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ProVa – Provider Value Evaluation for Integrated Product Service Offerings

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Abstract

Through the provision of integrated products and services, solution providers have more to gain than solely profit. This paper introduces the concept of provider value, which is novel in the area of integrated products and services. Further, a method is proposed (ProVa) to identify and evaluate the provider value of an integrated product service offering (IPSO) during the development process. ProVa allows for an assessment in terms of monetary value, but also with respect to other categories such as information and customer relations. In addition, aspects such as uncertainty and experience curve effects are considered. The functionality of ProVa is shown by application to a case in IPSO design.

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1. Introduction

Industrial Product Service Systems (IPS[2]) provide an opportunity for creating added value and growth while disconnecting this growth from an increased resource use during production and delivery of an offering [1–3]. The combination of products and services and their integrated development under a life cycle perspective is central to Integrated Product Service Offerings (IPSO) [4] – the term which will be used in this paper to emphasize the focus on integrated development and use.

Industrial adoption of IPSO is still low [5] and environmental benefits alone are insufficient to motivate companies to change their business-model [4]. In part, this may be attributed to a lack of broadly accepted methods for the design of IPSO [6]. Several methods for IPSO design have been proposed. Meier [7] outlined a customer-specific service design method considering contractual elements, while Aurich *et al.* [8] proposed an approach for an integrated product service design process. A more concrete method by Arai *et al.* [9] reveals which design parameters should be focused on to efficiently meet customer value (CV). Another method by Sakao *et al.* [10] enables evaluation and selection of IPSO concepts from the viewpoint of the customer, and Komoto *et al.* [11] developed an IPSO simulation tool to quantify such value as product function and life cycle cost.

The focus on CV is clearly present in these IPSO design methods – however, the provider side has been largely overlooked up to this point. Due to the extended and intensified relationship between provider and customer, a company has much more to gain from a business-transaction over the lifetime of an IPSO than just profit alone, which is typically the focus when optimizing an offering with a focus on the provider side.

Based on the above, the objective of this paper is to introduce the concept of Provider Value (PV) for IPSO and to operationalize this concept through the ProVa method for the PV evaluation of product- and service-components of IPSO during the development process.

The paper begins with the introduction of PV in section 2. Hereafter, section 3 describes the ProVa method, its structure and operation as well as the classification of PV. Section 4 presents the application of the method to a case, partly based on [12]. Subsequently in section 5, the results are discussed, followed by the conclusion in section 6.

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2. Provider Value

As shown by the IPSO-methods and literature discussed in the introductory section, there has been a diversified and multidimensional approach to CV in IPSO design research in the past. With respect to the provider, the approaches have been much less varied, with a focus on a single indicator of PV: Monetary value. This narrow view overlooks the extensive opportunities for value creation that IPSO provide, and this may lead to dissatisfactory decisions when designing an integrated offering or evaluating the possible introduction of integrated offerings in the first place.

When comparing with traditional product sales offerings, additional value creation opportunities arise from the extensive business relationship between an IPSO-provider and -user. While services such as maintenance can be valuable to and demanded by a customer, they bring various types of value to a provider in addition to the obvious, monetary value. Typically, tightening customer connection is included in such value, and is often perceived as a driver for providing services (e.g. [13]). New information about the products that could be obtained through providing services (as stated by Meier *et al.* [1]) can also be seen as value, because it can be a source for additional commercial services and developing new products.

Being aware of PV during the design process is not only relevant for service components, but also for physical parts of the offering. Whereas in a product-sales-scenario, a provider would try to maximize profit with respect to all components in order to optimize the total return, the IPSO business model allows or even requires a different mindset: Even if a customer is unwilling to pay the price of a certain component at the time the offering is designed, it may be well worth for the provider to include this component, although this means incurring a loss on this part. An example may clarify this reasoning: If the IPSO is marketed under an availability-oriented business model [1] over an extended period of time, any upgrades and retrofits may negatively affect a providers bottom line. If, due to a shift in environmental regulations, a provider can foresee, that a certain component will have to be taken off the market half-way into the length of the contract, it may be reasonable to use an improved though more expensive one right from the start, even if the customer is unwilling to pay for the additional cost at this time. The PV of this modern component would be higher, even though the CV is identical for both variants and therefore the willingness to pay may be low. Another example is the use of sensors giving feedback to the provider about the operational state of the machine. The direct CV incurred by this is very low, and customers will be unwilling to pay for them. However, the ability to anticipate wear or failures when operating an IPSO in an availability-oriented business model is of tremendous value for the provider side and is therefore highly desirable even without direct monetary reward.

Being aware of these issues when designing a new IPSO may be crucial and could mean the difference between a successful offering and a failing one.

3. The ProVa Method

ProVa aims to fill the gap initially highlighted with respect to the lack of focus of current IPSO design methods on the concept of PV.

First, the classification of PV in six mutually exclusive categories is described. With respect to these categories, all of the product and service components will be evaluated. Subsequently, the process is introduced in its entirety along with the evaluation scale developed for the purpose of scoring for PV.

3.1. Classification of Provider Value

PV is the essential unit of measurement for the method. The determination of PV within the area of IPSOs is a complex task. PV may be viewed differently and, for instance, classified into financial, operational, strategic, and social. The paper introduces six mutually exclusive categories of PV that are addressed in ProVa. In this paper, PV is also assumed to be identified per given product or service component in an IPSO. Each PV is explained below, but is not ordered by degree of importance. The possible impact of the respective categories of PV is explained.

PV1 – Environment: IPSOs give rise to opportunities to improve the environmental aspect [1–3]. This can be PV as it contributes to environmental sustainability. In fact, several real business practices of IPSOs have been calculated to decrease environmental impacts quantitatively [4]. An example for “Environment” as a PV may be the comparison of two service components, both of which ensure continuous operation – while one of them incurs a lower number of on-site visits, thus improving the environmental performance of said component and increasing PV. Further, being aware of coming environmental policy developments and ensuring compliance over the lifetime of the IPSO may substantially improve its PV whilst being beneficial for the environment.

PV2 – Customer relations: As shown in [13], strengthened customer relations are one of the main benefits in industry through providing services. Services facilitate not only longer relations [1], but also more frequent contact with customers, as well as customers’ dependency on the provider [14]. Therefore, a component facilitating closer customer interaction may result in a higher PV for this component, even though no immediate monetary award is perceived.

PV3 – Information: The information about the provided IPSO accessed by the provider can be seen as a source for new commercial services and developing new products [1], and thus be PV. This information includes: customer feedback, directly or indirectly provided by the component; knowledge gained through design and production of the physical component; knowledge gained through servicing and maintenance; and information about the use of the component and the offering as a whole. This information could be maintained by limiting access by the customer (or a third party) e.g. to the product details by making the product’s processes a black box [15].

PV4 – Infrastructure: Infrastructure refers to the foundation that can be used commonly for different IPSOs.

This includes a physical base such as communication network and a service base, e.g. a support center for local customers. The investment to build infrastructure often does not pay off at the time it is initially made [1]. In a method that supports rational decision making, this is to be taken into account as PV. This may mean that a component for which production facilities are already present would receive a higher score than a component requiring the construction of new facilities.

PV5 – Time-to-market: IPSOs were found to contribute to a shortened time-to-market based on an industrial case with a new technology [15]. If an IPSO supports the product function properly according to a user's requirements through before-use consultation and installment as well as offer of solving unexpected problems (e.g. product malfunction) the probability of the customer receiving the expected result is increased (especially for result-oriented services).

PV6 – Monetary value: This refers to the revenues and costs for the provider over the lifetime of the IPSO.

3.2. Structure and Operation of ProVa

Figure 1 shows the evaluation process of ProVa. The method is to be carried out in a linear fashion. However, additional insight may be gained if the method is used iteratively, including possible lessons learned in the evaluation and performing sensitivity analyses in cases of inconclusive results.

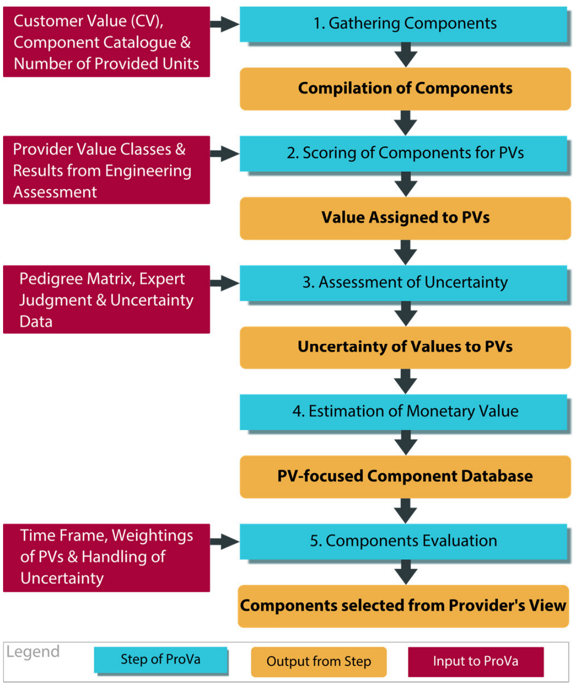

Fig. 1 – Description of the ProVa evaluation process

In order to simplify the process of choosing components that provide an optimized benefit to the provider, certain characteristics are assigned to these components and evaluated.

Phase 1-4 are aimed at collecting the relevant data and building a database for evaluation. Phase 2 and 3 are carried out with semi-quantitative information, while for phase 4, quantitative data is used for point estimation. In phase 5, the actual component selection for use in an IPSO is performed.

Phase 1 – Gathering components: All components, whether physical or service, should be collected. This is fulfilled by either reusing data from previous designs or creating new components. Previous data may for example come from Product Data Management (PDM)-databases – however, the management of component data is not an inherent part of ProVa.

Phase 2 – Scoring of components for PVs: In order to convey the different degrees of influence a certain component has on a PV, it is necessary to assign a score to each PV. To do so, except for monetary value, which is assessed in phase 5, a scoring scale modeled after the one used in Cost Utility Analysis [16] is used, as shown in Table 1. This approach aims to provide a common ground of reference in case more than one person is performing the evaluation or the person scoring is not the same as the one assessing the results.

Since not all the PVs apply to the components, a score of zero may be assigned or the respective field may be left empty, as shown in the case in section 4.

Table 1. Scoring scale for provider value assessment (extended from [16]).

Score	Label	Explanation
0	None	This category of PV may be omitted for the evaluation of this component.
1	Inadequate	Component benefits regarding the PV in question are negligible.
2	Weak	Benefits regarding the PV yielded by the component are almost negligible.
3	Acceptable	Very slight benefits regarding the PV can be expected from the component.
4	Sufficient	Below average, component benefits of PV less than expected.
5	Satisfactory	Benefit to PV is on-par with expectations for this component/function.
6	Fair	Slightly above expectations for possible PV benefit for the component in question.
7	Good	Benefits regarding the PV notably exceeding expectations on this component.
8	Very Good	Benefits regarding the PV notably exceeding expectations on this component.
9	Excellent	Benefits exceeding expectations by a large margin regarding PV for the component.
10	Optimal	Best performance in terms of PV for the respective component.

Phase 3 – Assessment of uncertainty: When assessing the PV of a component during the design of an IPSO, a number of uncertainties are involved. In order to manage (assess and reduce) uncertainty, each components assessment is scored using a Pedigree matrix, see Table 2 [17]. That means, that for each component, a basis of estimate (u_b), the rigor in assessment (u_r), and the level of validation (u_v) are evaluated and subsequently, the sum of the evaluations is calculated: $u = u_b + u_r + u_v$. This constitutes an assessment of the sources of the information, of its quality, and of the way it was utilized. Particularly with designing IPSO for the first time, these uncertainties may be substantial. This phase of the evaluation is intended to sensitize the user for these uncertainties, as the semi-quantitative assessments in phase 2 may easily create a feeling of confidence in figures that are based on low-quality information. For that reason, color indicators will show whether or not the evaluation is backed by high-quality data. The color codes for Pedigree scores are as follows for *u* (color): ≤6 (green), 7-12 (yellow), and ≥13 (red).

Table 2. Pedigree matrix for scoring uncertainties [17].

Score	Basis of Estimate (u_b)	Rigor in Assessm. (u_r)	Lvl. of Validation (u_v)
1	Best possible data, large sample, use of historical field data, validated tools and independently verified data	Best practice in well-established discipline	Best available, independent validation within domain, full coverage of models and processes
3	Small sample of historical data, parametric estimates, some experience in the area, internally verified data	Sufficiently experienced and benchmarked internal processes with consensus on results	Internally validated w. sufficient coverage of models, processes and verified data. Limited independent validation
5	Incomplete data, small sample, educated guesses, indirect approximate rule of thumb estimate	Limited experience of applied process with lack of consensus on results	Limited internal validation, no independent validation
7	No experience in the area	No established assessment processes	No validation

Phase 4 – Estimation of monetary value: Cost and revenue are, despite the novel categories for provider value introduced in this paper, certainly essential criteria when deciding whether or not to include a certain component in an IPSO. Because in the case of monetary value, quantitative data is present, the evaluation is carried out separately from the other PV assessed in phase 2.

Revenue is simply a product of a number of units and the unit price. Entering cost data is done by entering cost per unit (i.e. component), which considers all the costs from in-house and outsourcing as well as the number of units.

Two types of effects on cost will be taken into account in ProVa. First, in particular with respect to service components, the effects of the experience curve [18] will be considered. This refers to the decline of cost per unit as the number of units provided increases and workers gain experience so as to save working time. The user may, based on previous data and experience in the field, choose a slope of the curve, which will then be taken into account. In general, the slope of the curve lies between 80-96% [18], i.e. a unit cost becomes 80-96% of the previous each time the time spent on a certain task doubles. Second, economies of scale are considered. This refers to a relation between a unit cost versus the quantity of provided units. Typically, the unit cost decreases as the quantity increases at a low level of quantity, while it increases in reaching the maximum level. Economies of scale are more likely to occur with physical components. For reasons of redundancy of both effects, they are typically not applied at the same time, although this decision is left to the user and expert judgment when using the ProVa method.

Phase 6 – Components Evaluation: The evaluation here aims at selecting components for a given CV. The following three inputs are needed: The first input is a time frame; the period in which the revenue and cost is calculated needs to be set, as the accumulated revenue and cost can be non-linear. This enables the estimation of the profit of each component, which is used as a score for the PV "Monetary Value". The second input is weightings on PVs; each design can have a different set of weightings on the categories of PV. This is represented as a vector. The third input is information regarding how the semi-quantitative assessment of uncertainty of PV is used.

The evaluation is conducted as three-criteria decision making (the values of these three parameters cannot be summed up): **a)** profit within the given time frame, **b)** the sum product of the weightings $\boldsymbol{w} = (w_1,\ldots,w_5)$, and the scores $\boldsymbol{s} = (s_1,\ldots,s_5)$ of the five PV classes (note w_i and s_i refer to the weighting and the score of the ith PV class, respectively). It is defined that the sum of the weightings w_i for all PV be 1, therefore the average weight being 0.2. Lastly, **c)** *u* in case the assessment of uncertainty of PV is used.

4. Application of the method on a case

To verify the method, ProVa was applied on a wood chipper for professional use with its related services. Section 4 focuses on how Phase 6 was conducted, as it shows the method's effectiveness best. Table 3 shows the database of components as an input to Phase 5; each component's scores to PVs (except for Monetary Value), *u*, and its expected profits. The profits are displayed for time frames of 3, 5 and 10 years.

These values were calculated by assigning different slopes to the experience curves of the service components (e.g. 98% for Monitoring), while the physical components were assumed to only provide profit through the initial sale of the offering (as their lifetimes are expected to be longer than 10 years). The component catalogue has been simplified and grouped into functions (e.g. Intake and Feed) to improve legibility and make the case description easier to understand.

Three different provider strategies and priorities have been adopted to illustrate their influence on selection of both product and service components in three respective cases, as follows.

Case 1 – Candidates of components were compiled, with the CV in focus being "Throughput of at least 20m³/h of wood" (CV1). The components capable of fulfilling CV1 are marked in the last-but-one column in Table 3, and those without the mark (e.g. Flatbed for Intake and Crane for Feed) are not evaluated in Case 1. When selecting a component for a function, the user first used criterion b) $\boldsymbol{w}\cdot\boldsymbol{s}$ (the weighted scores of PV) and in the case this was inconclusive, criterion a) (profit over time) with 3 years as the frame was used. Criterion c) was not used in case 1. Table 4 shows the components chosen after this evaluation. In the case of the Power Unit, an identical $\boldsymbol{w}\cdot\boldsymbol{s}$ (of PTO and Hybrid) leads to reliance on the profits in order to arrive at a decision. CV1 had no filtering effect by itself on the service components but the ranking was determined and the top three are shown (with the ranking in a parenthesis) in Table 4.

Table 3. Database of components, scoring for PV and relevance to given CVs on the cases.

Function	Component	Environment	Customer Relations	Information	Infra-structure	Time-to-Market	Uncertainty, u	Profit over 3 years	Profit over 5 years	Profit over 10 years	Fulfills CV1	Fulfills CV2
Intake	Flatbed	7			8	6	5	500				X
	Conveyor			4			9	1000			X	
	Funnel					4	7	500			X	X
Feed	Drums	3		4			13	500			X	
	Conveyor			4			7	2000			X	X
	Crane	7			10	10	3	0				X
Chip-ping	Drums	4		4		6	13	0			X	
	Disc	7		4	6		7	1000			X	X
	Crusher			4	3		7	2000			X	X
Extru-sion	Screw	5		4		4	7	500			X	X
	Fan	2				8	7	500			X	
	Plate				2		11	500				X
Power Unit	PTO	3		3		8	7	1000			X	X
	Hybrid	7		7			9	5000			X	
	Diesel			5		6	3	3000			X	X
Services	Monitoring	8	5	8	5	7	7	836	1376	2866	X	X
	Diagnosis	8	7	9	3	4	7	657	1137	2385	X	X
	Phone Spt.	9	5	5	5	9	5	-63	-63	-32	X	X
	Inspection		8	9	8		5	100	239	555	X	X
	Wear/ Tear	2	6	6	4		11	2314	3601	7634	X	X
	Availabil.	4	9	8	4	2	15	3000	5000	10000	X	X
	Refurb	8	5	9	5		3	500	500	500	X	X

Table 4. Components chosen for CV1 with their respective profits.

Function	Components	$w \cdot s$	3 Years Profit
Intake	Conveyor	0.8	1000
Feed	Drums	2.8	500
Chipping	Disc	3.4	1000
Extrusion	Screw	3.6	500
Power Unit	Hybrid	2.8	5000
Services	Monitoring (1)	6.6	836
	Phone Support (2)	6.6	-63
	Diagnosis (3)	6.2	657

Analysis of Case 1 – The outcome of this evaluation shows that the chosen components differ significantly from where the monetary value is the most prioritized criterion. The service component "Phone Support" is particularly remarkable; because of its obvious usefulness as indicated by the PVs, the provider ranked this high, even though it suffers a loss there. In addition, how the profits change over time is presented differently between service components in Table 3 due to the differently set curves. This shows potential for different components to be chosen, depending on the given time frame.

Case 2 – The CV in Case 2 (CV2) was "Long-term reliability". The components particularly useful in this regard are marked in Table 3 in the last column. Parallel to targeting CV2, the provider intended to reduce its initial investments. The weightings of PVs are described in parentheses under PVs in the first row of Table 5, with $\sum(w_1,\ldots,w_5)=1$. In the Services, the top three were chosen in Cases 2 and 3.

Table 5. $\boldsymbol{w \cdot s}$ value used for Cases 2 and 3 and u value used for Case 3.

		Env. (0.1)	**Cust. Rel. (0.25)**	**Info. (0.15)**	**Infra. (0.35)**	**T-to-M (0.15)**	$\boldsymbol{w \cdot s}$	$\boldsymbol{u}$
Intake	**Flatbed**	0.7			2.8	0.9	4.4	5
	Funnel					0.6	0.6	7
Feed	Conveyor			0.6			0.6	7
	Crane	0.7			3.5	1.5	5.7	3
Chip-ping	**Disc**	0.7		0.6	2.1		3.4	7
	Crusher			0.6	1.05		1.65	7
Extru-sion	**Screw**	0.5		0.6		0.6	1.7	7
	Plate				0.7		0.7	11
Power Unit	**PTO**	0.3		0.45		1.2	1.95	7
	Diesel			0.75		0.9	1.65	3
Services	Diagnosis	0.8	1.75	1.35	1.05	0.6	5.55	7
	Phone Spt.	0.9	1.25	0.75	1.75	1.35	6.0	5
	Inspection		2	1.35	2.8		6.15	5
	Wear/Tear	0.2	1.5	0.9	1.4		4.0	11
	Availability	0.4	2.25	1.2	1.4	0.3	5.55	15

Analysis of Case 2 – The different CV and $\boldsymbol{w}$ have led to different products and services chosen from Case 1 – these are marked in bold print in Table 5. The weightings also facilitated decision-making with particular focus on infrastructure. Thus, components with excellent scores in this PV were chosen. The only component not matching this pattern is Availability. It was nevertheless included because of its excellent PVs in Customer Relations and Information, two areas crucial for reliability (the CV addressed here). Behind the change from Case 1, there might exist interdependency between certain products and services. However, it is not represented as it is out of the scope of this paper.

Case 3 – In contrast to Cases 1 and 2, Case 3 focuses on partial decision-making from the provider's viewpoint. Fulfillment of a specific CV is not an issue in this part, thus the number of available components is not restricted. A risk-averse provider is considered: the first criterion was the weighted PV $\boldsymbol{w \cdot s}$. In cases where this criterion was indecisive, the second was uncertainty u (instead of profit). The risk-averseness of the provider has no impact on the scoring itself, therefore the scores in Table 5 are still valid. The components chosen in this scenario are underlined in Table 5.

Analysis of Case 3 – No significant change is brought as compared to Case 2; a difference is selecting Diagnosis instead of Availability in the Services – Diagnosis brings less profit but PV with more certainty than Availability.

5. Discussion

As described with the application of ProVa (Section 4), the proposed method has been shown to be scientifically innovative as well as practical benefits. The main scientific innovativeness lies in consideration of PVs in an IPSO design method. For instance, selecting components of a so-called cost center, which is practiced in the industry, is systematically justified by the proposed method. The method can support the provider's decision-making process in practice and is easy to apply in their daily business (even in SMEs), due to virtually no need for special knowledge, detailed quantitative data about PV, or software for this method's users, i.e. IPSO designers. Practitioners may also perform the evaluation without using the different decision-making criteria (weighted score, uncertainty score, monetary value) as separate from one-another, but as a joint evaluation, balancing PV and profit for a certain CV while keeping in mind the uncertainty assessment. Further, it may be possible to use ProVa to evaluate PV for large sets of data, as they are present in PDM-systems. Through this, PV can become a helpful supplementary decision-making criterion that can be introduced into established processes in the industry without resulting in additional, repetitive tasks for each IPSO design.

Limitations of this method include at this point the lack of consideration for possible interdependencies among components. Addressing this aspect within ProVa is a future research endeavor. A part of this would be grouping mutually depending components by e.g. Design Structure Matrix.

ProVa provides IPSO designers with just one side of the IPSO evaluation. The value of the method can be substantially increased through combining it with an evaluation of CV and therefore, considering both sides of the same coin and working towards IPSOs that provide win-win-results for both customers and providers. A method for CV evaluation has been developed [10], and presenting a way of integrated use of both PV and CV is a future area of research interest.

PV itself is not a fundamentally new concept. Life cycle design methods often address environmental performance of the product life cycle, and thus are methods to evaluate one part (type) of the PV. With respect to this, the scientific innovation of ProVa is its coverage of various types of PV in a comprehensive method.

In fact, a seminal work on product design [19] takes a producer itself into account as an initial input. This means that a product design should consider, for instance, the strategies, technologies and information of the provider. Still, most methods for product design do not address PV explicitly. A reason is deemed to be that there is no need to do so, because the main task of product design was specifically to increase the product quality while decreasing the production cost with a given lead time. On the other hand, services bring in different benefits to the provider as well, partly because of its character of value co-creation [20]. Incorporating PV acknowledges additional value creation opportunities that arise in the course of implementing an IPSO business model and is a step towards a comprehensive IPSO design method.

6. Conclusion

This paper presented an innovative, structured method to evaluate the PV of products and services for designing IPSO. ProVa enables a provider to take into account various types of value in a systematic manner. For instance, it can suggest such components bringing little *economic* value (or even loss) but *other* types of value, such as information or benefits to the relation to customers. The method aims to complement existing methods focusing on CV. The use of ProVa is not over once the process has been completed one time – reassessing and rethinking what led to prior assessments is another task central to this method. Because the paper is the first one to present an IPSO design method addressing PV, it hints at several further research areas. One of them is addressing the impact of interdependency of components on PV as described in Section 5. In addition, a software simplifying the processes laid out in this paper is now under development, which would facilitate the use of the method in the industry. Lastly, a comprehensive handbook is being developed. This handbook is meant to support the understanding of ProVa and its most important points, and aims to make the information about PV in IPSO easily accessible to a large audience of practitioners in this field.

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