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THE APPLICATION OF QUANTITATIVE METHODS FOR THE MODIFICATION OF A BUSINESS MODEL IN THE DIGITAL ERA, WITH THE SUPPORT OF THE MAPLE SYSTEM

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Abstract. *Businesses can gain strength and thus purposefully optimize their commercial models by means of implementing open innovations. The innovation process is increasingly conditioned by the innovative activities of customers. It is necessary to perform quick, low-cost, and rational research so that outputs can be updated and implemented into business models in-time. Digital transformation supports these processes because it represents a good opportunity for free spatial-temporal communication, and for the timely interaction of the participating parties.*

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This contribution stems from research (under the supervision of the paper's co-author, von Böhlen, 2021) performed in the German automotive industry, and follows up on the work of Simberova and von Böhlen (2021). The aim is to perform further and more detailed analyses and to interpret facts that ensue from selected research outputs.

These analyses are oriented solely towards the issue of open innovations as seen from the customer's perspective: innovations used for scaling business models in the automotive industry. Focus is especially placed on factors and relationships which affect customers' willingness to enter the open innovations process. The customer's social status has been taken into account. The rate and willingness of customers to engage in innovation activities has been measured – in connection with a whole range of factors, especially financial, those based on benefits, and others. Another form of analysis was a statistical evaluation that identified the degree of interest in some selected types of benefits. The independence of selected agents that stem from the survey evaluation was also considered, and quantitative methods, mainly statistical calculations, and transparent statistical visualizations were employed for this purpose. The methods of descriptive statistics and categorical analysis were used for processing data sets in the environment of the advanced Maple System.

These findings confirm that the customer is becoming a non-stationary and important source of information and possibly also a source of inferences regarding open innovations. Society is thus increasing its potential to work not only for the customer, but also with them. It is necessary to be ready to react to current pitfalls and to communicate with the customer continuously. Pertaining to implementing open innovations, these analyses have given interesting concrete output and findings regarding decision-making in the process of amplifying the business model in the automotive industry, as seen from the customer's viewpoint, and in the era of digitization. Further, they have opened a whole range of challenges related to further analyses of the matter at hand.

Keywords: *automotive industry; business model; Maple; statistical methods; open innovation; questionnaire evaluation; visualization*

JEL Codes: *C02; C10; M19; O36*

1. Introduction

The term innovation, especially open innovation, has been playing an important role in the sphere of commercial enterprises. Currently, in this process, the customer represents the key factor. The innovation process begins with an impulse – an idea, a proposal, a thought – and ends with the implementation on the market; more precisely, it ends with feedback. Producers and employees ought, naturally, to be willing to hear the customer domain, and should likewise offer enough space for communication with customers and for utilizing their innovative capabilities. Customers, on the other hand, ought to want to be motivated by producers and employees, and to have a convenient pathway to share their ideas and thoughts on a product or service, its innovation, and its implementation.

Business companies may amplify and thus optimize, in a meaningful way, their business models. This can be a part of the innovation process which is conditioned by customers' innovation activities. Innovations are, at present, seen as a moving force of a firm's performance – especially for the support of its competitiveness, prosperity, economic development, sustainability, efficiency, ability regarding digitization and automation, and so on. At the same time, the assessment of innovation projects, the management of innovative strategies, and the costs linked to these processes all pertain to important implementation factors.

Not only acceleration and turbulence in all spheres of human life, but also the stormy protests of planet Earth as it reacts to the heavy, unfavorable, and ill-advised interventions of man are necessarily leading to concrete changes along with new forms of human activities. The deployment of information and communication technologies (ICT) and the digital transformation of society represent basic instruments for the implementation of changes, in order to bring about rational and sustainable life on planet Earth.

For the formation or amplification of business models, it is necessary to perform inexpensive, rational, and telling research. A suitable digital transformation can provide free communication space-time for the timely interaction of the producer, seller, employee, and customer. Recently, blogs, online panels, and open customer communities have emerged as popular communication platforms. For instance, Eugene Ivanov's views are discussed on the *Innovazione* blog, which considers from this vantage point the issue of using crowdsourcing, and probes for opening innovations in connection with forming three basic commercial models based on: market-created innovation, sustainable innovation, and efficient innovation (La Vopa, 2017).

Many experts occupy themselves with the open innovations issue. In the Czech Republic, this phenomenon is supported by the Ministry of Industry and Commerce (MPO). In May, 2021, the MPO published the "Výzva programu podpory Inovace-Inovační projekt v rámci implementace Operačního programu Podnikání a inovace pro konkurenceschopnost 2014–2020" (in English – "Call of the Innovations Support Program – Innovations Project as Part of the Implementation of the Enterprise and Innovation for Competitiveness Operational Program 2014–2020).

Let us mention Veber et al.'s (2016) publication, in which the authors dealt with innovations both from a macroeconomic and a microeconomic point of view – namely: designing corporate innovation strategies, considering the implementation cycle of innovations as a tool to support prosperity and competitiveness, and perceiving innovations' coverage of all areas (tangible and intangible). The authors concern is also with the transformation of the German economy into a clean energy one.

The *Hospodářské noviny* newspaper (in English – *Economic Newspaper*) presented, as early as 2007, in the words of Laura Moris, the process of innovation implementation in several points. Briefly, this began with the tracing of a suitable community for collaboration, launching, and directing the innovation process; then involved communications forums; then testing by means of feedback; before finally performing the innovation process (*Zákaznické inovace*, 2008).

At present, a project supported by the Czech Technology Foundation (in Czech – *Technologická agentura České republiky*) listed as TL02000215 is being implemented at the Faculty of Business and Management of the Brno University of Technology, under the supervision of the co-author of this article, I. Simberova. The faculty website observes: "The project aims at strengthening the innovative capacity, competitiveness, sustainability and level of digitization of SMEs. It enables SMEs: a) to evaluate a level of digital maturity b) to increase innovation activity c) to generate sustainable value creation for customers d) to apply the implementation of digital transformation to business models e) to increase company performance f) to accelerate the learning process and the development of competencies in the business models and digital transformation g) to internationalize."

American professor Henry William Chesbrough (2003) introduced the term *open innovation* thus: "Open innovation is a paradigm that assumes that firms can and should us external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology. Open innovation combines internal and external Ideas into architectures and systems whose requirements are defined by a business model."

Chesbrough's recently published important and ambitious work is called *Open Innovation Results: Going Beyond the Hype and Getting Down to Business* and "offers a clear-eyed view of the challenges that limit organizations' ability to create and profit from innovation and practical tools for overcoming those challenges". Moreover, "it is not enough to do pilots or proofs-of-concept in your innovation unit. Your innovation results must be broadly shared throughout the organization, across the siloes, and the businesses themselves must invest in time, money, and people to absorb the new innovation and take it to market" (Counts, 2019).

In Faber (2009), the author is concerned with the definitional and theoretical-conceptual basics of open innovations, and presents the approaches of other experts to the question at hand. For instance, Faber analyses Chesbrough's open innovation approach.

Eamurai, Khantanapha, and Piriyakul (2019) described research results for the purposes of an awareness of the open innovations of car-part producers in Thailand. It is pointed out that information stemming from the customer needs to be shared because it is an important source for the development and improvement of organizations' innovations.

Open innovations do not necessarily expand the company's innovative performance, as analyzed by Yapa, Senathiraja, Poesche, and Kauranen (2019). They point out that open innovations are based on knowledge flow: "We argue that boundary conditions matter in innovation performance and sequential coherence can explain why some succeed while others fail in open innovation... ability to scan the entire chain of knowledge flow across boundaries and taking corrective measures for any bottlenecks or hindrances observed can bring better results from open innovation initiatives."

The concept of innovation can be seen from different perspectives. The authors of this article, Volkova and Jākobsone (2016), have previously observed the importance and application of design and design thinking as significant sources of potential for innovative methods, which lead to strengthening competitiveness in difficult business conditions. Through their research, they confirmed design as an effective innovative method for improving business processes and business models.

Wang and Peng (2020) dealt with open-source patent strategy (Tesla's open-source patent strategy, in particular), which encourages technology sharing and innovation and solves the logic of intellectual property protection. The authors also referred to the possibility of the application of their ideas in China's new energy vehicle industry.

In connection with the study of human-resource outsourcing models in both the manufacturing and service sectors, Žitkienė and Blusytė (2015) noted that innovations in information and communication have created opportunities to produce and consume services in different places; however, people who would process those technologies are needed.

Geels (2004) made four contributions by addressing some open issues for the "Sectoral systems of innovation," which have emerged as a new approach in innovation studies.

According to Franco and Haase (2020), smaller companies implement open innovations with a higher probability. The reason for this involves the acquisition of a competitive advantage and solidification of their market confidence.

According to Jočienė (2015): "Revolutionary work was carried out by Osterwalder and Pigneur (2010), leaders in the field of business model innovation. They introduced the concept of a business model through the generalised view of 470 practitioners from a number of different countries. They used business models in an attempt to better explain how firms do business. The summarised business models were presented in nine building blocks and called the 'Business Model Canvas', which was considered to be the best schematic model representing a simplified version of a business organisation from a high-level perspective."

Ili, Albers, and Miller (2010) dealt with external sources to increase innovativeness: "Open Innovation proves to be more adequate in the attempt to achieve a better R&D productivity for companies in the automotive industry than a closed innovation model."

Kortum, Rebstadt, Gravemeier, and Thomas (2021) dealt with the optimization of customer communication based on customers' daily behavior. The basis of their analysis focused on the creation of a platform concept as an open innovation model.

Due to the ramifications of the fundamental resulting facts in the area of open innovations and business models, and due to the scope of this paper, let us further discuss only selected authors who deal with the mentioned area, i.e., open innovations, innovation strategies, innovation management, organizational and technological changes, the effects of the external environment, the market, and similar. These authors include: Enkel and Gassmanni (2009), Goffin and Mitchell (2016), Krstevski and Mancheski (2016), Skarzynski and Gibson (2008), and many others.

Although there are a number of publications related to this field of study, the bibliographical review of scientific databases and the verification of other resources performed within the framework of this research have shown that there is no suitable study relating to the mapping of how customers evaluate the space for open innovation in the area of the automotive industry.

This detailed survey was conducted in May–June 2021 in the German automotive industry in the form of an online questionnaire (an appropriate approach in the pandemic context) with the aim of performing analyses and interpretations on two planes: from the

customer's, and from the employee's viewpoint. This research was very extensive, and offers a wide range of scientific analyses. Our article is based on an analysis of research outputs at the customer level – how customers assess the topic of open innovations and their implementation. It is necessary to uncover the potential of whether and how open innovations provide "material" for scaling the business model in the automotive industry sphere. The relevant aspect under study is to consider how this knowledge can be used to strengthen competitiveness, but it is equally necessary to map the customer's perception of open innovations' implementation with regard to the development of the price elasticity of supply and demand.

2. Methodology

From the point of view of methodology, this article is based on an analysis of selected research outputs, i.e., on an analysis of the statistical data file generated by customer responses in the tracking of particular statistic characteristics. Let us briefly lay out the characteristics of the questionnaire survey: the questionnaire was structured – the first set of questions was only indicative for the researcher; a key set of questions followed, which were aimed at generating customers' and employees' responses and signaling their attitudes; and the last group of questions served to identify the respondents. There is no need to address a set of non-customer queries for the purposes of this article. The questions were of a mostly closed and often dichotomous character. The final form of the questionnaire was comprised of 23 questions, although the respondents answered more questions (in more detail). The evaluation of some of the 23 questions involved the merging of several sub-replies into a single reply.

Quantitative methods – mainly statistical calculations and transparent statistical visualizations – were used to evaluate the questionnaire itself. These methods involved: descriptive statistics; categorical analysis for processing data sets – statistical characteristics, contingent tables, statistical graphs; pie charts; histograms; column graphs; bar graphs; mosaic plots (explanatory facts from a 2D and 3D point of view); and the four-part tables as a special case of contingency tables, with an χ^2 test of the independence at the appropriate level of significance (according to the *p*-value, here at the 95% confidence level). The received quantitative outputs were interpreted with the aim of verifying the possibilities or properties of the innovation process in forming business models in the automotive industry area.

Quantitative output processing was conducted in the Maple system – a product of the Canadian company Maplesoft, Inc. This product has been developed for almost 40 years; a new release version is published annually, responding to the present impulses. The system is connected with a whole range of contemporary technological paraphernalia, and employs the intuitive character of work. Calculations are performed not only in numerical, but also in a precise symbolic mode, and it is also possible to employ a complete variety of interactive elements as well as sophisticated and modifiable 2D and 3D visualizations and simulations. This system offers a range of calculations, table processing, and

visualizations, employing the manipulation of practical sliders; a further advantage is found in the several procedures of the readily accessible Help feature.

When assessing this research, the Statistics package was used. This package "is a collection of tools for mathematical statistics and data analysis. The package supports a wide range of common statistical tasks such as quantitative and graphical data analysis, simulation, and curve fitting. In addition to standard data analysis tools the Statistics package provides a wide range of symbolic and numeric tools for computing with random variables. The package supports over 35 major probability distributions and provides facilities for defining new distributions. Much of the functionality in the Statistics package is accessible through the Context Panel. Context-sensitive functionality is available when selecting any data container (such as a Vector, list, or Array), known probability distributions (such as Normal(1,2)), or random variables" according to the Maple system's 2021 Help section. Maplesoft, Inc. considers its product a complex system: it creates platforms (sub-systems) designated for communication of users with specific aims, for concrete issues; and it also offers an application center, learning webinars, and a whole range of further possibilities for solving the challenges we are faced with today.

3. Results, comments, and discussions

It should be noted at the beginning that debate is led alongside commentary next to the partial outputs, especially regarding the possibilities of contrast with the obtained visualizations.

3.1. Gradual concrete steps

Firstly, for orientation, a sample of respondents is presented descriptively according to the selected statuses (gender, age, average monthly income in euros, current employment status, highest educational qualification).

Then, focus shifts to confronting the willingness of customers to engage in the process of implementing open innovations "with" and "without" benefits offered to customers (i.e., with all the possible combinations of answers to two questions simultaneously) based on their average income (at levels of €0, €500, €1,500, €2,500, €3,500, €4,500, €6,000, €8,500, €10,000+). From the point of view of mathematics, we observe the dependence of the explained variable on two explanatory variables (the 3D model – see below). We consider the impact of the financial indicator to be a useful finding. At present, in the context of a global environmental, climate, epidemiological, economic, and social crises, the financial aspect plays a key role in the preferences of customer utility; all the more so within decision-making in the area of the automotive industry. Thus, we have focused on the link between the two basic survey questions, considering the respondent's social status.

Other characteristics include: the respondent's gender, age, education, and profession, which we have also marginally considered in the interpretations of the outputs.

Another analysis is a statistical evaluation that identifies the degree of interest in some selected types of benefits.

Finally, we have dealt with the independence of the selected pairs of questions of the questionnaire.

3.2. Identification of the set of participating respondents

First, let us briefly introduce and identify the sample of the *research* respondents (of the questionnaire survey) who, as customers, are willing to be interested in issues related to the issue of open innovations and their implementation or participation in optimizing the business model. Visualization using pie charts offers a quick orientation to the issue.

(A) Gender: *What is your gender?*

This question was close-ended and dichotomous (male/female). The gender representation (%) can be seen in Fig. 1:

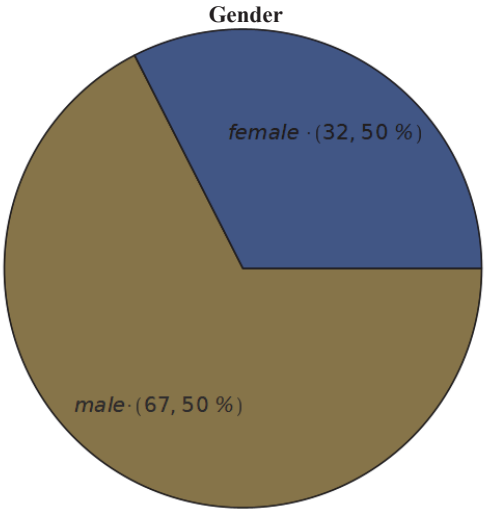

Figure 1. *The proportion of female and male respondents, %*
Source: *authors' elaboration*

Comment and discussion: The survey respondents – i.e., those who have an interest in open innovation in the automotive industry – were approximately two thirds male and one third female. There were twice as many men as there were women. This majority could be assumed to represent the notion that men are more interested in cars and that they often also care for women's cars. However, the percentage of women is not negligible, which also signals their emancipation when making decisions in the area of the automotive industry. The business model should respond to this.

(B) Age distribution: *How old are you?*

This question was close-ended, with five options (see Table 1). The age scales were divided into 10-year intervals, the left boundary not being included in the interval, the right boundary being included; i.e., we understand the intervals as left-open, right-closed. The age distribution can be seen in Fig. 2:

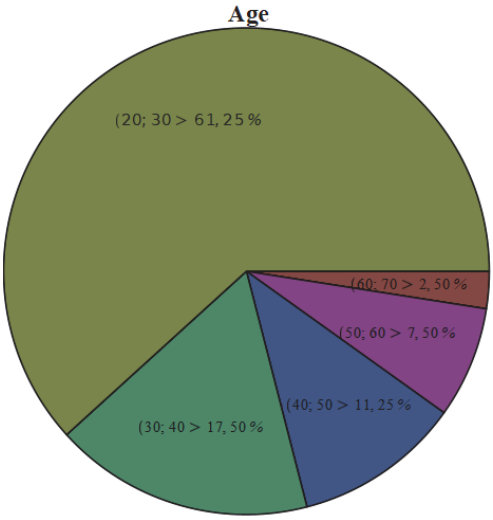

Figure 2. *The age distribution, %*
Source: *Authors' elaboration*

Table 1. *The age distribution, %*

Age (years)	(20; 30>	(30; 40>	(40; 50>	(50; 60>	(60;70>
Frequency	61.25 %	17.50 %	11.25 %	7.50 %	2.50 %

Source: *Authors' elaboration*

Comment and discussion: The youngest respondent was 21, and the oldest was 67 years old. If we divide the age groups into 10-year intervals, we can see that more than 60% of respondents were within the youngest group. This is logical, as members of this group likely have a great interest in forming their future at the onset of their productive age and they consider the car an important means for life. On the other hand, they feel experienced enough for their opinion to be taken into account. In fact, however, this may pose a contradiction, and can be misleading. The other age groups did not dominate as much, and over 60 years old was the least occupied group. Nevertheless, these people, although possibly very experienced, also have an interest in contributing to further development in

the automotive industry despite their proximity to retirement – an encouraging and pleasing observation. This is another important piece in the formation of the business model.

(C) Average income: *What is your average income? (rounded)*

The question was close-ended, with nine answer options: €0, €500, €1,500, €2,500, €3,500, €4,500, €6,000, €8,500, €10,000+), monthly.

For a better understanding of the matter, the following options were selected. A rounding of the average monthly income of the respondents (in euros) was taken into account – these values were taken as mid-points of the corresponding classes of the real income sets.

For our purposes, considering quite an irregular frequency in partial eventualities, some neighboring eventualities were, logically, merged as follows:

- An important reality is zero income;
- Averages incomes around €500 and €1,500 were merged, because both values represent a low-income level;
- Average incomes around €2,500 and €3,500 dominated, therefore they were left separate (they possibly represent a frequent level of average income and interest in open innovation, considering also the age distribution of the sample of participating respondents);
- Average incomes around €4,500 and €6,000 were merged;
- Average incomes around €8,500 and €10,000 or more (i.e., €10,000+) were merged;
- This means that after this modification, we have obtained a total of six categories (see Fig. 3 and Table 2).

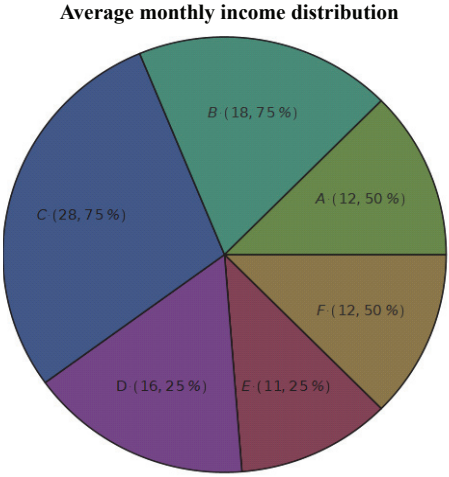

Figure 3. *The average income distribution, %*

Source: *Authors' elaboration*

Table 2. *The average income distribution, %*

	Average monthly income	Frequency
A	€0	12.50 %
B	€500, €1,500	18.75 %
C	€2,500	28.75 %
D	€3,500	16.25 %
E	€4,500, €6,000	11.25 %
F	€8,500, €10,000+	12.50 %

Source: *Authors' elaboration*

Comment and discussion: We can see that the average incomes of €500, €1,500, €2,500, and €3,500 represent more than half of the total respondents who were interested in the relevant issue. It is not insignificant that a fairly large part of the respondents who contributed their opinions had zero income. Thus, a business model also needs to take into account the opinions of customers such as students, homemakers, and other people who are financially dependent on others. High-income groups are obviously interested in innovation.

(D) Current employment status: *What is your current employment status?*

This question, once again, was close-ended. Eleven answer options were selected from: apprentice; dual student; employee; full-time student; independent; official; other; part-time student; retiree; unemployed; and worker. Current employment status is presented in Fig. 4 and in Table 3:

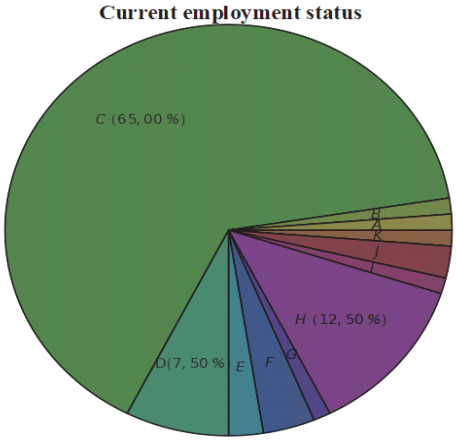

Figure 4. *The current employment status distribution, %*
Source: *Authors' elaboration*

Table 3. *The current employment status distribution, %*

	Current employment status	Frequency
A	Apprentice	1.25 %
B	Dual student	1.25 %
C	Employee	65.00 %
D	Full-time student	7.50 %
E	Independent	2.50 %
F	Official	3.75 %
G	Other	1.25 %
H	Part-time student	12.50 %
I	Retiree	1.25 %
J	Unemployed	2.50 %
K	Worker	1.25 %

Source: *Authors' elaboration*

Comment and discussion: Employees clearly dominated the sample of the participants (65%). It seems that employees are greatly interested in implementing open innovations, and thus also in the option of intervention of the end-user when the business model is being formed in the area of the automotive industry. Students came next. Due to the very scarce frequency of all of the other options of employment status, we have not written the percentage values on the pie chart – Table 3 provides a detailed overview. Employees and students (who are enhancing their qualifications via education) felt the need to express themselves regarding business model formation. Unemployed and retired people, however, were also interested in exercising their opinions. We consider this to be an important factor, and we suppose that these respondents were people who commonly actively involve themselves in similar challenges.

(E) The highest educational qualification: *What is your highest educational qualification?*

This question was, once again, close-ended. Nine answer options were selected from: advanced technical college; bachelor's; diploma; general university entrance qualification; master's; other; promotion; secondary school diploma; and vocational training. The highest educational qualifications of the respondents are presented in Fig. 5 and in Table 4:

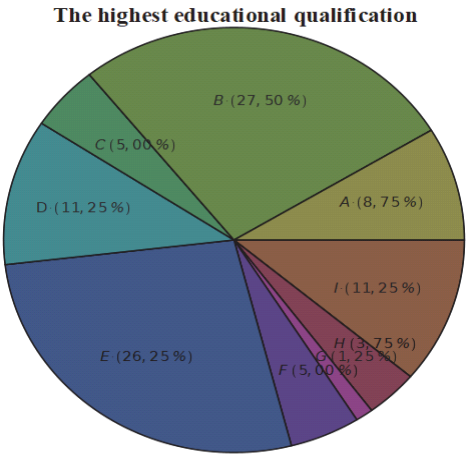

Figure 5. *The highest educational qualification, %*
Source: *Authors' elaboration*

Table 4. *The highest educational qualification (%) – respondent frequency*

	The highest educational qualification	Frequency
A	Advanced technical college	8.75 %
B	Bachelor's	27.50 %
C	Diploma	5.00 %
D	General university entrance qualification	11.25 %
E	Master's	26.25 %
F	Other	5.00 %
G	Promotion	1.25 %
H	Secondary school diploma	3.75 %
I	Vocational training	11.25 %

Source: *Authors' elaboration*

Comment and discussion: Respondents with a bachelor's or master's degree show the greatest interest in open innovations and their implementation, representing more than half of the proportion of all participating respondents. Nearly one quarter is then formed by the general university entrance qualification and vocational training group. Overall, when forming innovation strategies, it is worthwhile to focus on customers with an education and with expertise. We may say that this reality provides the assumption of a wide variability of opinions, and it is probably a good indicator for scaling the business model.

3.3 Confronting the findings from questions A and B based on social status defined by average level of income

Question A. *Would you actively send improvements to a product to an automotive manufacturer or dealer?*

Answer options
Yes
No

Question B. *Would you actively provide an automobile manufacturer or dealer with improvements to a product if you received benefit for them?*

Answer options
Yes
No
I would also provide information free of charge

The financial viewpoint very often plays an important part in a person's – or, more importantly, a customer's – decision-making process. We deem it appropriate to know whether a given respondent wishes to contribute to the open innovations process (the strength of their willingness to engage in certain steps beyond their purchasing obligations) with or without any benefit or support, and information about how this relates to the respondent's financial status.

Therefore, in this part of the paper, we mutually confront questions A and B, based on the respondents' social status, as defined by average income levels. This can further be imagined as a combination of two inputs on a segmented basis formed by the levels of the respondents' average income. Other social statuses will also be marginally included in the final quantitative evaluation and interpretation.

We have already mentioned that the viewpoint of the average incomes is slightly modified – in congruence with the descriptive results coming from the research – by means of creating only six categories of answers from the original nine by merging some neighboring responses. The resulting numerical values will be, for reasons of more synoptic comparison, listed in percentages, while the number of respondents of the current category in each of the six categories will be taken as the base.

This is why we also list purely the graphic visualization using histograms for every eventuality. In order to avoid rounding errors, we have processed the calculations in Maple as symbolic calculations, precisely.

All of the combinations of answers to questions A and B may be easily expressed. Question A contains two answers: *yes* and *no*; question B contains three answers: *yes*, *no*, and *I would also provide information free of charge* (for simplicity's sake, we will abbreviate the third option to *also free of charge*) – so a total of six combinations.

Let us map the situation in Table 5 from the point of view of a mathematical concept, i.e., in an analogy expressing the arranged pairs in a Cartesian product of the given answer sets.

Table 5. *The arranged pairs of answers to questions A and B*

also free of charge	[*yes*; *also free of charge*]	[*no*; *also free of charge*]
no	[*yes*; *no*]	[*no*; *no*]
yes	[*yes*; *yes*]	[*no*; *yes*]
B. / A.	***yes***	***no***

Source: *Authors' elaboration*

It is clear that the resulting graphs can be presented in the form of a 3D visualization. In this simple case, we will convert the 3D visualization into a 2D one, arranging both triplet columns alongside each other in the figures, in order to achieve a more synoptic display. This is done for each average income level – see the histograms in Figures 6–12.

All combinations of *yes* answers to question A are, in the graphic expression, colored red, and the *no* answers carry the blue color.

The column mid-points on the horizontal axis are marked by numbers – 1, 2, 3, 6, 7, 8. The column's mid-points 1 and 6 mean *yes*, 2 and 7 mean *no*, and 3 and 8 *also free of charge* in reply to question B. On the vertical axis, we are monitoring the frequency of the answer-pairs' individual eventualities, in percent.

The percentage always corresponds to the number of respondents in the given category.

(A) Category: average monthly income €0 *(Fig. 6)*

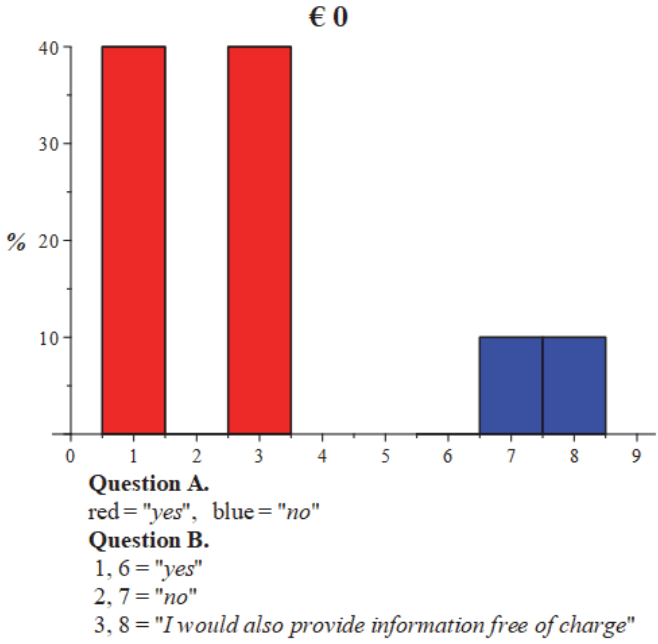

Figure 6. *An average income of €0*
Source: *Authors' elaboration*

Comment and discussion: Most participating respondents in this category clearly want to join the open innovations process actively, and many even without remuneration despite their zero income. Let us note that a further output (analysis) of the research (which we do not list here for reasons of brevity) says that these are men and women aged, on average, 37 years, with various types of education. Their age, enthusiasm, and possible expectations seem to positively inspire them.

(B) Category: average income €500 and €1,500 (*Fig. 7*)

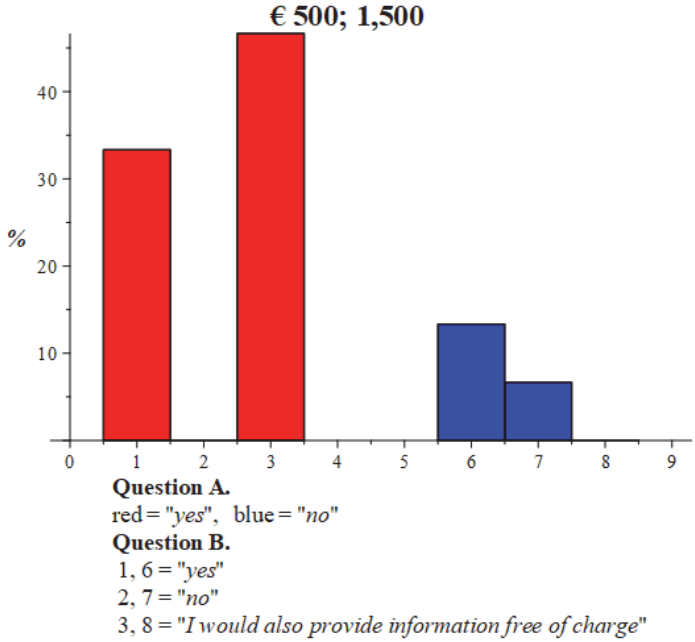

Figure 7. *An average income of €500, €1,500*
Source: *Authors' elaboration*

Comment and discussion: This figure shows that a majority of the respondents is interested in participation in the process of open innovations. This interest, however, decreases in the case of a €500 income. These people may be quite busy and their very low-level income causes them to be less concerned with the innovations process. Alternatively, they may be so financially comfortable that they do not need to earn themselves money and are not interested in customer activities. The age average of respondents in this category is around 30 years; in the €1,500 income category, however, older people are represented as well. This category is made up of mostly employees and people with a certain degree of expertise. Men as well as women are present here.

(C) Category: average income €2,500 *(Fig. 8)*

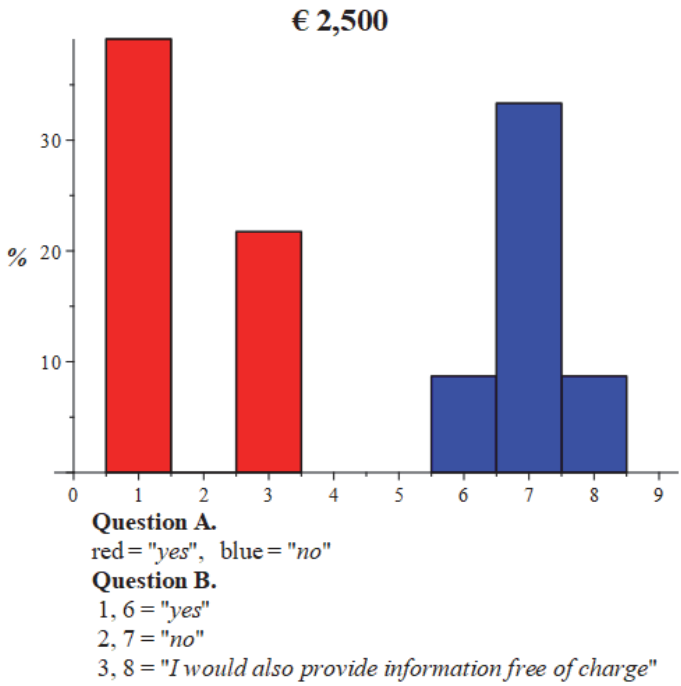

Figure 8. *An average income of €2,500*
Source: *Authors' elaboration*

Comment and discussion: This category is represented the most. The interest in the innovations process is most pronounced as well. Interestingly, a relatively large percentage of respondents in this category retains no enthusiasm despite the offer of benefits. Further consultation with the research outputs implies that women represent one third of this category, whilst men represent two thirds, with the age values drifting towards higher levels. Nevertheless, the predominant group here is around 30 years of age. Employees form an expected majority, although there is considerable variability in employee/educational social status.

(D) Category: average income €3,500 *(Fig. 9)*

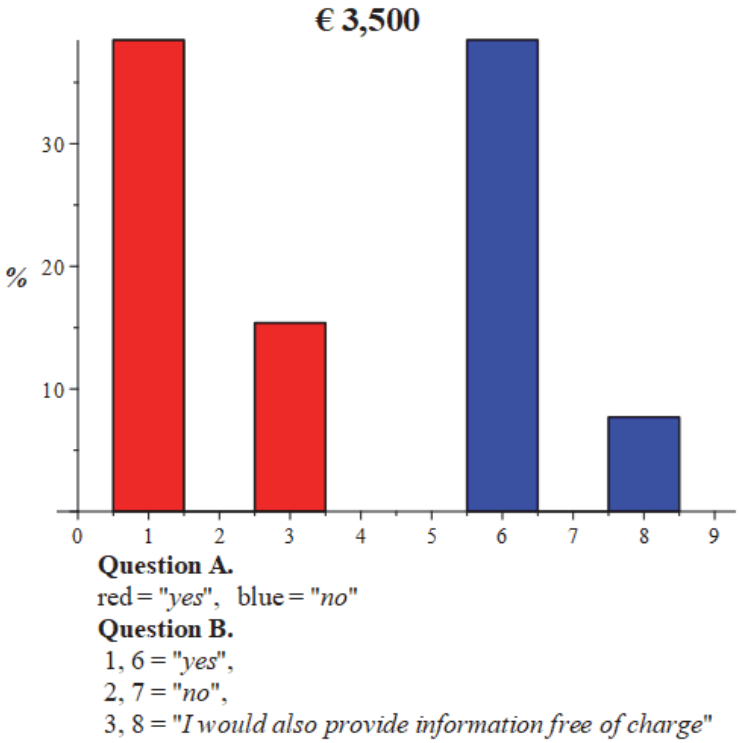

Figure 9. *An average income of €3,500*
Source: *Authors' elaboration*

Comment and discussion: This group of respondents is also quite numerous, is formed mainly by employees, and resembles category (C) in its social characteristics, although with a higher number of men. Figure 9 interestingly shows that the majority bears a positive attitude towards participating in the innovations process; and that those who expressed their disinterest in these issues in question A are motivated to change their opinion owing to benefits.

(E) Category: average income €4,500 or €6,000 *(Fig. 10)*

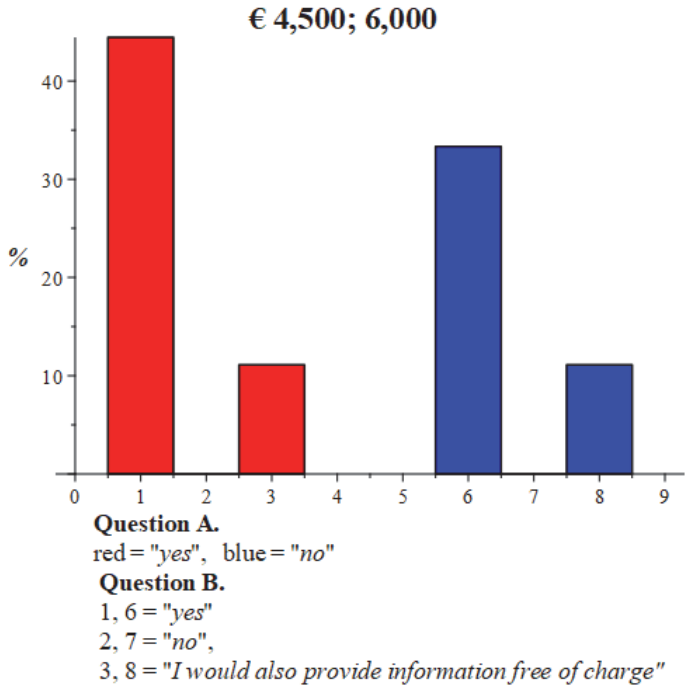

Figure 10. *An average income of €4,500, €6,000*
Source: *Authors' elaboration*

Comment and discussion: We can see that quite a large number of respondents are interested in taking part in the open innovations process (moreover, that benefits are a good motivator). The age average of this group sits around 34 years. It seems these could be successful and maybe also experienced people who want to put forward their opinions on the future. Both men and women are represented.

(F) Category: average income €8,000 or €10,000+ *(Fig. 11)*

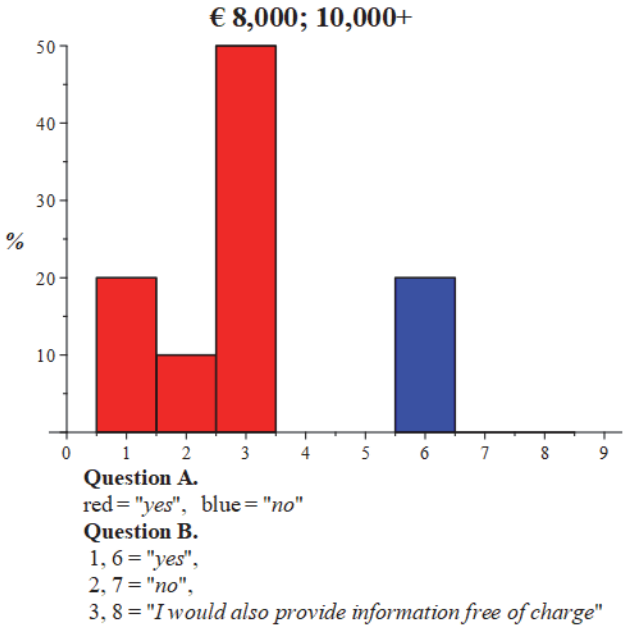

Figure 11. *An average income of €8,000, €10,000*
Source: *Authors' elaboration*

Comment and discussion: Figure 11 shows that these richer people are accustomed to taking part in making decisions themselves and are interested in achieving their goals. Their education status points to especially accomplished people with varied job types. All of the respondents in this group are men around 30 years of age. Their willingness to participate without benefits is significant.

(G) In summary – all categories – average monthly income *(Fig. 12)*

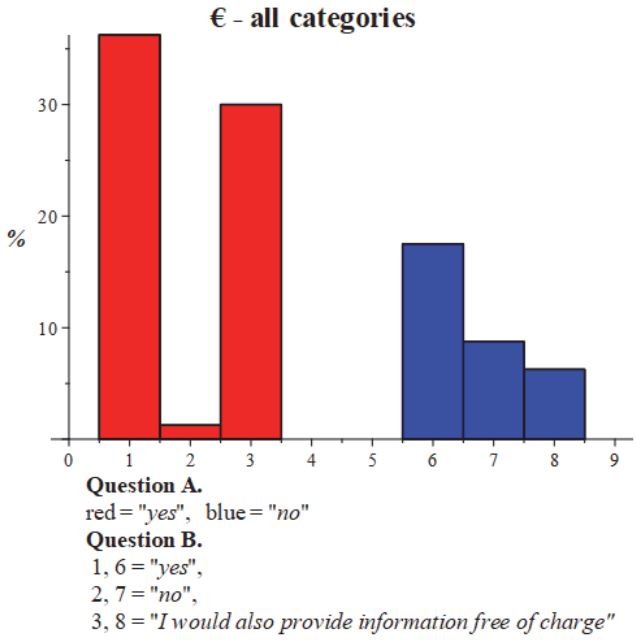

Figure 12. *Average income – all categories*
Source: *Authors' elaboration*

Comment and discussion: Figure 12 shows the sum of all average income level categories (i.e., the percentage corresponds to the total number of the respondents in the research). This means that we are monitoring the opinions of all respondents. We may say that this respondent sample is mostly interested in actively forming the business model in the automotive industry, and to contribute thus to the implementation of open innovations with the support of their own suggestions and ideas. Adequate, appropriately targeted benefits can also be a motivator here.

3.4. Identifying the degree of respondents' interest in some selected types of benefits

We further analyzed in great detail the set of benefits which generated respondents' interest (they could have chosen more than one simultaneously). For our analyses, we selected the following: payment method, first access to new products, discounted product prices, free test drive for a period of 1–3 months, and extended warranty. The relationships of disinterest and interest of respondents in the selected benefits is visualized using column graphs (the bar graph) in the Maple system in Fig. 13a and 13b.

The benefits were labelled as follows: A = *payment method*, B = *first access to new products*, C = *discounted product prices*, D = *free test drive for a period of 1–3 months*, and E = *extended warranty*.

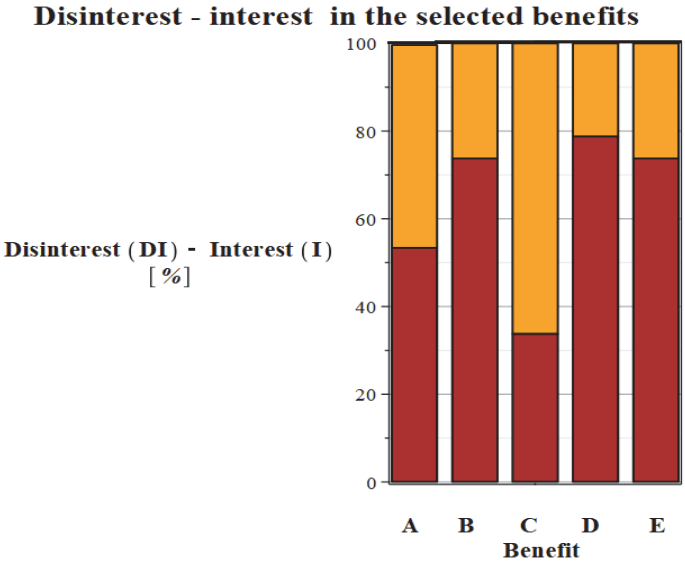

Figure 13a. *The proportion of respondents' disinterest to interest in selected benefits (DI – red, I – yellow), separately, %*
Source: *Authors' elaboration*

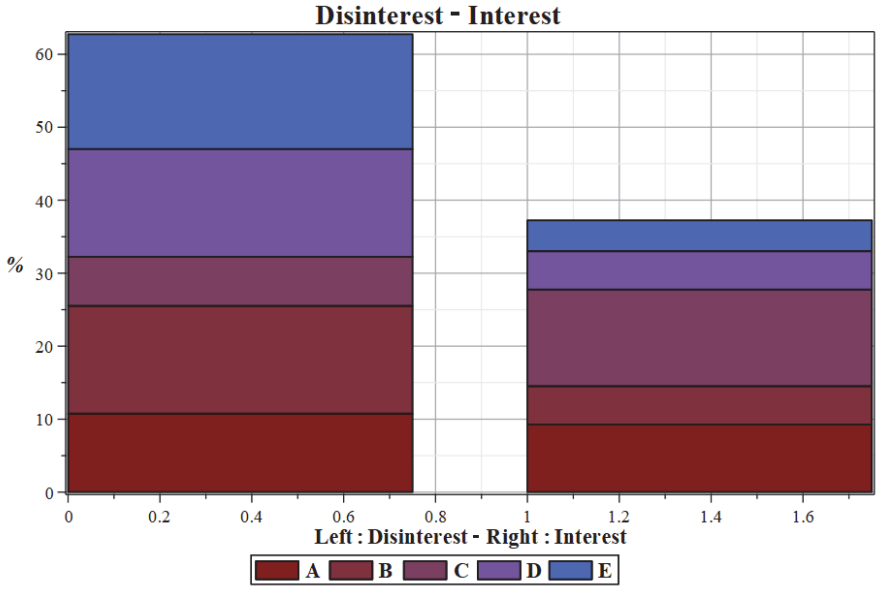

Figure 13b. *The proportion of respondents' disinterest (left) to interest (right) in selected benefits, total, %*
Source: *Authors' elaboration*

Comment and discussion: The assessment of the visualizations (Fig. 13a and 13b) shows that an interest in the benefits offered does not play a dominant role, with the exception of a lowered price (see the top lighter part of the columns; the bottom darker part of the columns indicates disinterest, 13a; by analogy, 13b presents this fact), which also corresponds to our other analyses and findings, and which supports the correctness of our choice of social status (above) as focused on the respondents' financial status (which most probably plays a key part in customers' activities and decision-making).

Respondents are least interested in the trial period, as 78.75% of respondents were disinterested, as opposed to those who are keen on this benefit, i.e., 21.25%.

A similar situation in similar proportions occurs with the interest in the two benefits of access to new products and an extended warranty; i.e., 73.75% of respondents were disinterested, and 26.25% interested.

Payment method generated similar proportion of disinterest to interest, with 53.75% saying *no* and 46.25% saying *yes* to this.

Product price discount doubtless holds the most prominent position among all benefits, with only 33.75% of respondents disinterested and 66.25% interested.

3.5. Analysis of the independence of the respondents' answers to selected questions of the questionnaire using a four-part contingency table

Finally, we will consider the evaluation of the independence of respondents' answers to selected questions of the questionnaire (to some extent in connection with the previous analyses).

Four-part tables (a special case of contingency tables) have been used for the analysis of selected questions when the measured tokens take on only one of two categories. For the analysis of independence, we have applied the characteristic of the χ^2 test.

The results of the hypothesis test (according to the *p*-value – here at the 95.0% confidence level) determine whether it is possible and meaningful to accept or reject the idea of the mutual independence of two statistical features (here, this relates to customer decisions or reactions).

We therefore took an interest in the potential mutual influence or non-influence of the testimony forces of some dichotomic question-pairs from the questionnaire survey. We established an H_0 zero hypothesis on the independence of alternative statistical indicators, and used a four-part table.

We do not reject the hypothesis at the = 0.05 significance level, where t, where is the tabulated (1--quantile of the Person's chi-squared test, with the degree of freedom, and is the so-called "hypothesis non-rejection scope".

The chosen set of questions from the questionnaire survey for the independence tests were as follows:

Question 1: Have you ever been asked by a manufacturer or retailer what could be improved about the product?

Question 2: Would you actively provide a car manufacturer or dealer with improvements to a product?

Question 3: Why would you not tell companies about your ideas/wishes – would companies not implement such wishes anyway?

Question 4: Are you prepared to pay more for a future car that better suits your needs/expectations?

Question 5: Do you think an automotive company would generate more revenue/sell more cars if it implemented its customers'/users' ideas better?

The set of mosaic plots (TreeMaps) in Figure 14 visualizes the distribution of paired answers to the questions whose independence we examined – i.e., questions: 1 versus 4; 1 versus 2; 2 versus 3; 4 versus 5; 1 versus 5; and 2 versus 5).

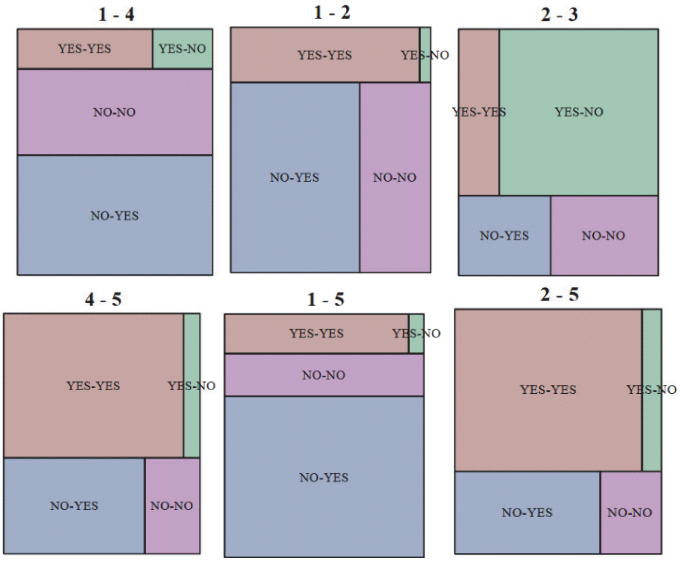

Figure 14. *The distribution of paired answers to questions*
Source: *Authors' elaboration*

For each question pair, we calculated the Chi-Squared statistic at the 0.05 significance level (confidence level 0.95), and we verified whether or not they pertain to the rejection scope. From this, we derived the non-rejection or rejection of the hypothesis concerning the independence of statistical characters determined by the question form. These results are presented in Table 6.

Table 6. *The Chi-Squared test of independence*

Pairs of questions	Test	Statistic	Degree of freedom	Significance level	Confidence level	Hypothesis H_0
1–4	Chi-Squared	0.55109	1	0.05	0.95	Cannot reject
1–2	Chi-Squared	6.09981	1	0.05	0.95	Can reject
2–3	Chi-Squared	5.69557	1	0.05	0.95	Can reject
4–5	Chi-Squared	5.52622	1	0.05	0.95	Can reject
1–5	Chi-Squared	1.24584	1	0.05	0.95	Cannot reject
2–5	Chi-Squared	5.36078	1	0.05	0.95	Can reject

Source: *Authors' elaboration*

Comment and discussion: Out of the six estimated options, we cannot reject independence only in two cases; in the others, we do reject independence.

The manufacturer's/seller's request for the customer's suggestion for improvement of the automobile does not affect the customer's willingness to pay an elevated price for acquiring an improved automobile. This means that the manufacturer/seller should inform the customer of the car-producing company's possibilities so as to generate interest in product improvement in connection with the formation of the level of automobile prices.

The manufacturer's/customer's request for the customer's suggestion for improvement of the automobile does not affect the company's turnover increase. This is an interesting conclusion which probably shows, in the automotive industry, a certain form of "worlds apart" of the these two parties.

In all the other cases we have rejected independence, and this is relevant because these links are logical ones.

The customer's request for the customer's suggestion for improvement does affect (is connected with) the customer's willingness to actively engage and offer their thoughts to manufacturers/sellers. Thus, the customer is clearly being motivated by the manufacturer/seller on the one hand; on the other, the customer is being actively helpful here.

The customer's willingness to offer their suggestions to manufacturers/sellers is affected by the direct knowledge of whether or not the manufacturers/sellers are going to implement the customer's efforts.

The customer's preparedness to pay a higher price for an automobile purchase probably affects their presupposition of a link to the automobile company's increased sales and profits; it would be interesting to determine these reasons.

The customer's willingness to provide suggestions and thoughts on improvements is influenced by their awareness that assumes a connection to generating higher revenue or increasing automobile sales; the question is whether this connection is backed by only shallow knowledge, or rather based on automatic judgement.

The abovementioned outputs show that a bilateral, active approach between the customer and the manufacturer/seller (through motivation, willingness, and open access to information) is a moving force for the implementation of open innovations, and thus also for the scaling and optimization of business models in the automotive industry.

4. Conclusion and final discussion

Our paper is based on research (under the supervision of the paper's co-author, von Böhlen) performed in the German automotive industry, and follows the paper of Simberova and von Böhlen (2021) with the aim of performing further analyses and interpretations of the facts stemming from the research. The mentioned research also follows up on some facts in connection with the solution of the project at the Faculty of Business and Management, Brno University of Technology (under the supervision of the paper's co-author, Simberova).

The summary of these analyses gradually builds the basis for a future holistic achievement of the project goal. In particular, we want to support these points: to increase innovation activity, to apply the implementation of digital transformation to business models, and to increase company performance.

The study of Simberova and von Böhlen (2021) is concerned with the possibilities of forming a business model of the automotive industry through open innovations. It analyses facts on two levels – from the customer's stance and from the producer's viewpoint. It finds deficiencies on both of these levels: in the spheres of open innovations and their applications. Namely, these are "…employees also see changing customer behavior and the considerable adjustments resulting from digitization as the greatest challenges for their industry, …, it makes sense, particularly for the automotive industry, to intensify contact between the customer and the company even more and to organize open innovation properly…" (Simberova & von Böhlen, 2021). Research has shown that in a high percentage "… the automotive industry has never really involved its customers in the development process…," (Simberova and von Böhlen, 2021), although approximately "… 70% of those surveyed are willing to provide information to the industry and participate in development as part of open innovation…" (Simberova & von Böhlen, 2021), while nearly one half of customers would be interested in buying a vehicle should new concepts and greater flexibility be introduced.

This research gives us ample ground to deduce further and deeper opinions, be they reasoned or consequential ones, regarding identifying information leading to the application of open innovations and possibly forming new concepts for the amplification and optimization of commercial models. This study presents a summary of factual information. The customer platform is shown to include an entire range of diversified attitudes. In our contribution on using quantitative approaches, we aim at identifying a more detailed awareness of the experience and attitudes of the employee towards open innovations in the automotive sphere.

The term innovation, especially open innovation, has been playing an important role in the sphere of commercial enterprises. As we have mentioned, in this process, the customer currently represents the key factor. The innovation process begins with an impulse, an idea, a proposal, a thought, and ends with the implementation on the market – more precisely, it ends with feedback. Producers and employees ought, naturally, to be willing to hear the customer domain; they should likewise offer enough space for communication with customers and for their innovative capabilities. Customers, on the other hand, ought to want to be motivated by producers and employees, and to have a convenient pathway to share their ideas and thoughts on a product's or service's innovation and its implementation.

At the beginning of this work, we laid out our research issues with the following focus-points: to identify key phenomena/processes within human resources with an emphasis on the implementation of the open innovations for creating, scaling, and optimizing the business model in the automotive industry; to target the customer exclusively as well as their interest and motivation for creating open innovations in the business model; and to implement selected quantitative (especially statistical) methods with the support of the Maple System for a final assessment and interpretation of the survey's outputs.

A bibliographical review of scientific databases and the verification of other resources has shown that there is no suitable study relating to the mapping of how customers evaluate the space for open innovations in the automotive industry; therefore, a detailed

survey was conducted in the German automotive industry in May–June 2021 in the form of an online questionnaire performed by the paper's co-author. Our article is based on an analysis of selected outputs of this research.

Open innovations and the optimization of business companies are undergoing a great boom, but at the same time, it is appropriate to identify the partial opportunities and risks of this new transformation.

Opportunities – our findings suggest appropriate activities of automotive companies that might aim at customers for the support of the process of open innovations. These are as follows:

- involve customers by increasing awareness, motivation, remuneration, and benefits (offers of which needs to be considered, analyzed, and selected in detail), etc.;
- show interest in the customer's views and ideas;
- reflect, in particular, the financial level from both an individual and a general point of view, against and the background of global events;
- organize regular product (improvement/development) workshops;
- publish problems and seek solutions coming from the customer community;
- adjust the contact platform and communication comfort for customers – for example, by using digitization or automation;
- honor and diversify customers' social status, gender, age, and avoid underestimating isolated ideas; here, exceptions ought to be taken into consideration (either age-wise or income-wise), and experience can play an important part, as can differentiated interests in benefits;
- acquire, sensitively and purposefully, new customers with a willingness to participate in the process of open innovations and, in conjunction with this, in feedback.

The commentaries in the previous paragraph include an entire range of more detailed findings.

Possible pitfalls – in the course of our analyses, we have identified a number of risks, both predictable and unpredictable. These include:

- the duration of the current pandemic; the ecological, economic, and environmental crisis; and a possible future outbreak;
- the risks arising from government regulations;
- generating additional costs;
- changing customer behavior in connection with the change of customers' social status;
- digitization that cannot be kept up with;
- non-connectable systems, the need for manual processing or personal participation;
- incorrectly set metrics.

Fig. 15 shows the summary of some key topics for the implementation of open innovation.

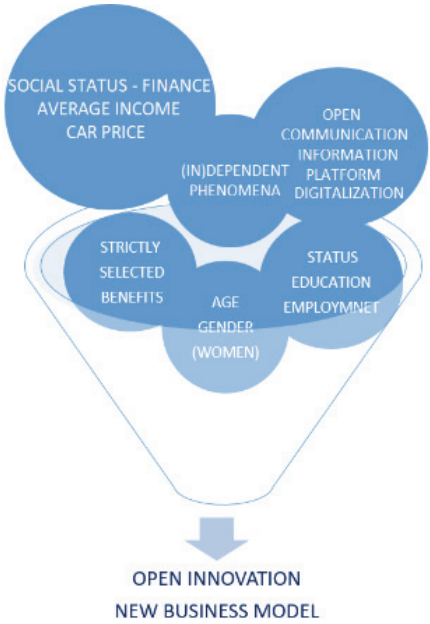

Figure 15. *The filter for the implementation of open innovation for business model optimization*
Source: *Authors' elaboration*

Our analyses have shown significant specific outputs and data in decision-making for the expansion of the business model in the automotive industry in the era of digital transformation in connection with the introduction of open innovation from the customer's point of view.

An appropriate grasp of the creation of the business model based on the implementation of open innovations allows one to streamline the processes within companies of the automotive industry and thus gain a competitive advantage, including adequate feedback.

We believe that it is not appropriate to underestimate the area of customer contacts as well as the principles of sustainable development.

This research opens a whole range of challenges for solving problems related to the implementation of innovation processes in the automotive industry sphere. In the future, we presuppose more diversification of the assessment and analyses of research in several possible manners: a) the modification of the questionnaire as a reaction to the present evaluation of its contents; b) a repeated enquiry of the already participating respondents and an expansion of their numbers; and c) further bibliographical research, or collaborations, respectively. We also mean to touch on problems that have not been dealt with fully yet.

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