131 | -0.0500 | -0.0450 | -0.0666 | -0.110 |
| Gdp | 0.525*** | 0.542*** | 0.624*** | 0.502*** | 1.842*** | 0.631*** | 0.438** | 0.654*** |
| Int_rate | 0.0877 | 0.430*** | -0.170 | 0.468*** | -2.187*** | 0.468*** | 0.431*** | 0.418*** |
| Work_hours | 9.202*** | 1.732 | 9.377*** | 2.055 | 9.584*** | 1.709 | 9.907*** | 1.336 |
| Renew_prod_Xrd | | | -0.0821** | | | | | |
| Int_rateXrd | | | 0.0359 | | | | | |
| GdpXrd | | | -0.0251 | | | | | |
| Ren_prodXsales_abro | | | | | -5.274*** | | | |
| Int_rateXsales_abroad | | | | | 2.960*** | | | |
| GdpXsales_abroad | | | | | -1.780*** | | | |
| Renew_prodXToyota | | | | | | | 0.812*** | |
| Int_rateXToyota | | | | | | | -0.518*** | |
| GdpXToyota | | | | | | | 0.143 | |
| N | 17959 | | 17959 | | 17959 | | 17959 | |

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Using the mlogit command, it was possible to relate all the variables in the model and extract the mean and standard deviation of the coefficients. The latter provides a measure of the heterogeneity in the effects. In particular, it is possible to notice the significant heterogeneity of the coefficients of the variables Renew_prod_, Int_rate and Gdp: a percentage of the investments in the sample is negatively influenced by the production of renewable energy; another percentage of investments is instead directed to destinations where the Gdp does not grow; finally, a very high percentage of investments is concentrated where the interest rate is lower, although the average is positive, not significantly. In the second model, where a set of interaction effects between Renew_prod_, Int_rate and Gdp and rd is included: the effect of R&D is negative for the coefficient of renewable energy production and gdp while it increases the coefficient of the variable Int_rate. This suggests that the company that is more R&D-oriented tends to weight the production of renewable energy less.

Otherwise, all meanings of the means are preserved while the heterogeneity of patents acquires significance, surely a signal of the fact that one of the two houses is more inclined to innovation.

In the third model, the introduction of interactions with sales abroad make count_bilate lose its significance and Int_rate acquires it, with its coefficient definitely negative.

Sales_abroad is a variable describing the car manufacturer's sales outside its original headquarters, in Germany for Volkswagen and in Japan for Toyota; this value significantly varies the heterogeneity of the variables under analysis, making the sign of the relationship change in a way opposite to the initial one. Specifically, the results indicate that renewable energy production and overall demand weigh less for the company with more sales abroad tends to weigh. On the contrary, a higher level of the interest rate increases the probability that the company locates in a specific country whether the company has a higher share of sales abroad; this is probably due to the fact that VW has the highest percentage of sales abroad, and VW is less influenced than Toyota by the declining interest rate, having already demonstrated heterogeneity for this variable.

In the fourth model Int-rate loses significance to reacquire it in the fifth model; in both cases there is still a parent company that is positively influenced by the presence of licenses in the investment destination, while one is negatively influenced.

Furthermore, the Toyota and Vw dummy variables were made to interact with the variables of renewable energy production, interest rate and gdp: Toyota's investments are clearly more localised in the countries where renewable energy production is greater; the variable interest rate also presents considerable heterogeneity:  this could be because Toyota's cost reduction strategy pushes it to invest in places where the business is certainly less expensive thanks to the interest rate; according to this result, the figure 4.5.1 and 4.5.2 where the tendency linear line for United States and China for the indicators renewable productivity and interest rate with opposite slope: USA and China are the favourite place for FDI by Toyota, even though they represent only a portion of the destinations in the model.

Finally, the two companies do not display a significant difference in their sensitivity to GDP as a location determinant.

## 5   Conclusion

From the results obtained, Toyota would seem to be more avant-garde and oriented towards the use of new powertrains, but Volkswagen is moving accordingly, suggesting that the two rivals will remain at the top of the world rankings for a long time to come.

Neither Toyota or VW can certainly be considered laggards with respect to the use of one technology rather than another, although Volkswagen seems to have delayed the introduction of electric or hybrid powertrains more by market choice than by lack of technology; at the same time, Toyota will be able to enjoy the benefits of having been a first mover in hybrid powertrains over the next few years, which is certainly set to be one of the most likely scenarios in the near future.
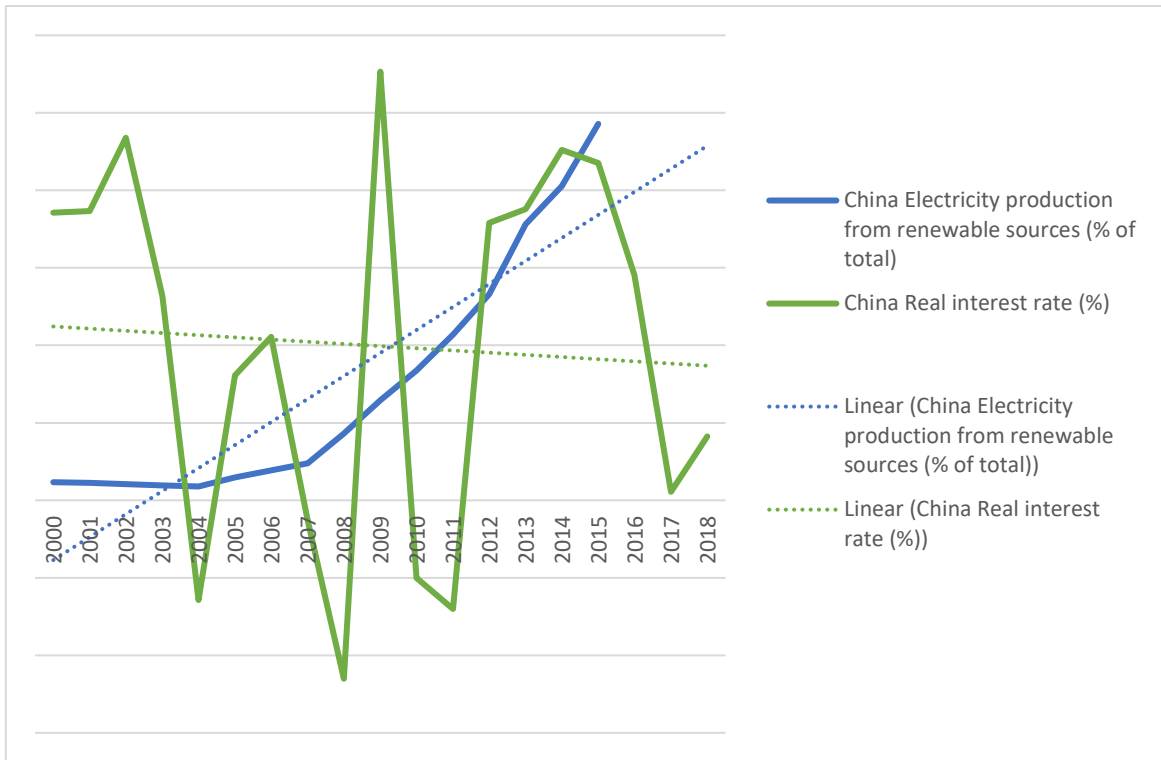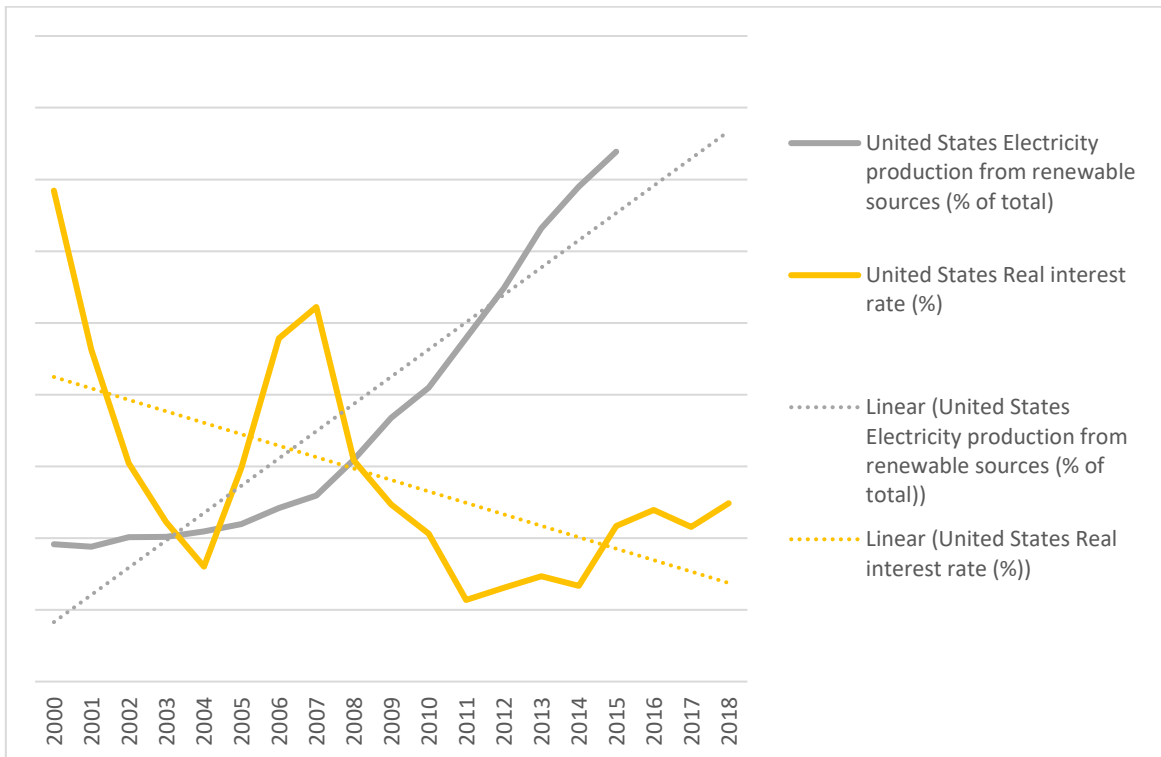
Figure 4.5.1, source: WDI database



Figure 4.5.2, source: WDI database

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