International Journal of Business and Management Study – IJBMS
Volume 2 : Issue 2 *[ISSN : 2372-3955]*
Publication Date: 19 October, 2015

Technology Adoption with Reference to Embedded Systems

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***Abstract*—Embedded Systems (ES) are information processing systems consisting of a hybrid combination of hardware and software components integrated into a technical environment. Controlling, regulating and monitoring a system under real-time requirements to achieve efficiency, reliability and specificity is their primary object. The employment of ES in a wide-ranging application field, e.g. automotive, aviation, telecommunications as well as machinery and plant engineering, underlines their essential technological importance. Enterprises operating in such a competitive high tech market have to cope with the establishment of new technologies to gain and maintain competitive advantage. This is principally related to two main tasks: the adoption and diffusion of new technologies. Consequently, our paper analyses the process of how new technologies are approved and rejected in companies operating within an ES-oriented environment.**

The research method chosen for our study are semi-structured interviews which have been conducted with 48 experts from several industries in the European Metropolitan Area of Nuremberg (EMN), Germany. The compiled data has been subject to a qualitative content analysis, which is an appropriate method to extract relevant information from text material following a predefined scheme.

The results show that technology adoption as well as diffusion play an important role for ES-oriented enterprises. Regarding information diffusion, seven methods constituting both on- and offline channels are employed. Moreover, it is significantly influenced by persons, networks, suppliers and customers, whereas conflicts between individuals, contrary to theory, play a minor role. In addition, there exists a range of eleven different reasons for technology rejection, e.g. costs, own developments and a missing customer value.

The findings of this study are highly relevant for the analysis of technology adoption processes as part of innovation, technology and knowledge management which are critical for being competitively successful in a high tech market. This study concerning technology adoption with reference to ES serves as a basis to further analyse the transformation of ES-technologies into marketable products and/or services, all associated management decisions as well as the transferability of our results to other technological fields.

***Keywords*—Embedded Systems, Technology adoption, Technology diffusion, Qualitative content analysis, Technology and knowledge management, Innovation management**

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I. Problem outline

Globalisation and subsequent increase of competition, innovation in telecommunications, increasing and changing customer expectations as well as technological changes are revolutionising markets [1][2][3][4]. Among others, these factors trigger new technological developments in companies serving as a basis for competitiveness and competitive advantage [5]. Consequently, the implementation of new developments is crucial for the long term continuity and strategic orientation of a company [6].

When it comes to technological change, Embedded Systems (ES) play an important role. The ES market experiences steady growth and is considered to be the most important application area of information and communication technology in the upcoming years. Its global volume is estimated at 60 billion euros, in other words about 100 times the desktop market [7][8][9].

ES are "information processing systems embedded into enclosing products" [10], i.e. microcontrollers to monitor, control or assist the operation of equipment, machinery or plant [11]. By this means, they interact either directly with their environment via communication devices or indirectly via sensors that capture data such as temperature or movement, as well as with actors that transform those data into action [7]. The number of ES integrated in a product varies from at least one to ten in simple consumer products to several hundreds in complex professional systems so that an average household utilises easily 50 ES [8].

Their importance manifests in a considerably increasing number of fields of technological applications, e.g. automotive, electronics, avionics, railways, telecommunications, health sector, security, consumer electronics, fabrication equipment, smart buildings, logistics, robotics and military applications [9]. To give a concrete example, airbags, braking systems or power locks are nowadays inconceivable without ES [7].

In the following section, the theoretical basis concerning the adoption of technologies, the diffusion of knowledge and information as well as reasons for the rejection of technologies is provided as well as the research questions are derived. After that, the methodology applied, i.e. expert interviews and qualitative content analysis, is outlined. It is followed by the constitution of the (ES-specific) empirical findings in terms of methods and the influence of persons, networks, suppliers, customers and conflicts with reference to knowledge spreading as well as reasons for the rejection of novel ES. Finally, the paper is topped off with concluding statements.

II. Theoretical foundations

A. *Technology adoption*

Besides the identification of technologies whose importance is highlighted by [12], the adoption and diffusion of technologies in enterprises also play an important role. Companies can be considered as systems of adoption and change that consist of different parts interacting both with each other and their environment [13]. There exist several perspectives of adoption, which can be differentiated into dimensions with reference to the predefined in-house change as well as into the environment, time and dynamics of change [14]. For example, a company predefines a change or an adoption in order to appropriately react to (external) threats, risks and potentials within the respective market or business environment [15].

In this context, the approval of new ideas by an individual or an entity depends on the time at which an individual adopts an innovation or innovations [16][17]. Five categories can be differentiated according to this fact: *Innovators*, *Early Adopters*, *Early Majority*, *Late Majority* and *Laggards*. Its form follows a Gaussian distribution curve illustrated in fig. 1. *Innovators* are the first to accept an innovation due to being curious about testing new ideas, which merely applies to a small group of individuals. These are followed by the *Early Adopters* and *Early Majority* that approve new ideas before the majority of society does. The *Late Majority* adopts innovative ideas just after the average member of a society. Last, innovations are accepted by *Laggards*, when there is a next generation of ideas outperforming the former one already available [17].

In this paper, the adoption or approval of a technology is referred to as the achievement and application of an invention or innovation. With regard to the approval of a recent technology, diffusion is considered to be the distribution and spreading of technology and respective information within a social system or network and consequently in a company [17][18]. Thereby, the participants of such a social network generate and exchange information with each other in order to gain a common understanding of an innovation [17].

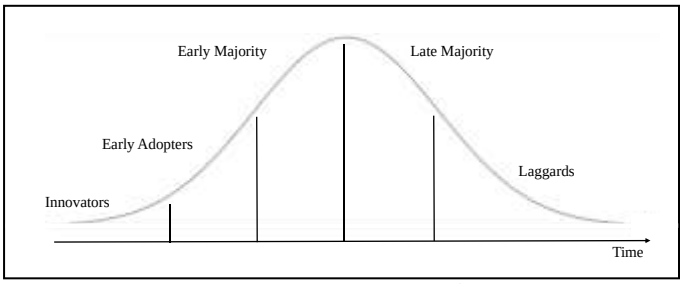

Figure 1. Adopter categorisation on the basis of innovativeness [17]

B. *Knowledge and technology diffusion*

The information diffusion among individuals within an organisation affects the potential approval of technological developments and trends [19][20]. The distribution of knowledge between employees in an enterprise can basically take place in two ways. “Face-to-face”-channels consisting of not less than two persons belong to offline diffusion [21][22][23], whereas online-based knowledge spreading is another possibility [23][24][25]. Technical infrastructure is an important resource serving as a network of individuals in the context of information sharing [26]. Here, tools such as email, internet and intranet are applied to spread information [26][27].

According to [17], the persons and entities belonging to the different categories shown above (see fig. 1) act in different networks and are therefore informed about technological trends in different ways. Attention should be paid to the fact that a larger personal network positively influences the adoption of relevant technologies [28]. *Early Adopters* restrict themselves to local social systems, whereas *Innovators* go beyond local sources. Potential users are oriented towards *Early Adopters* and source advises and information from them. The *Early Majority* serves as the connection between those belonging to a category of an early approval and those constituting late adoption categories. The *Late Majority* sources within its own social system and approves exclusively innovations being affirmed by other members within their closer environment. By contrast, *Laggards* are isolated with regard to social systems and predominantly rest upon their own past [17].

Thereupon, the information flow and accordingly the approval of technologies is influenced by several factors. By way of example, two new technologies (X+Y) appear on the market aiming at replacing an existing and outdated technology (Z). Initially, it is not obvious which of the former (X+Y) is the more appropriate one to supersede technology Z. The *Innovators* and *Early Adopters* decide to apply one of those, e.g. technology X. Consequently, more information is generated about the relevant technology X than the other one (Y). If it is ascertained that innovation X is related to an improvement compared to the existing technology Z, it will be implemented. On this basis, further information is generated which is again retrieved by individuals or entities belonging to later adoption categories. Due to the fact that technology X outperforms Z, *Laggards* will assuredly not consider the alternative technology Y. Otherwise, they would possibly face the risk of investing time and money to collect appropriate information about technology Y which eventually turns out to be the inferior compared to Z. Hence, *Laggards* will choose the technology (X) for which an information basis already exists, proved successful and tops an established technology [29][30]. With reference to this procedure, external networks can significantly influence technology approval, for instance, if a supplier sends positive signals for one and by implication against another technology or jointly develops a technology together with its customer [29].

During the process of distributing information and knowledge, conflicts between single persons or groups of persons can also affect the spread and approval of knowledge. Up to a distinct degree, they may positively influence it due to the inherent reflection of different perspectives. If the conflict´s intensity is too high, the diffusion of information and performance of tasks will deteriorate [31]. Associated with the distribution of information, the collection and storage of expertise, knowledge and information holds the potential to represent a competitive advantage [32].

Obviously, the influence of information is crucial and may result in the rejection of recent technologies. Therefore, the following section elaborates on likely causes for technology rejections within companies.

C. *Reasons for technology rejection*

As previously explained, several categories with respect to the approval and adoption of new technologies exist. The differences regarding the point of time when information is approved depend both on the willingness to take risks and the availability of financial resources [17][33]. By way of example, an Innovator should consider being able to compensate for losses associated with unprofitable investments in recent developments [17]. Hence, technology-based companies are continuously facing uncertainties [14].

As a consequence thereof, there is a variety of potential reasons for the rejection of technologies within enterprises. Here, the size of the company may play an important role in terms of influencing the adoption or rejection of novelties [29][34][35][36]. Larger companies possess more financial resources than smaller ones that can be used to compensate for negative results. For this reason, they are rather willing to take risks related to new developments [29][36][37]. Furthermore, due to the broader portfolio of large companies, innovations fit more probably to established projects or products than within small-sized enterprises, which mainly focus on a distinct technology [29][36].

Another important factor in the diffusion of technologies are suppliers. According to [29], suppliers are highly influencing decision-making with regard to the approval of novelties because of their important role in both providing information about new ideas and recent technological developments, and their price and service conduct. Moreover, a supplier is responsible for providing the new technology tailored to the customer´s expectations. Hence, suppliers are crucial when it comes to the decision between an old or new technology [29]. In addition, established technologies prevent technological novelties from being approved [29]. Furthermore, costs play another critical role. Besides the procurement costs, there are "learning and search costs" [29]. These are reduced by the intensive utilization and examination of the new technology in the course of time. Here, the influence of "switching costs" has to be considered as well [29]. Competition is another aspect affecting the diffusion of recent technological developments. *Innovators* and *Early Adopters* will build market entry barriers after having successfully implemented a technological novelty in order to prevent competitors from also using it [29].

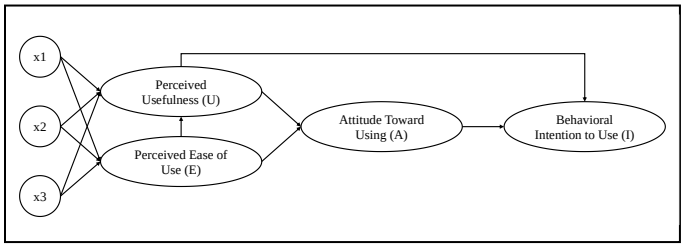

Figure 2. Technology Acceptance Model [38]

Moreover, the approval or missing acceptance of a technology depends on the user´s perception. The "Technology Acceptance Model" (TAM), illustrated in fig. 2 provides the basis for this [38]. According to the TAM, the attitude towards using a technological novelty (A) depends on two critical factors: first, the perceived usefulness (U) and second, the perceived ease of use (E). In turn, these are influenced by external conditions (x1, x2, x3). Eventually, the decision to adopt or reject a recent technology (I) is subject to the attitude (A) and the perceived usefulness (U) [38][39][40].

III. Research questions

The previously illustrated theoretical findings prove that academic literature definitely deals with technology diffusion and adoption. Nevertheless, almost none focus on companies being concerned with the implementation or integration of ES.

With reference to the diffusion of knowledge and information, several methods have been revealed from literature (e.g. [23][25]). In this context, it is also possible that besides the mentioned diffusion methods, further methods, that are particularly important and therefore serve as success factors, exist. For instance, it is possible to apply methods that have been adapted to the company's environment or the respective industry.

According to scientific literature, the diffusion of novelties is multifactorially influenced and affects the potential approval of technological developments and trends [19]. Here, the influence of persons, networks, suppliers, customers and conflicts play a particular role [17][29][31], which should be subject to a detailed analysis in this study. Despite the fact that the approval of recent technologies is crucial for a company's continuity, as a matter of fact, only few are implemented [41][42]. Consequently, the following five research questions (RQ) can be derived:

i. **RQ 1**: Which set of methods in terms of spreading knowledge and information with regard to ES does exist?

ii. **RQ 2**: How important is the influence of persons or networks on the spread of knowledge and information with regard to ES?

iii. **RQ 3**: How important is the influence of suppliers and customers on the spread of knowledge and information with regard to ES?

iv. **RQ 4**: How important is the influence of conflicts on the spread of knowledge and information with regard to ES?

v. **RQ 5**: What are the reasons for rejecting technologies in terms of ES?

Hence, this paper analyses different types of methods and several influencing factors with regard to knowledge and information spreading. Conclusively, it is examined why recent technological trends are turned down by companies operating in the field of ES.

IV. Methodology

A. *Method of data collection*

Data collecting is based on expert interviews. This method is recommended as it fosters trust and cooperation that are needed to inquire sensitive data [43]. The requested information in this study can be considered as sensitive data as it contains e.g. information that might be useful for competitors. In total, 48 experts have been interviewed who occupy different positions and work in companies of all sizes from several industries like automotive, electronics, avionics, telecommunications and fabrication equipment that play a particular role regarding ES. As the research project, this paper is based on, was supported with funds from the Bavarian government, all respective companies are located in the European Metropolitan Area of Nuremberg (EMN), which represents one of the strongest economic regions in Germany. The sample size of 48 interviewees balances the intensive resources required for in-depth interviews against the little marginal benefit of additional interviews [44].

In contrast to a quantitative method that applies structured (or closed) interviews, qualitative approaches make use of interviews that apply open-ended questions. This type of question allows the respondents to expand their answers and go into detail regarding issues of high relevance for the respondents. Moreover, such an interview allows flexibility regarding the wording and sequence of the questions [43]. Consequently, the questions are not compulsory identical in the qualitative proceeding. Equally, no response options are provided as they could influence the respondent. This leads to a broader base of information and additionally allows answers that have been unexpected beforehand.

The 48 interviews discussed in this paper follow the concept of guided interviews. In the course of this, a coherent list of questions is applied that involves all questions the interviewee should answer. Thus, a consistent proceeding can be ensured by the given questionnaire. This approach should lead to an easier evaluation referring to comparability of results [45]. The guideline used for the interviews in this study is divided into three sections and starts with the diffusion of knowledge in terms of new ES. This part should examine, what methods are applied to spread knowledge and information with regard to ES. The second part of the guideline is particularly concerned with several influencing factors with reference to the spread of knowledge. Here, the respondents are asked about the importance of individual persons or networks for the diffusion of knowledge with regard to recent ES-related technologies. Furthermore, this section dwells on the importance of suppliers' and customers' influence on information sharing as well as on that of conflicts. The last section of the interview guideline covers factors that are responsible for rejecting recent advancements in terms of ES.

B. *Evaluation method*

The interviews have been evaluated by employing a qualitative content analysis as this method is recommended in literature [46][47][48][49]. Each compiled research question deals with a superior issue that consists of several elements. Consequently, there exist various subordinated questions in the interview guideline referring to one research question. The research questions and the interview guideline serve as an orientation guide for the evaluation of the interviews. Individual categories are crucial for the evaluation [50][51]. The categories should depict different opinions or approaches. These are derived deductively from theory or inductively from the interviews [48][52][53]. As a result, categories that are the basis for the evaluation arise for each question in the interview guideline. On the one hand, these categories can consist of an ordinal scale, for instance with the manifestations "not at all – little – much". On the other hand, the categories can be comprised of particular types of manifestations and proceedings. These categories do not refer to an ordinal scale, but to the existence of a specific procedure or method. An example would be categories referring to relationships to customers and suppliers that influence the diffusion of new advancements. Among others, here are categories like "source of information" or "evaluation by customer" included. In this context, the data is perused tentatively in the beginning to check if the already chosen categories can be applied to the data and to what extend further categories have to be added [48].

In the next step, each interview is analysed based on the category system. Thus, nearly every question is particularised whereas some questions can be elaborated together. Particular parts of the interviews are selected and allocated to one category, for instance at the above already mentioned question "In what way do existing relationships (e.g. to customers, suppliers) influence the diffusion of new advancements?" Besides the named categories "source of information" and "evaluation by customer", additional categories are created according to the stated process. Afterwards, the answer of each interviewee is allocated to at least one of the derived categories.

In parts, the categories are consolidated in a meaningful way. This is e.g. the case, if it becomes apart that categories are very similar and therefore a separation is quite difficult or if certain categories coincide. Consequently, a superordinate category is introduced that involves previously similar categories. For instance, this is the case for the categories "company magazine", "whiteboard" and "system" that are allocated to the superordinate category "internal communication systems" (ICS). The subordinate category "system" thereby refers to all statements about a general company-internal communication system and both categories "company magazine" and "whiteboard" represent two tools to spread knowledge. The ascertained results of these

subordinated categories are then allocated to the superordinate category ICS.

The evaluation follows the frequency analysis [46]. This means that for each answer that is allocated to a category, a "1" is referred to that category in the respective interview. If a category does not pertain, it stays empty respectively is marked with a "0". For example, if an interviewee says that the adoption process is influenced by information the company receives from customers as well as by customers who take over the assessment of new advancements, both categories "source of information" and "evaluation by customer" receive a "1". Respectively, all other categories receive a "0". Thus, the statements are quantified and attributes that occur more or less often can be identified.

V. Results

A. *Knowledge and technology diffusion*

RQ 1: Knowledge and information spreading methods

The initial step with regard to technology adoption is represented by information about the respective advancements based on which a decision for or against the particular technology is made. Being asked about the spread of information in the respective company, 30 out of 48 interviewed persons (~ 63 %) hold the opinion that they get sufficiently informed about new ES. Only three respondents (~ 6 %) feel barely informed about such developments, while 14 experts (~ 29 %) state that they obtain information through individual initiative. One respondent (~ 2 %) was not able to make a statement. In the following, the single methods applied to spread information and knowledge are depicted.

Fig. 3 illustrates the different opportunities to spread information within a company respectively to obtain information.

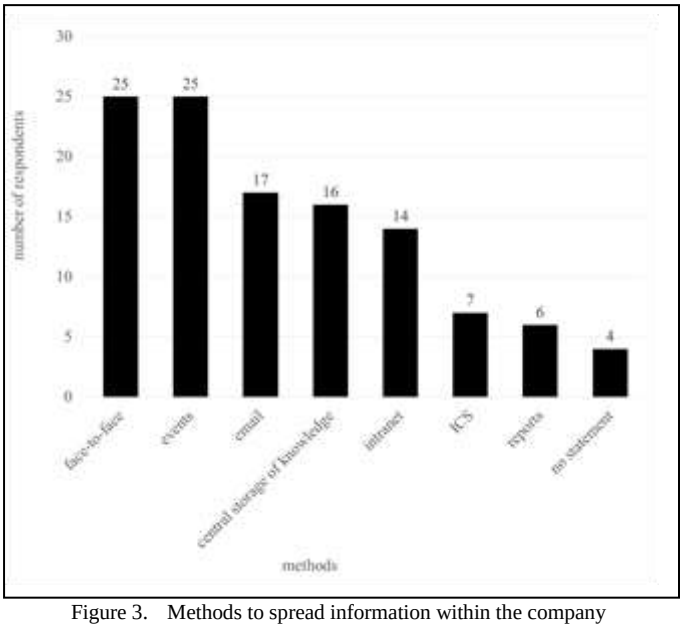

Figure 3. Methods to spread information within the company

Here, in most cases each expert mentions more than one method, whereas four respondents (~ 8 %) did not make any statement. One of the most often mentioned method is **face-to-face**, i.e. a personal (offline) exchange of information. One interviewee who argues that in reference to personal contact, conversations at the coffee machine are very important, highlights this. In total, this method counts 25 indications (~ 52 %), exactly like **events**. In contrast to the prior method "face-to-face", they take place due to a beforehand arranged appointment, but also being considered as offline spreading of information. This opportunity to share information consists of several different types, e.g. seminars, trainings, workshops and meetings. One interviewee instances in this context arranged workshops with the goal to instruct the participants about current advancements.

Email as a tool to spread knowledge is stated by 17 respondents (~ 35 %). As exemplified by one expert, this category also includes newsletters that are sent via email and contain condensed information. If interested in it, the recipient can subsequently gather further information via the intranet or internet. Another method is the **central storage of knowledge** like wiki systems. This is mentioned 16 times (~ 33 %) and is related to the **intranet** with 14 indications (~ 29 %). According to one expert, the company's intranet is used to provide information about project work and project status reports of each department.

For 7 out of the total 48 respondents (~ 15 %), **ICS** constitute a way to spread information. One interviewee serves as an example who adduces a chat system that is applied by employees who do not write emails and do not like to make phone calls. **Reports** as the last mentioned category are stated by six interviewed persons (~ 13 %). These include documents that register experience and perceptions, like lessons learned catalogues or failure databases, as mentioned by two experts.

RQ 2: Influence of persons and networks on the spread of knowledge and information

Being asked about the influence of individual persons or their networks on the spread of information and knowledge, 18 out of the total 48 respondents (~ 38 %) see a high influence. In this context, one expert adduces an introverted employee as an instance who does not share his ideas although he has the required knowledge for a new development. Contrary to that statement, another respondent refers to the already mentioned wiki systems to ensure that every employee has access to existing information. According to him, this proceeding limits the individual influence. This is confirmed by eight more interviewees (~ 19 %), who see only low influence regarding individual persons.

According to seven respondents (~ 15 %), individual persons and their networks have no influence on the spread of information. This is for instance due to a voluntarily sharing of information in the entire company as one expert says. No statement is made by 14 experts (~ 29 %).

RQ 3: Influence of suppliers and customers on the spread of knowledge and information

Besides the company's strategy and own developments, suppliers and customers can also affect technology

affirmation. This is confirmed by 40 out of the total 48 experts (~ 83 %). Only four respondents deny any influence of suppliers or customers on the approval of technologies. Likewise four interviewees made no statement about the influence of suppliers and customers.

Fig. 4 illustrates, in what way relations to customers and suppliers have the potential to affect the adaption of technologies, whereas some respondents named more than one influencing factor. According to 29 respondents (~ 60 %), both customers and suppliers influence the respective companies by providing information, therefore acting as a **source of information**. This is exemplified by one respondent who explains that, in some cases, his company gets a second opinion by suppliers and customers to make sure not to miss any relevant information.

16 out of 48 experts (~ 33 %) mention **customers who evaluate** new technologies as an influencing factor. One example would be an interviewee who argues that it is always the customer who finally assesses the development. Another influencing factor is the **portfolio** of the customers or suppliers that determines the products customers require respectively suppliers offer. This is mentioned by nine experts (~ 19 %) and illustrated by one who emphasises that they precisely analyse which supplier offers which products. Furthermore, this expert highlights that his company scrutinises if a new product is really new or just an update. Moreover, the **dependency on suppliers (S) and customers (C)** play a sufficient role. For example, a company may depend on know-how of suppliers or be influenced in assessing a technology by the price the supplier charges for it. Those dependencies are mentioned by 6 out of the total 48 experts (~ 13 %). Finally, both suppliers and customers may serve as an **initial spark for a detection**, as it is stated by four respondents (~ 8 %). One interviewee who adduces a customer's suggestion in reference of a new development illustrates this.

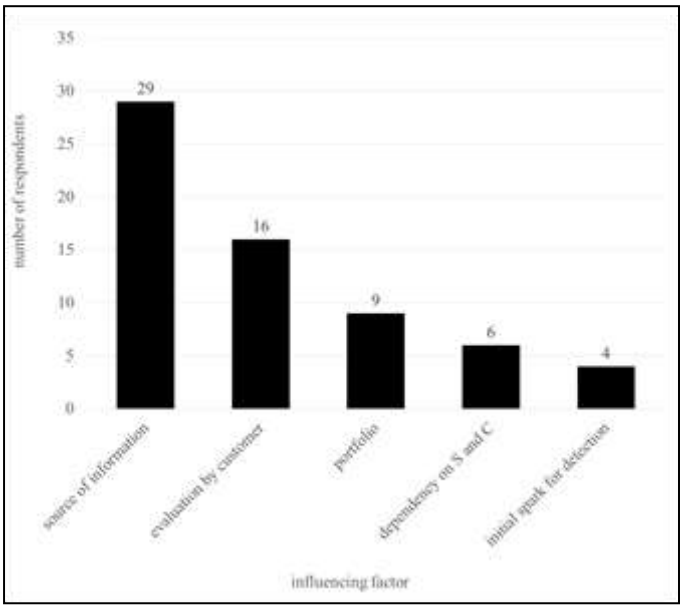

Figure 4. Influencing factors regarding customers and suppliers

RQ 4: Influence of conflicts on the spread of knowledge and information

Conflicts between employees can influence the spread of information within a company as well. Securing one's own position can be one reason why employees refuse to share information, as one expert outlines. This is supported by eight more experts (~ 19 %), who see conflicts as a notable restricting factor regarding information sharing. Besides the already mentioned example, another respondent identifies a high potential for conflicts in the competition between employees or business locations. According to 23 interviewees (~ 48 %), conflicts have only minor impact on the spread of information. They can sometimes result in a delay in information sharing, but occur only occasionally. One respondent additionally highlights the necessity to resolve such disputes quickly to prevent significant impacts. In nine cases (~ 19 %), no conflicts occur, since teams have a manageable size and all members are on a hierarchically comparable level, as one expert explains. Seven respondents did not make a statement on this aspect.

B. Technology rejection

RQ 5: Reasons for technology rejection

After dwelling on spreading information and how this could be influenced in the previous sections, the following will focus on personal as well as company-related reasons for rejecting new ES. Here again, several respondents named more than one reason. As shown in fig. 5, **costs** are the most often stated reason, for which new technologies are rejected. In total, this is named 39 times (~ 81 %), since costs are always a driving force, as one expert explains. The second-most often stated reason are **own developments**, which are stated by 30 experts (~ 63 %). This is exemplified by one interviewee who states that the general framework for internal suppliers makes it difficult to use external technologies as own technologies should be applied preferably. External technologies are only allowed after an approval process, which is associated with significant effort. Moreover, for 26 interviewees (~ 54 %), **customer value** plays an important role, as a product without value for customers is not sellable. Therefore, one respondent exemplifies that he would reject such technologies.

Twenty experts (~ 42 %) mention the **time** required to develop a mature technology as a reason for rejection. In this context, one respondent sees the risk of too many warranty claims if the technology is not yet mature. Likewise twenty interviewed persons (~ 42 %) state **technology characteristics** resulting in the refusal of new technologies. These are technologies that are unacceptable for ethic or moral reasons for the respective respondent or company. For instance, one interviewee would reject military or nuclear technologies.

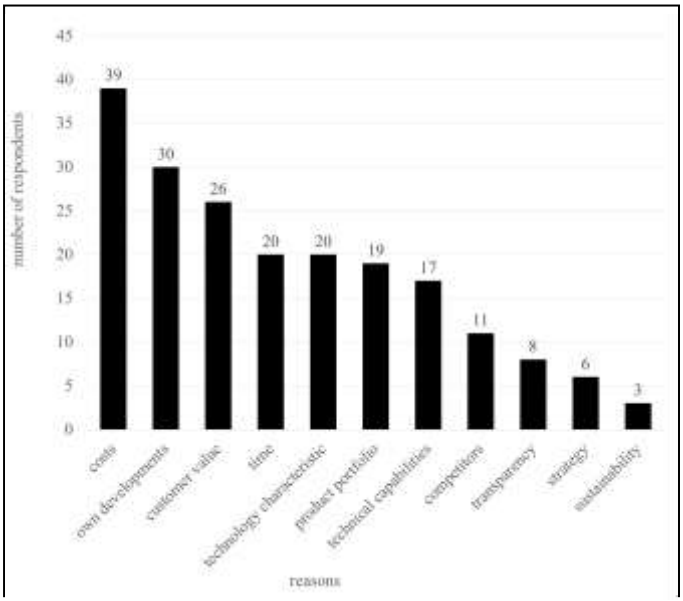

Figure 5. Reasons for technology rejection

For 19 out of the total 48 experts (~ 40 %), it is important that a new ES fits to the respective company's **product portfolio**. Otherwise, it can lead to a refusal. **Technical capabilities** are another significant reason regarding technology rejection. This is explained by one respondent, who denies technological alternatives if his company is not able to further develop them. According to eleven interviewees (~ 23 %), **competitors** could also be a reason for refusing new technologies. This is the case if a competitor already masters the technology and therefore has an advantage, which constitutes a market entry barrier. The non-existent **transparency** is a rejection reason for eight respondents (~ 17 %). One expert argues that it is not possible to offer a sufficient service if the technology is like a black box and no one knows exactly how it works.

The company's **strategy** is for six interviewed persons also a criterion to deny a technological advancement. This is illustrated by one expert, who highlights the importance to focus on core competencies and products. Additionally, for three respondents (~ 6 %), it is important that the technology is **sustainable**. One expert serves as an instance, who would reject a new technology if it was clear that it created no value in the long term.

VI. Conclusion

Our literature review serving as a basis for this study revealed that there is a lack of theoretical analyses regarding the adoption of technologies in terms of ES. Consequently, this paper focuses on the approval and affirmation of technologies, knowledge and information diffusion as well as reasons for technology rejection in the context of ES.

The qualitative content analysis of the conducted 48 expert interviews resulted in the finding that there exists a set of seven methods to spread knowledge and information within an enterprise operating in the market area of ES. The most important among these are face-to-face communications and events, representing offline methods [21][22][23], whereas online methods [23][24][25], e.g. email or intranet, play a subordinate role. We argue that companies that economically act within the highly competitive environment of ES should preferably apply a combination of both on- and offline methods. The reason therefore lies in the fact that offline channels, which are predominantly characterised as being more personal, provide more recent and direct information. Nevertheless, offline methods of communication should additionally be utilised in order to underpin novel perceptions of technological trends and developments. To conclude, despite the growing dissemination of innovative information and telecommunication technologies, offline communication still is of significance.

Moreover, our study observes that persons or networks of persons have a critical influence on the spread of knowledge and information within ES-companies. This is not surprising as it is the individual who identifies, collects, interprets/filters and eventually shares ES-specific information with his/her network. It has to be taken into account that the evaluation of information is predominantly shaped by subjective views. This is due to the reason that collected data has to be interpreted in most cases [54]. Consequently, leaders should try to ensure the reduction of subjectivity as far as possible, which equals the increasing use of objective knowledge spreading tools, e.g. wiki systems to make relevant information available to all employees.

In addition, this paper clearly notices that also suppliers and customers are seriously affecting the distribution of information about recent technological trends. This is, among others, traceable to the suppliers´ responsibility of providing customers with the novel customised ES-technology, which is highlighted by both theoretical findings [29] and the interviewees` experiences. When it comes to customers, it is crucial if they accept, value and are willing to pay for an innovation. Hence, both suppliers and customers must not be disregarded in order to ensure both the complete provision of new trends with regard to ES and the generation of revenues respectively profits.

Contrary to our theoretical findings [31], the empirical results show that conflicts between individuals being involved in the process of spreading technological information about novel ES are hardly influencing this process and associated decision-making.

Similarly to the diversity of diffusion tools of ES, several reasons for the rejection of recent technological advancements have been revealed: Companies concerned with the implementation of new ES predominantly face the difficulty of costs exceeding their available (financial) resources. Furthermore, own technology developments being useful for the solution of confronting problems result in the denial of external advancements, since the former should be applied preferably in order to, among others, maintain internal expertise and justify prior investments. The third-most mentioned cause for the disapproval of innovations is a missing customer value, similarly to the deliberations made above. As a consequence, we advise enterprises operating in the market area of ES, which aim at being successful in their

actions and doings, to focus on technologies which are complementary to own developed technologies in upstream phases, e.g. technology identification, as well as are expected to generate additional customer value. As a matter of course, the given financial conditions have to be taken into consideration, too.

The findings of this study are highly relevant for the analysis and understanding of technology adoption processes as part of innovation, technology and knowledge management that are critical for being competitively successful in a high tech market, which truly applies to the ES market.

Nevertheless, due to the geographic limitation of our research, future studies have to prove that these results hold true beyond the region of the EMN. Furthermore, the focus on technology adoption in terms of ES and its corresponding outcome within the context of this paper serves as a starting point for further research elaborating on transforming those technologies into marketable products and/or services, all associated management decisions as well as the transferability of our results to other technological fields.

Acknowledgment

This work is partially financed by the Bavarian Ministry of Economic Affairs and the European Funds for Regional Development (EFRE) in the framework of the Embedded Systems Initiative (ESI) of the Friedrich-Alexander University Erlangen-Nürnberg (FAU).

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