THE CORRELATION OF INFORMATION AND KNOWLEDGE IN REGARD TO THE ACCEPTANCE LEVEL AND THEIR IMPLICATION ON SELF-DRIVING CARS IN GERMANY

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Abstract
Driver assistance systems are on the rise and shall prospectively develop to autonomous (also called: self-driving or driverless) cars. Their broad acceptance has not been thoroughly scientifically researched until now. In a previous paper, information and knowledge has been hypothetically identified as a key influencing factor in the acceptance forming process (Geldmacher et. al., 2017). For this purpose, information and knowledge is equalized by major events and news over the past five years in the field of self-driving vehicles in this paper. Acceptance is equalized by positive evaluation and effect and operationalized by a subjective evaluation of above described events and respective reactions on the stock market.
Given the premises that no other unknown variable further influences the level of acceptance through information and knowledge, above deployed hypothesis is proven.

Key words: autonomous cars, self-driving cars, innovation, technology acceptance, automobile industry, UTAUT

JEL Classification: O31

I. INTRODUCTION

Autonomous cars are on the rise, not only because of the technological advances, but also due to society's demands that are based on changing social and economic changes and trends. Although this innovative transport mode is characterized by several advantages, critics emphasize weaknesses and threats that include social acceptance (Geldmacher and Plesea, 2016). Acceptance among the society is there for a key success factor for self-driving cars and can be defined as both positive evaluation and resulting affect (Geldmacher et al., 2017).

Models and theories in regard to technology acceptance have evolved over the last decades to describe the acceptance forming process and measure the influencing factors. An analysis of the most fundamental acceptance models and theories has revealed three key components that include (Geldmacher et al., 2017):

- individual influencing factors,
- external influencing factors and
- stages or phases of use.

While elaborated models and theories are partly theme-specific, they do not fully refer to the application of measuring the level of acceptance of non-existent innovations, such as self-driving cars in a car sharing model. The modification of existing models was therefore proposed by Geldmacher et al. (2017).

The suggested modified model is primarily based on the unified theory of acceptance and use of technology (UTAUT) by Venkatesh et al. (2003). The modified model incorporates, among other changes to UTAUT, the replacement of the influencing factor "experience" by "knowledge/ information". This replacement was suggested due to the fact of non-existence and thereof experience of car sharing model with self-driving cars. The proposed hypothesis by Geldmacher et al. (2017) of including information or knowledge as a key influencing factor in the acceptance forming process is verified in the context of this paper.

This hypothesis is tested, based on a trend analysis that compares the desire for information or knowledge (measured by Google trends) on the topic of self-driving cars and its correlation with news and the effects on stock market trends. The research is elaborated for the German market.

II. INFORMATION AND KNOWLEDGE

Information as an immaterial good is defined as the (new) knowledge about an object, a person or circumstances (Springer Gabler Verlag, s.a.). Knowledge is based on extensive information, including data. Knowledge can be gained actively or passively and can be clustered as follows in regard to products and services (Brucks, 1986):

Abstract-declarative: general knowledge about products and their characteristics (e.g. driver assistance technologies in cars)

Specific-declarative: knowledge about a specific product and its characteristics (e.g. Tesla's software for self-driving cars)

Abstract-procedural: knowledge about product handling (e.g. turning driver assistance systems on or off)

Specific-procedural: knowledge that is gained through individual habits and experiences (e.g. experience with self-driving cars)

Evaluative: knowledge that is directly related to a personal positive or negative evaluation of a product or service (personal preference to drive cars with driver assistance systems)

Brucks (1986) clustering of knowledge emphasizes the subjective influence (evaluative knowledge).

Based on the definition of information, knowledge and acceptance, information is characterized as a prerequisite for knowledge that develops throughout time. Information and knowledge along with numerous other influencing factors is expected to be one of the prerequisite to acceptance (cf. figure 1).

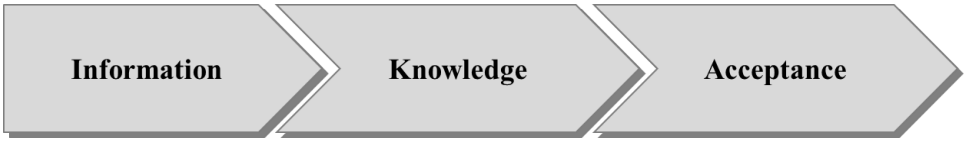


Figure 1: The process from information to knowledge to acceptance (own figure)

In order to verify that acceptance is a consequence of information or knowledge, a definition for "acceptance" is required: Acceptance describes a psychological process that is characterized as a conglomeration of evaluation and affect (Geldmacher et al., 2017). Combining the above outlined definitions, the following empirical formulas can be derived, showing the correlation of information, knowledge and acceptance:

$$I * x = K$$
$$A = EV + AF$$

Hypothesis: $K + x = EV + AF$

A = Acceptance
K = Knowledge
I = Information
EV = Evaluation
AF = Affect
x = amount

Formula 1: The correlation of information, knowledge and acceptance

The following analysis is based on actively sought information measured by Google Trends (period under review: mid-2012 until mid-2017). However, this sort of analysis has its limitations as it does not include passively gained information or generated knowledge. This limitation can be avoided by assessing the level of information and knowledge, regardless of the form (actively or passively) through a questionnaire and correlate their impact on the level acceptance.

III. THE RISING IMPORTANCE OF SELF-DRIVING CARS

The news broadcast on self-driving cars has subjectively increased in the last year. In order to verify this subjective feeling and the importance of information and knowledge in regard to acceptance, the Google search index is used as an indication. For that purpose, the following German similar terms that are used in the literature and in newspaper articles are searched to define the most common term that relates to self-driving cars:

- "selbstfahrende Kraftfahrzeuge" (equivalent to "self-driving vehicles")
- "selbstfahrende Autos" (equivalent to "self-driving cars")
- "autonome Autos" (equivalent to "autonomous cars")
- "autonome Kraftfahrzeuge" (equivalent to "self-driving vehicles")

Google Trends (databasis: Germany) shows a clear online search preference of the term "selbstfahrende Kraftfahrzeuge" (equivalent to" self-driving vehicles"), followed by "selbstfahrende Autos" (equivalent to "self-driving cars"). Both terms are interchangabely used in this paper. The trend analysis that reaches back as far as 2012, also clearly shows an increasing search index until July 2017 with several observable peaks and lows (cf. figure 2). In addition to a clear search preference of a particular term, the trend analysis reveals an overall rising search index for this topic (and all analysed terms), indicating a steadily increasing interest, thereby a high level of information and consequently a braod knowledge in this topic.

Google Trends index for selected terms related to self-driving vehicles

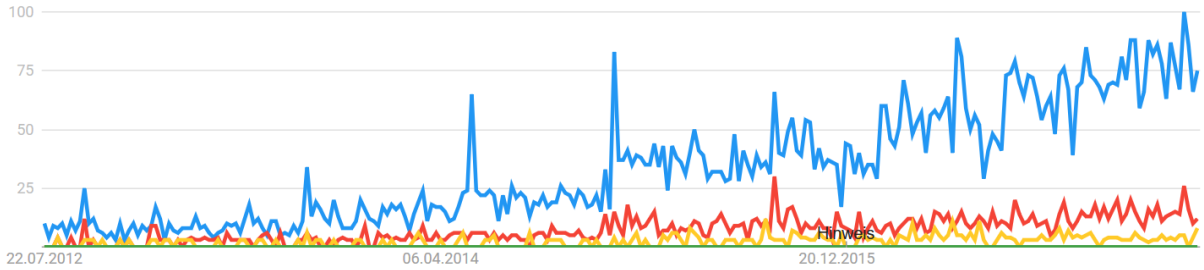


Figure 2 – Trend analysis (2012 - 2017), Source: Google Trends (www.google.com/trends) (date of assessment: 22nd July 2017)

Putting the most reserached term of the above selected similar terms "selbstfahrende Kraftfahrzeuge" (equivalent to" self-driving vehicles"; marked as ● in figure 3) in correlation with "Fahrerassistenzsystem" (equivalent to driver assistance systems; marked as ● in figure 3), an intresting development can be observed: While the amount of searches for both terms is relatively low in 2012, both terms rise in importance throughout the last four years. However, while driver assistance systems were of higher research importance from 2012 until 2015, the last quarter of 2015 reveals a trend change. From 2015 until mid 2017 the Google index of self-driving vehicles has outpaced driver-assistance systems with one exceptional peak in December 2016.

Google Trends index for selected terms related to self-driving vehicles

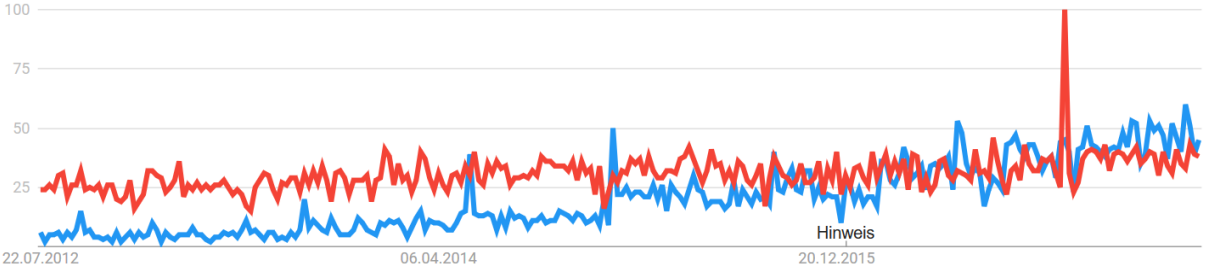


Figure 3 – Trend analysis (2012 - 2017), Source: Google Trends (www.google.com/trends)

Google searches are considered as a source of information, that can then be transformed into knowledge and consequently possibly into acceptance per derived empirical formula.

IV. EVALUATION AND AFFECT AS A CONSEQUENCE OF KNOWLEDGE

Well-known technology acceptance models have excluded the role of information and knowledge in the acceptance forming process to the greatest possible extent. However, research has shown the importance of this

variable, especially in regard to innovations. Existing cognitions can influence the human's behavior in regard to evaluation and affect (acceptance), as knowledge can help to understand the product's characteristics (Binsack, 2013). While knowledge on similar products or services and their respective connotations is displayed on the innovation (self-driving cars), knowledge is one of the most important sources for evaluation (Herbig und Kramer, 1994). An analysis on electro mobility also shows the correlation of knowledge and acceptance (Fazel, 2014).

The following approach that aims at declaring evaluation and affect acceptance as a consequence of knowledge is characterised by limitations: The reaction at the stock market (= evaluation and affect) is only a fraction of the subjective preparatory evaluation that is subjectively done as it is supported by additional previous knowledge and its respectice influence.

Despite the limitations, an approach was defined that can partially prove the correlation of evaluation and affect with knowledge. This approach is subdivided by three steps and relates to the timeframe mid-2012 until mid-2017:

1. Analyze the level of information/knowledge on self-driving vehicles (based on Google Trends)
2. Estimate the subjective evaluation of the identified peaks (events) that lead to an increase of information desire (hence an increase of the search index)
3. Compare the expected evaluation with effects on the stock-market

For that purpose, five significant peaks for searching the term "selbstfahrende Kraftfahrzeuge" (equivalent to "self-driving vehicles") from the last 5 years were chosen and highlighted in the following figure (cf. figure 4) for further analysis.

Periodic peaks for "selbstfahrende Kraftfahrzeuge" (equivalent to "self-driving vehicles")

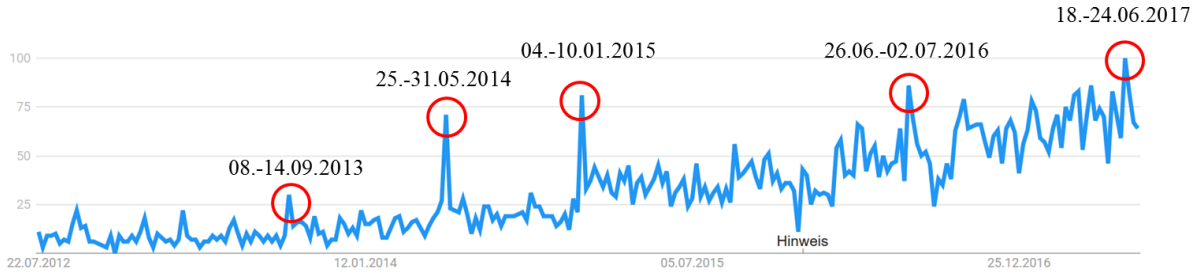


Figure 4 – Trend analysis (2012 - 2017), Source: Google Trends (www.google.com/trends)

The above identified peaks are then analysed in regard to the released news on the respective dates. The search for news is done through Google and limited to the respective timeframe of the peak. The search is done with the above referred most used terms: "selbstfahrende Kraftfahrzeuge" (equivalent to "self-driving vehicles") and "selbstfahrende Autos" (equivalent to "self-driving cars"). The identification of reasons for peaks reveal major events that range from the presentation of models with self-driving abilities to announcements and legislative adaption. The following table 1 summarizes the events:

Date	Event/ news	Company	Source
08.-14.09.2013	International Motor Show (IAA) as the world's biggest exhibition for the automitive industry ➔ Release of new technologies that are presented at the IAA	-	Grünweg, 2013
25.-31.05.2014	Presentation of the Google self-driving car project	Google	Google self-driving car project, 2014
04.-10.01.2015	Presentation of the current status of self-driving cars at the consumer electronics show; focus: Daimler	Daimler	Zeit Online, 2015
26.06.-02.07.2016	Accident with a Tesla car	Tesla	Hengstenberg and Hucko, 2016
	Announcement of BMW to release a self-driving vehicle until 2021	BMW	Handelsblatt, 2016
18.-24.06.2017	Definition of ethical requirements for self-driving cars	-	Heuzeroth, 2017
	Full implementation of self-driving	-	Deutsche Welle, 2017

	cars is expected by 2040		

Table 1 – Major events and news around self-driving vehicles

Three of the fice identified peaks for searches are not directly correlated to a company and thereof do not allow the third step of the above described approach. This reduces the number for further investigation and application of the approach to four events, referring to Google, Daimler, Tesla and BMW.

Based on the identified events and announcements, a subjective evaluation of these is added. This evaluation states whether or not the identiefied event is characterised by a positive or negative personal connotation and is based on the author's opinion (cf. table 2).

Event/ news	Subjective evaluation
Presentation of the Google self-driving car project	Positive connotation
Presentation of the current status of self-driving cars at the consumer electronics show; focus: Daimler	Positive connotation
Accident with a Tesla car	Negative connotation
Announcement of BMW to release a self-driving vehicle until 2021	Positive connotation

Table 2 – Subjective evaluation of selected news events

In the third and last step the evaluation of the events is to be reconfirmed by a certain affect when taking into account that acceptance is a conglomeration of positive evalution and affect. The affect is equalized by a reaction on the stock market for the concerned company. As a rule of thumb, positive events lead to a positive development on the stock market, while negative events lead to a negative stock price (Schnobrich and Bartz, 2013).

In order to analyse the subjective evaluation and its effect on the stock market, the stock price of the respective companies is examined one month in advance and one month after of the identified event (Wallstreet online, 2017). The given trend is related to the highlighted event date and the development of the stock price one month after the event. A summary of this investigation is illustrated in table 3 and supplemented by explaining interpretations below.

Event/ news	Company	Development stock market
Presentation of the Google self-driving car project	Google	523,10 USD (25.04.2016) **571,65 USD (30.05.2016)** 685,20 USD (24.06.2016) Trend: positive 14.07.2017: 976,91 USD (Wallstreet Online, 2017) 
Presentation of the current status of self-driving cars at the consumer electronics show; focus: Daimler	Daimler	66,58 EUR (12.12.2014) **69,42 EUR (09.01.2015)** 82,35 EUR (06.02.2016) Trend: positive 14.07.2017: 64,87 EUR (Wallstreet Online, 2017) 

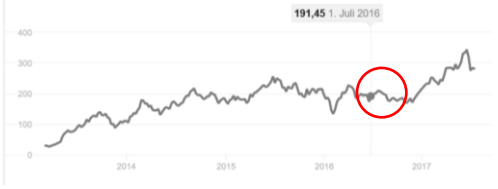
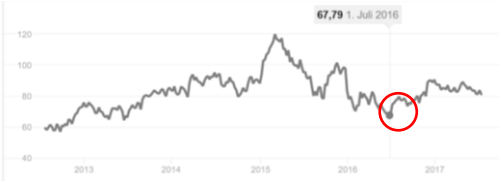
Accident with a Tesla car	Tesla	218,99 USD (03.06.2016) **216,50 USD (01.07.2016)** 230,03 USD (05.08.2016) Trend: negative (if compared to June 2016) 14.07.2017: 327,78 USD (Wallstreet Online, 2017) 
Announcement of BMW to release a self-driving vehicle until 2021	BMW	72,27 EUR (03.06.2016) **67,79 EUR (01.07.2016)** 77,92 EUR (05.08.2016) Trend: positive 14.07.2017: 83,74 EUR (Wallstreet Online, 2017) 

Table 3 – Implications of events and news on the development of the stock market

The trend analysis of the stock market shows a clear correlation of subjective evaluation and stock price in all investigated cases (4 out of 4). The results of this correlation are summarised in the following table (cf. table 4):

Event/ news	Subjective evaluation	Stock market trend	Match of evaluation and stock market trend
Presentation of the Google self-driving car project	Positive connotation	⇗	✓
Presentation of the current status of self-driving cars at the consumer electronics show; focus: Daimler	Positive connotation	⇗	✓
Accident with a Tesla car	Negative connotation	⇘ (if compared to previous month)	✓
Announcement of BMW to release a self-driving vehicle until 2021	Positive connotation	⇗	✓

Table 4 – The correlation of evaluation and stock market trend (= affect)

Based on these results, the above suggested hypothesis is to a large extent confirmed ($K + x = EV + AF$) based on this investigation. As mentioned before, the chosen approach has its limits, as the reactions on the stock market and thereby the stock price is also influenced by further events, such as personal reasons or mergers.

V. CONCLUSION

The terms information and knowledge are strongly interrelated and were proven to be a prerequisite for acceptance. The suggested hypothesis to include information and knowledge in acceptance models by Geldmacher et al. (2017) was thereby confirmed for this example.

The selected approach that evaluated acceptance solely based on the stock market development is recommended to be reconfirmed by further analysis of the correlation of information/knowledge and acceptance.

The authors suggest to conduct a questionnaire on the topic of self-driving cars, evaluating the acceptance and correlation of information/knowledge and acceptance, based on structural equation modeling.

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