Why does Non-Commercial Early Adopter shun Battery Electric Vehicles?

A Longitudinal Study of Private Customers in Germany

Thomas M. Fojcik and Nicole Schleiffer
University of Duisburg-Essen, Faculty of Engineering,
Chair of General Business Administration & International Automotive Management,
Duisburg (Germany), Email: thomas.fojcik@uni-due.de; nicole.schleiffer@uni-due.de

***Abstract* — In recent years, the electrification of the powertrain determines the entire automotive industry. But the broad market penetration of electric vehicles is still slow. Despite this disappointing development the transition to electric mobility is far from an end. Recent surveys indicate that despite low sales figures of hybrid or electric vehicles the automotive industry will not turn away from electric mobility. Nevertheless, the question remains, why especially the customer group of early adopters, who were identified in a variety of studies as the first prospective customers and who should provoke a broad market penetration, still avoid a purchase of electric vehicles. Against this background the following paper reports about a longitudinal study, which determines the extent to which early adopters, identified in 2010, already have been purchased battery electric vehicles and why - despite a high level of acceptance and willingness to pay - some of those have not completed an acquirement of battery electric vehicles until 2015. The empirical study shows that a market penetration of battery electric vehicles may be triggered by early adopters. However, this can only be achieved if the economic purchase barriers attract more attention and are incorporated in considerations to promote the market diffusion of battery electric vehicles.**

Keywords — Acceptance, Battery Electric Vehicles, Early Adopters, Longitudinal Study, Market Diffusion, Willingness to Pay

I. INTRODUCTION

In recent years, the electrification of the powertrain determines the entire automotive industry. But the broad market penetration of electric vehicles is still slow. Actually, only 33,630 hybrid vehicles (including 11,101 plug-in-hybrids) and 12,363 electric vehicles were sold in Germany in 2015 mainly to commercial customers (market share: < 1%) [1]. Also in other countries electric vehicles are not really gather momentum despite various incentives and subsidies. Thus, it becomes apparent that the initial "E-Hype" seems to come to an end. Despite this disappointing development the transition to electric mobility is far from an end, but is currently evaluated by automotive experts more realistic [2].

Recent surveys indicate that despite low sales figures of hybrid or electric vehicles the automotive industry will not turn away from electric mobility. Rather, high expenditures in research and development, a high level of political pressure as well as economic conditions will still stimulate the transition to electric vehicles [3]. Nevertheless, the question remains, why especially the customer group of early adopters, who were identified in a variety of studies as the first prospective customers and who should provoke a broad market penetration, still avoid a purchase of electric vehicles. Compared to other customer groups this appraisal is surprising, because early adopters generally imply low purchasing barriers [4]. Taking together this argument, the question remains why some non-commercial early adopters still shun electric vehicles (especially battery electric vehicles).

Against this background we replicated in 2015 an own empirical study on acceptance and willingness to pay for electric vehicles (in terms of battery electric vehicles) [4] in order to determine the extent to which early adopters, identified in 2010, already have been purchased battery electric vehicles and why - despite a high level of acceptance and willingness to pay - some of those have not completed an acquirement of battery electric vehicles until 2015. Our paper is organized as follows: In a first step, we describe the current market situation of (battery) electric vehicles. Then we introduce early adopters as first customers of innovative products and services and examine the important role of early adopters for the market diffusion of battery electric vehicles. In a second step, we illustrate a longitudinal study of early adopters conducted in Germany between 2010 and 2015. We present our analysis, followed by the description of the empirical design and the results. Finally, we discuss our results and the need for further research within this field of interest.

II. CURRENT MARKET SITUATION OF ELECTRIC VEHICLES

Although the global vehicle market continuously increases per year, the development of electric vehicles still proceeds very slowly compared to traditional propulsion technologies. In 2014, about 74,763 battery electric vehicles (BEVs), plug-in-

hybrid electric vehicles (PHEVs) and range-extended electric vehicles (REEVs) were sold in the largest global automobile market China. This represents a market share of electric vehicles of 0.32 percent [5]. Even in the second largest global automobile market USA, only 120,213 electric vehicles were recorded in 2014, which means a market share of 0.73 percent [6]. A similar trend is also observed in other important automobile markets, where electric vehicles were well below one percent of total sales in 2014 (e.g. Germany: 13,079 electric vehicles – 0.43 percent [7][8]; South Korea: 856 – 0.06 percent [9]; Japan: 32,418 – 0.69 percent [10].

Table 1: Total Vehicle vs. Electric Vehicle Sales in the Main Global Markets (2010-2014)

	Total Sales				
	2010	**2011**	**2012**	**2013**	**2014**
Germany	2,916,260	3,173,634	3,082,504	2,952,431	3,036,773
China	18,061,900	18,505,100	19,306,400	21,984,100	23,491,900
South Korea	1,465,426	1,474,637	1,534,000	1,137,027	1,453.811
Japan	4,212,267	3,524,788	4,572,332	4,562,282	4,699,590
USA	11,588,783	12,734,356	14,441,814	15,531,706	16,435,286

	Electric Vehicles (BEV, PHEV, REEV)				
	2010	**2011**	**2012**	**2013**	**2014**
Germany	541 0.02%	2,154 0.07%	2,956 0.10%	7,436 0.25%	13,079 0.43%
China	1,466 0.01%	8,159 0.04%	12,791 0.07%	17,642 0.08%	74,763 0.32%
South Korea	66 0.00%	335 0.02%	n.a. n.a.	n.a. n.a.	856 0.06%
Japan	7,719 0.18%	n.a n.a.	n.a. n.a.	29,716 0.65%	32,418 0.69%
USA	345 0.00%	17,813 0.14%	52,526 0.36%	97,562 0.63%	120,213 0.73%

n.a. = not available

Source: Own compilation based on statistics from national automotive associations or press releases

From the customers' point of view the main cause for the low market share are the high purchase costs of electric vehicles [4]. In contrast, the high battery costs and the technological uncertainty, which advanced drivetrain technology (PHEV, REEV, BEV or pure hybrids (HEV) respectively fuel cell electric vehicles (FCEV)) will successfully penetrate in the future, prevent a broad and fast market diffusion of electric vehicles from manufacturers and suppliers point of view [11]. Despite these limiting factors, in particular early adopters could contribute to a fast market penetration of especially battery electric vehicles. Therefore early adopters have to be addressed as a specific group of customers in the next section of the paper.

III. EARLY ADOPTERS AND BATTERY ELECTRIC VEHICLES

In the marketing literature, customer identification and segmentation is a fundamental prerequisite for a successful market launch of new and innovative products as well as services. This, because (I.) potential customers can be detected in an early stage of a market launch, especially so-called innovators and early adopters (in accordance with the diffusion theory of innovation), which can accelerate the market diffusion of new products and services in their role as opinion leaders, (II.) differences between potential customer segments can be identified, so that pricing considerations can be done client-oriented and preferred distribution channels can be detected, (III.) a better satisfaction of customer needs can be achieved by providing a high degree of identity between the new products as well as services and the needs of potential customers, and (IV.) addressee oriented communication tools can be identified between companies and potential customers that will help to reduce purchase barriers as well as barriers to take up new products and services [12]. In contexts of new product or service launches, the customer segment of early adopters was identified as an important customer group, because early adopters are characterized as customers, who use a new product or service in an early stage of the market diffusion and also provide considerable feedback to help product or service launching firms to refine future releases as well as the use of distribution and service channels [13]. Furthermore, early adopters are willing to pay higher prices than customers, who adopt a new product or service in a later stage of the diffusion process, so that firms can already benefit from high revenues in the market launch phase [14].

According to the importance of early adopters, these are intensively studied in the context of (battery) electric vehicles. Here, empirical studies differ in particular in the research objective, if new early adopters should be identified first of all, or existing early adopters should be analyzed on their usage of (battery) electric vehicles [15][16][17][18][19][20][21]. Regardless of the primary research objective, empirical studies show matching results on the characteristics of early adopters in the context of (battery) electric vehicles. Hereinafter, early adopters are mainly characterized as: predominantly male, young respectively middle aged, high educated, live in rural or suburban areas, have environmental concerns, own multiple vehicles in the household, have a high income and show a high technological acceptance and willingness to pay for innovative products and services in general. Furthermore, past studies assume that theoretically around three to seven percent of the population of Western countries tends to this categorization of

early adopters. In light of the characteristics and the distribution of early adopters in the population it is surprising, however, why the market diffusion of especially battery electric vehicles is still slow and why many early adopters avoid a purchase of battery electric vehicles up to date.

Thus an empirical investigation is necessary to examine, why early adopters avoid the purchase of battery electric vehicles as well as the reasons behind this kind of non-purchasing behavior. Such an empirical investigation has been carried out in Germany and will be presented in the following section of the paper.

IV. EMPIRICAL STUDY: METHODOLOGY AND RESULTS

Methodology: Our empirical investigation was divided into two single studies (subsequent denoted as study I and study II). Study I (see for a detailed description of the methodology also [4]) was conducted in 2010 using an online-based survey among non-commercial car customers. Study I was limited to the largest cities in North Rhine-Westphalia in Germany, e.g. Cologne, Bochum, Essen, Duisburg and Dortmund, because such populous urban areas are supposed to be the primary market for battery electric vehicles. In order to not entirely exclude peripheral regions from the investigation, also rural areas were incorporated into the sample, e.g. the district Wesel. Potential survey participants were selected randomly from the above mentioned population, in each case according to the size of the city or district. The total sample consisted of 43,289 non-commercial customers. Each potential survey participant was contacted by postal mail and asked to participate in an online-based survey. If an online-based-participation was not possible, these participants could also attend to the survey in written form. In sum, 2,623 non-commercial customers participated in the survey. This represents a response rate of 6.06%. The final sample indicated no significant differences in the response rate between the selected cities and districts. Furthermore, no significant differences could be identified in the attitude of the survey attendees to battery electric vehicles. Insofar, the final sample included non-commercial customers, who are positive respectively either undecided or critical about battery electric vehicles. For this reason, a sample bias could be ruled out. Thus, the generated survey responds can be regarded as representative. Characteristics of customers as decision-making units as e.g. age, gender, educational level, average monthly income and personal knowledge about battery electric vehicles were surveyed in the questionnaire. Furthermore, customer acceptance and willingness to pay for battery electric vehicles were determined. Customer acceptance was measured as a composite factor consisting of eight sub-variables (relative advantage, compatibility, complexity, trialability, observability, individual behavior as well as subjective norms, perceived usefulness and perceived ease of use). To measure relative advantage, compatibility, complexity, trialability as well as individual behavior and subjective norms items from Peters et al. [20] were adapted in a condensed form. Perceived usefulness and perceived ease of use were operationalized using adjusted items from Sawng et al. [22]. Because literature does not provide much help in developing measures for the variable observability, a new measure was developed. Survey participants were asked to rate the visibility of battery electric vehicles on the street or in media reports along two seven-point scales ranging from unfrequent to frequent. After the exclusion of non-meaningful items from the further analysis, the ratings of the survey participants indicated based on principal components analysis that all other items loaded mainly on a single factor due to the above mentioned variables. Hence, all items were summed up in a single, composite index-factor ranging from 1-100 points, which reflects customers' overall acceptance related to battery electric vehicles. Index-levels lower than 33 points, 33 up to 66 points and higher than 66 points indicated a low, a medium and high customer acceptance of battery electric vehicles. Customer willingness to pay was examined on the basis of choice-based conjoint logic according to pricing research literature [23][24][25]. By means of choice-based conjoint analysis, customers were asked to reiteratively evaluate (notional) battery electric vehicles with varying attributes (e.g. price, car segment, top speed, range, charging time, max. vehicle payload, etc.), if they would buy or reject one or more of these different choice-sets. Statistical analysis of these evaluations followed research literature and included the likelihood-ratio-test and McFadden-R^2 [26]. Furthermore, a supplementary cluster analysis was conducted to derive different customer segments as well as to identify early adopters of battery electric vehicles.

Study II was conducted in 2015 and thus five years after study I. In study II only early adopters, who were examined in 2010, were considered in more detail. In addition to the individual characteristics, the customer acceptance and willingness to pay, which were measured by the same methodology as in 2010, also possible rationales were evaluated, why some early adopters have already purchased respectively have not purchased a battery electric vehicle. To compare the means of customer acceptance and willingness to pay ratings between the both investigated time points an one-way analysis of variance (one-way ANOVA) was conducted using the F-distribution [27]. The normal distribution was tested using the Kolmogorov-Smirnov-Test and homogeneity of variance using Levene's-test [28].

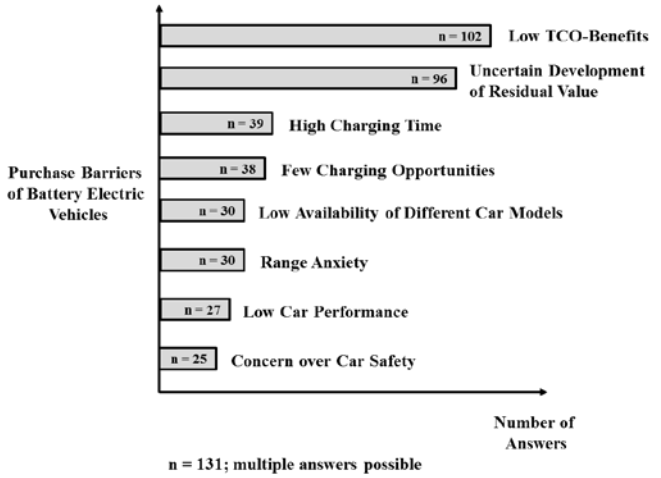
Results: In the first study, the total sample consisted of 2,623 private customers, of which 186 (7.09%) belonged to the early adopter group. The segment of early adopters comprised green enthusiasts which are mainly innovators as well as high-end consumers. These customers had a strong environmental and innovation orientation or distinct status considerations. Furthermore, a high customer acceptance score (CAS) on an average of 86.2 points (CAS_{2010} = 86.2; $CAS_{Max.}$ = 100.0; $CAS_{Min.}$ = 0.00) and a willingness to pay (WTP) of 29,600 EUR for an illustrated battery electric vehicle (WTP_{2010} = 29,600 EUR) were measured. All early adopters intended to purchase a battery electric vehicle in the next three to five years (in the narrow sense: mini car segment, 24 kWh (lithium-ion battery pack), 7 h (charging time), 150 km (range), 130 km/h (top speed), 36 month (warranty)).

In 2015, a reexamination of early adopters was conducted. From 186 early adopters in 2010 still 131 (70.4%) participated in the replication study. Of the 131 respondents, 18 early

adopters (13.7%) have purchased a battery electric vehicle. The average acceptance and willingness to pay in this customer group was close to the level of the measurement in 2010 (CAS_{2015} = 82.4; WTP_{2015} = 28,200 EUR). Significant differences could not be revealed between both measurement points. In contrast, 113 early adopters (86.3%) have not purchased a battery electric vehicle. Surprisingly, the average acceptance among this group remained still at a high level and indicated no significant differences to the measurement in 2010 (CAS_{2015} = 79.4). The willingness to pay in this group, however, significantly decreased to a level of 21,400 EUR (WTP_{2015} = 21,400 EUR).

An additional analysis revealed that the acceptance and willingness to pay of early adopters were neither affected through technological limitations and conditions of the use of battery electric vehicles (e.g. charging time and opportunities, availability of different car models) nor through subconscious barriers (e.g. range anxiety).

Table 2: Purchase Barriers of Battery Electric Vehicles from the Point of View of Early Adopters



Source: Own calculation and illustration

Moreover, a majority of early adopters repeated the intention to purchase a battery electric vehicle in the near future, but at a significantly lower willingness to pay than measured in 2010. They justified the absence of a high willingness to pay with two economical barriers that clearly determinate the purchase of battery electric vehicles between 2010 and 2015:

(I.) Low total-cost-of-ownership (TCO) benefits of battery electric vehicles over conventional combustion vehicles. Many early adopters assumed that the high purchase costs of battery electric vehicles cannot be compensated through lower taxes, lower repair and maintenance costs as well as the favorable fuel costs.

(II.) High uncertainties related to the development of the residual value of battery electric vehicles. A majority of early adopters stated that they are currently not able to estimate the residual value of battery electric vehicles, whereby the willingness to pay significantly decreased compared to the measurement in 2010.

V. DISCUSSION AND CONCLUSION

Our analysis indicates that battery electric vehicles already find acceptance in Germany, especially in the customer group of early adopters. 13.7% of the early adopters, who attended to our study I and II, have already purchased a battery electric vehicle until 2015. The other part of early adopters is neither undecided nor critical in the face of battery electric vehicles as frequently observed in other customer groups. The acceptance of early adopters remained at a high level between the both measurement points. From this it can be concluded that battery electric vehicles (with their current technical equipment and configuration) are already very close to the needs of this customer group. Nevertheless, the customer willingness to pay for battery electric vehicles decreased between the both measurement points up to 21,400 EUR, and is around 5,000 and up to 10,000 EUR below current market prices in Germany. However, the reasons for the decline of the willingness to pay are not, as commonly reported, affected through technological limitations and conditions of the use of battery electric vehicles. Rather the decline is determinated through low total-cost-of-ownership benefits and concern over the development of the residual value of battery electric vehicles from the point of view of early adopters.

The results of the empirical study lead to the conclusion that a market penetration of battery electric vehicles may be triggered by early adopters. However, this can only be achieved if the economic purchase barriers attract more attention and are incorporated in considerations to promote the market diffusion of battery electric vehicles. Current political considerations due to financial subsidies for purchasing battery electric vehicles may certainly reduce the economic barrier of a negative total-cost-of-ownership total account. Disregarded in this case, however, remains the uncertain residual value, which also exacerbates the negative total-cost-of-ownership balance of battery electric vehicles and thereby determines today's purchasing decisions. Rudimentary market approaches of automotive firms to reduce the uncertainty of the residual value (especially of the battery) through leasing offers certainly represent an additional and adequate market solution. Regardless, further subsidies should be taken into account to reduce uncertainties especially of the residual value of battery electric vehicles. To which extent these economical barriers will be considered during the market launch stage of battery electric vehicles remains to be seen in the future. But precisely against this background, advanced studies can contribute to this field of interest by identifying market solutions, which are able to reduce these economical barriers.

REFERENCES

[1] **Kraftfahrt-Bundesamt (2016):** *Fahrzeugzulassungen im Dezember 2015*, Pressemitteilung Nr. 01/2016, Kraftfahrt-Bundesamt, 2016.

[2] **University Duisburg-Essen (ed.) (2013):** *Competitiveness of the EU Automotive Industry in Electric Vehicles, Final Report*, EU, Brussels.

[3] **Proff, H.; Fojcik, T. M.; Kilian, D. (2015):** Value added and competences in the transition to electric mobility – an analysis of the European automotive industry, *Int. J. Automotive Technology and Management*, Vol. 15, No. 1, pp. 20-42.

[4] **Fojcik, T.M.; Proff, H. (2014):** Accelerating market diffusion of battery electric vehicles through alternative mobility concepts, *Int. J. Automotive Technology and Management*, Vol. 14, Nos. 3/4, pp. 347-368.

[5] **CAAM (2015):** *Automotive Statistics*, China Association of Automobile Manufacturers, http://www.caam.org.cn/AutomotivesStatistics/20150114/0905144510.html.

[6] **NADA (2014):** *Automotive Statistics*, National Automobile Dealers Association, NADA, 2014.

[7] **KBA (2015a):** *Fahrzeugzulassungen 12/2014*, Kraftfahrt-Bundesamt, http://www.kba.de/SharedDocs/Publikationen/DE/PM/2015/pm_01_15_fahrzeugzulassungen_12_2014_pdf.pdf?__blob=publicationFile&v=5.

[8] **KBA (2015b):** *Statistik, Kraftfahrt-Bundesamt*, http://www.kba.de/DE/Statistik/Fahrzeuge/Neuzulassungen/MonatlicheNeuzulassungen/2014/201412GV1monatlich/201412_n_barometer_teil2_tabelle.html?nn=653844.

[9] **EV-sales.blogspot.de (2015a):** *South Korea December 2014* (Draft Edition), http://evsales.blogspot.de/2015/01/south-korea-december-2014-draft-edition.html.

[10] **EV-sales.blogspot.de (2015b):** *Japan December 2014*, http://ev-sales.blogspot.de/2015/01/japan-december-2014.html.

[11] **Altenburg, T. (2014):** From Combustion Engines to Electric Vehicles. A Study of Technological Path Creation and Disruption in Germany, *German Development Institute (DIE)*, Discussion Paper 29/2014, pp. 1-44.

[12] **Meffert, H.; Burmann, C.; Kirchgeorg, M. (2012):** *Marketing. Grundlagen marktorientierter Unternehmensführung. Konzepte – Instrumente – Praxisbeispiele*, 11. überarbeitete und erweiterte Auflage, Wiesbaden 2012.

[13] **Rogers, E. M. (1962):** *Diffusion of Innovations*, Free Press of Glencoe, Macmillan Company, 1962.

[14] **Proff, H.; Fojcik, T. M.; Kestner, K.; Schleiffer, N. (2014):** Das E³-Prinzip – Early Adopter als Enabler der Elektromobilität, *Zeitschrift für die gesamte Wertschöpfungskette Automobilwirtschaft (ZfAW)*, Ausgabe 02/2014.

[15] **EurotaxGlass's (2011):** *Electrification of the Automotive Industry – The European Consumer's View*, Eurotax-Glass's Report, Maintal, 2011.

[16] **Fojcik, T. M.; Schwarz, S.; Kilian, D.; Proff, H. (2011):** *Marktanalyse zur Zahlungsbereitschaft für rein batterie-betriebene Elektrofahrzeuge und Ladeinfrastrukturnutzung*, Abschlussbericht colognE-Mobil, 2011.

[17] **Peters, A.; Popp, M.; Agosti, R.; Ryf, B. (2011):** *Electric Mobility – a survey of different consumer groups in Germany with regard to adoption*, ECEEE 2011 Summer Study, Energie Efficiency First: The Foundation of a Low-Carbon Society, 2011.

[18] **Campbell, A. R.; Ryley, T.; Thring, R. (2012):** Identifying the early adopters of alternative fuel vehicles: A case study of Birmingham, United Kingdom., *Transportation Research Part A: Policy Practice*, Vol. 46, pp. 1318-1327.

[19] **Carley, S.; Krause, R. M.; Lane, B. W.; Graham, J. D. (2013):** Intent to purchase a plugin electric vehicle: A survey of early impressions in large US cites. *Transportation Research Part D: Transportation Environment*, Vol. 18, pp. 39-45.

[20] **Peters, A.; Dütschke, E. (2014):** How do Consumers Perceive Electric Vehicles? A Comparison of German Consumer Groups, *Journal of Environmental Policy & Planning*, Vol. 16, pp. 359-377.

[21] **Plötz, P.; Schneider, U.; Globisch, J.; Dütschke, E. (2014):** Who will buy electric vehicles? Identifying early adopters in Germany, *Transportation Research Part A: Policy Practice*, Vol. 67, pp. 96-109.

[22] **Sawng, Y-W.; Kim, S-H.; Lee, J.; Oh, Y. S. (2011):** Mobile services usage behavior in Korea: an empirical study on consumer acceptance of innovative technologies, *Technological and Economic Development of Economy*, Vol. 17, No. 1, pp. 151-173.

[23] **Louviere, J.; Woodworth, D. (1983):** Design and analysis of simulated consumer choice or allocation experiments. An approach based on aggregated data, *Journal of Marketing Research*, Vol. 20, No. 4, pp. 350-367.

[24] **Cohen, S. H. (1997):** Perfect union, *Marketing Research*, Vol. 9, No. 1, pp. 12-17.

[25] **Orme, B. K. (2009):** Which Coinjoint Method Should I Use?, *Sawtooth Software – Research Paper Series*, 2009.

[26] **Balderjahn, I.; Hedergott, D.; Peyer, M. (2009):** Choice-based conjoint analyse, Baier, D.; Brusch, M. (Eds.): *Conjointanalyse. Methoden – Anwendungen – Praxisbeispiele*, pp. 129-146, Heidelberg, 2009.

[27] **Field, A. (2005):** *Discovering Statistics using SPSS*, 2nd ed., London, 2005.

[28] **Levene, H. (1960):** Robust tests for equality of variances, Olkin, I.; Ghurye, S. G.; Hoeffding, W.; Madow, W. G.; Mann, H. B. (Eds.): Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling, pp. 278-292, Stanford University Press, 1960.

Biographical notes: *Dr. rer. pol. Thomas M. Fojcik is a Research Assistant at the Chair of General Business Administration & International Automotive Management at the University of Duisburg-Essen (Germany). He studied General Business Administration at the University of Hamburg and Corporate Management & Economics at the Zeppelin University in Friedrichshafen (Germany). His research interests are Strategic Management, Innovation, Organizational Change, Knowledge and Learning in the Automotive Industry.*

Nicole Schleiffer is a Doctoral Researcher at the Chair of General Business Administration & International Automotive Management and at the IN-EAST School of Advanced Studies at the University of Duisburg-Essen (Germany). She studied Business Administration at the University of Applied Sciences in Koblenz and at the Technical University in Dortmund (Germany). Her research interests are International Management and Strategy in the Automotive Industry.
