

### Topic and Research Question

The topic of the master thesis has been inspired by the dynamic development of the automobile and its role in our life. Technological advances are followed by years of uncertainty and stagnation. According to R. Maclaurin, the technological breakthroughs have discontinuous wavelike character and the entrepreneurial activity shows a trend to come in clusters (1955, p. 568). The thesis aims to position the automobiles of Volkswagen, Toyota and Hyundai Kia in this discontinuous set of innovations' emergence and poses the research question "How can the performance of the Korean and Japanese automotive companies Hyundai Kia and Toyota be measured against the technological achievement of Volkswagen from 1990 to the present?". The establishment of the electronic fuel system in the early 1990s defines the beginning of the investigation period. The thesis concentrates on the volume produced automobiles with an annual production of 100,000 units. Answering the research question, one can follow the downward migration of innovative solutions for the luxury segment to the middle class.

### State of the Art

An overview on the recovery of the Korean automotive business from the crisis in 1997/98 gives J. Ravenhill (2003). The report of the Swiss Business Hub Japan (2014) provides an analysis of the Japanese automobile industry and its national specifications. In dealing with the innovation capacity of the automotive firms, the reader can go through the paper „The highway to growth” (PwC, 2013). A comparison of the materials used in manufacturing the automobile's body back in the beginning of the 20<sup>th</sup> century and nowadays gives M. Wilhelm (1993). A further research on the application of polymer-composite materials present Strumberger, Gospocic & Bartulic (2005). An insight into the development of new safe assistance systems (ADAS) in the modern vehicles give Staszewski and Estl (2013).

### Methodology and Approach

In the pursuit of comparing the innovation capacity of Toyota and Hyundai Kia, the thesis relies on the tool of benchmarking and uses the technological advances of Volkswagen as a reference point. The framework the master thesis owes B. Godin, R. Maclaurin, the DfT & the CCAV in the UK, and the Oslo Manual. Criteria applied for the period under investigation are:

1. R&D expenditure of each automotive company
2. Capabilities in research - structure and focus of science laboratories/ collaboration with universities
  - Number of engineers & number of patents
3. Exploring the number of the new plants built
4. Annual sales volume of the improved products
5. Introduction of a new method of production
6. Development of new vehicle diagnostics
7. New materials in the manufacture- Al, Mg, MMCs
8. New technology- new drive technology (*Permanent All Wheel Drive*) and new injection technology (*turbocharged petrol engine*)
9. Integration of IT systems →ADAS- ACC, *Automatic Braking, Blind Spot Detection, Driver Drowsiness Detection, Park&Lane Assist, Bird's Eye Perspective*

### Main Facts

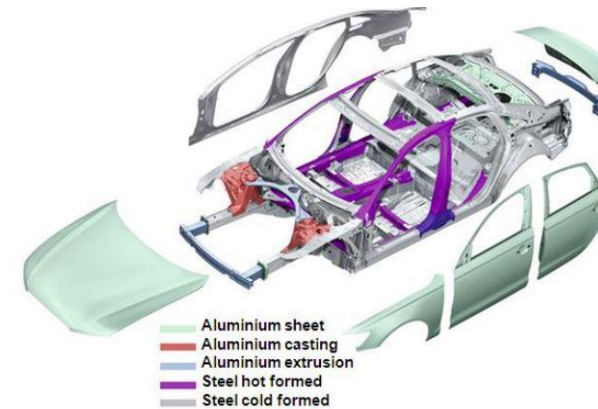
Toyota stands behind Volkswagen and is appointed to be 8<sup>th</sup> among the most generous automotive R&D spenders. Hyundai Kia invested ten times less in R&D operations compared to Volkswagen. The three companies command high tech equipped laboratories. There are no precise statistics on the professional qualifications of the employees engaged in similar tasks in the three companies. Volkswagen puts the emphasis on the applied research. The largest patent applicant is Toyota (in the sphere of electric automobiles). The companies expanded globally, but at a different pace.

In comparison to the combined Volkswagen's sales on the European, Chinese and North American markets, the performance of the Toyota and Hyundai Kia volume vehicles were weaker. Toyota achieved higher sales compared to Hyundai Kia.

The rivals command highly flexible industrial robots. They differ in the focus of their strategies for the future. Volkswagen and Hyundai Kia are in push toward increased automation. Only Volkswagen has developed a new method of production, reorganising processes.

Toyota and Hyundai Kia lack a comprehensive portfolio of diagnostic tools within a consistent system for the interaction with the new automobiles. The body structure and chassis of the volume automobiles with the emblem of Toyota and Hyundai Kia remain steel intensive as none of them uses non-ferrous materials (Al or Mg). Hyundai Kia focuses the Al application solely in the power-train area despite the aluminum casting facility at its disposal. The employment of MMCs of the three companies is limited.

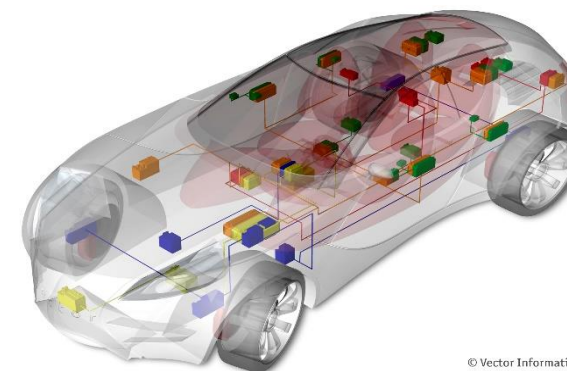
Image 1 Multimaterial body frame of Audi A6 2012



Note: Reprinted from European Aluminium Association, 2013, p. 80.

Volkswagen has integrated the permanent AWD in four volume automobiles. Toyota and Hyundai Kia do not offer a concept of permanent AWD. The companies differ in the level of uptaking the new turbocharged technology. Volkswagen has designed a petrol engine using a turbocharger in 2005, overwhelming the drawback of the turbocharging – the unburned fuel through the 4/6 fuel bores of the injector that disperse the air-fuel mixture into the cylinder. Toyota has not found a solution for the residue. Kia c'eed 2016 has adopted the advanced turbocharged technology in its Kappa engine.

Image 2 Electronic networking in the automobile



Note: Reprinted with permission from Vector Informatik (2017).

Six automobiles of Volkswagen can be designed with all the possible ADAS explored in the thesis. Toyota did not embrace any ADAS as standard and none can be optionally equipped with all of the ADAS. The most purchased automobile in the world– the Corolla features only Automatic Braking and Park Assist. To the majority of Hyundai Kia vehicles, ADAS have been integrated all in a breath – in 2015/16, but some models lack components as Automatic Braking.

### Results

There is no considerable distinction between the three companies in the recruitment policy for their R&D departments. Toyota and Hyundai Kia show preferences in the fundamental research and patenting activities. The annual sales do not reveal whether the models most purchased take advantage of all the technical specifications the thesis considers as innovative attributes. The resistance to the application of light-weight materials for the body structure and chassis indicates the reluctance of Toyota and Hyundai Kia to invest in the reorganisation of the production method and the development of alternative joining and spot welding techniques. They remain passive in the progress toward the creation of multiple and specialised diagnostic tools within a consistent system. The volume vehicles of Hyundai Kia and Toyota stand under the investigation period with restricted potential for enhanced reliability by fast acceleration and fuel efficiency. They wait unprepared for the downward migration of advanced driveline attributes from the high-class vehicles to the mass-produced, and not ready to react to the global pressure to weight reduction and the decline of diesel engines in mainstream models. However, there is a signal coming from the swift (and projected) integration of ADAS in the majority of Toyota and Hyundai Kia's vehicles within the last years, indicating an incipient embrace of several innovative solutions. The continual insistence on the lower selling prices of the volume segment since 1990, reveals that Hyundai Kia and Toyota do not consider the brand of the mass-produced automobiles as a field, where innovative technical solutions can be embedded, and is still restricted by the boundaries of conventional manufacturing processes.

### References

All references can be found in the full version of the MA thesis available at <http://othes.univie.ac.at/>

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