Measuring the Perceived Functional Affordances of Collaborative Innovation Networks in Social Product Development

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Abstract

The social model of open innovation allows all members of a community to participate in new product development. Social-media co-innovation platforms are the main enablers of this model of open innovation. One aspect of this business transformation model, co-innovation platform affordances, has captured the attention of researchers and practitioners. Although the importance of co-innovation platform affordances has been established, the development of a valid and reliable instrument to measure this construct in research studies has not been reported in the literature. This paper conceptualizes co-innovation platform affordances and develops a valid and reliable measurement instrument capturing critical facets of co-innovation, namely ideation, collaboration, and communication.

1. Introduction

Widespread adoption of information and communications technologies (ICTs) has further enabled businesses to innovate collaboratively with their customers and partners across geographies. These developments have coalesced in the phenomena and study of collaborative innovation networks (CoIN) [11,22,23]. Researchers and practitioners have highlighted the transformational potential of co-innovation in how businesses develop new ideas and bring them to market. Now further research is needed to examine CoIN IT infrastructure that enable co-innovation processes.

A recent and notable development with CoIN is the application of social technologies to engage actors through social mechanisms [3,15,18,29,38]. Distinctive from early open innovation approaches, the application of social mechanism in co-innovation represents a new business model enabled by social media technology platforms [1,38]. The social product development model extends open innovation beyond customer-involvement models to socially-engaged individual actors fully involved in ideation and development of new products [32,36]. Design of the co-innovation social platform can directly affect the quality and sustainability of value co-creation across the product innovation cycle. Therefore, CoINs social platform are designed to integrate affordances for critical innovation tasks.

While collaborative technology affordances have been an area of substantial IS research interest [25,44], research efforts to date have led to mixed and inconclusive outcomes. Inadequate definition and measurement of constructs have been identified as major causes for inconclusive outcomes [44]. Very few of the existing measurement instruments demonstrate adequate validity and reliability. Moreover, there is an absence of a comprehensive instrument to measure the variety of co-innovations affordances. Recent studies call for further examination of functional affordances [27], which is key to understanding co-innovation behavior and outcomes. An instrument measuring functional affordances will be valuable to open innovation researchers and practitioners. The research described here was undertaken to develop one.

This paper reports on the development of an instrument designed to measure the various aspects of functional affordances of CoIN platforms affecting co-innovation processes of ideation, collaboration, and communication. This instrument is intended as a tool for the study of the individual co-innovation behavior within CoIN organizations. Although the focus of this paper is on the functional affordances of the social model of co-innovation platforms, the measurement instrument developed is applicable more generally to a variety of co-innovations technologies.

In this paper, the construct of functional affordances was conceptualized based on the three characteristics of social mediating technology affordances suggested by Sutcliffe [44] from the HCI literature. The measurement items adopted from existing literature or developed via a case study of social product development underwent a two-round exploratory analysis to ensure face validity and content validity. The resulting instrument was subjected to two separate pilot tests and a field test. Following the final test, the instrument demonstrated acceptable levels of reliability and criterion validity. The result is a parsimonious, 12-item instrument comprising three sub-scales, which provide a useful...
tool for the study of co-innovation platforms and their relationships with individual collaborative behaviors.

2. Literature and theory

Gloor [11: 4] defined CoIN as “a cyberteam of self-motivated people with a collective vision, enabled by the Web to collaborate in achieving a common goal by sharing ideas, information, and work”. Stakeholders in a CoIN typically come from diverse backgrounds to work collectively on problems presented to, or proposed by members of, the virtual network [23,36,39,43]. With rapid growth and diffusion of social technologies, the co-innovation model has expanded to encompass networks of diverse actors who collaborate in innovation activities primarily through a social media platform. Social product development platforms such as Quirky are well-known and successful examples of co-innovation communities enabled by social media. Co-innovation platforms enable value co-creation across the innovation cycle, e.g., collaborative idea submission, evaluation, and development of co-invention activities. This combination of social technologies with open innovation strategies offers the potential for business transformation.

2.1. Co-Innovation models and platforms

The business model of a particular CoIN defines the scope of external actors’ involvement in co-innovation, which then becomes the base for designing the CoIN platform structure and organization. For instance, a CoIN may invite external actors to participate in product launch or product support activities, whereas another network may limit actors to contributing or commenting on new product or service ideas. Subsuming variations in the scope of activities, Gloor proposes three general and fundamental dimensions of actor participation in collaborative communities: creativity, collaboration, and communication [11]. In socially-enabled CoIN, creativity is referred to as ideation or co-creation of new product ideas, a critical component of co-innovation processes [40]. Collaboration and communication are essential to any socially-enabled co-innovation system [34]. Collaboration in a CoIN involves interactions among internal and external actors to address problems and find or improve solutions [38]. Because of the distributed nature of the CoIN model, communication between actors such as sharing information and knowledge is an inherent aspect throughout co-innovation processes and activities [36]. CoIN platforms therefore provide and participants utilize a variety of social technology features and functions to ideate, collaborate, and communicate.

2.2. Affordances

Effective design of co-innovation platforms entails affording the action possibilities that platform users desire as well as enabling them to act on the possibilities given the nature of the co-innovation context. Nambisan and Baron [33] advise that the sociotechnical design of co-innovation platforms must ensure that contributions are facilitated. Understanding CoIN platform affordances is a direct way to address this design necessity.

Rather than specifying platform design in terms of the rapidly developing array of ICT and social media features available at any given time, researchers have adopted the theoretical concept of affordances, first defined by Gibson, to characterize the sociotechnical elements of collaborative innovation platforms [29,38,42]. In Gibson’s words, the affordance of an artifact exists between a combination of its properties that provide a specific type of user an “opportunity for action” [10]. This definition topically refers to the functional affordance of an artifact [16,20]. IS researchers have also adopted the concept of affordance to understand the relationship between technology features and technology users [6,25,26,28,47,48]. In this stream of research, technology affordance is defined as “the mutuality of actor intentions and technology capabilities that provide the potential for a particular action” [25:39]. In other words, affordances are possibilities for action that a technology artifact provides the actor. Whether an affordance – or invitation to action – triggers action depends not only on the features and capabilities that the technology artifact offers but also on the actor’s ability to perceive the action possibilities [9,35].

2.3. Collaborative technology affordances

Although there are few empirical studies on collaboration technology affordances, such studies are starting to appear [41]. Malhotra and Majchrzak argued that the majority of the research on collaboration technology affordances has treated this technology as a ‘black box’, or limited the studies to one dimension of media richness theory [27]. These studies ignore the contextual characteristics of virtual collaborative settings. Malhotra and Majchrzak encouraged future research to consider situational (contextual) technology affordances [27].

The affordances of a collaborative technology such as CoIN platform are not synonymous with features [8] nor only associated with the technology per se but are derived from properties enabling collaborative
actions [19]. That means the same technology may have different affordances in different collaborative settings due to different business model structures, network, or co-innovation tasks. Therefore, following Hartson, we assume the functional affordance of a collaborative technology is the properties of its sociotechnical environments or tools that enable collaboration [16].

Since functional affordances are the main enablers of collaboration, the measurement model developed here addresses functional affordance enabling socially engaged actors to interact, communication, collaborate and co-create in co-innovation eco-systems. We therefore define functional affordances of a CoIN platform as the properties the platform offers or provides for co-innovation tasks. This approach is consistent with the comprehensive framework for sociotechnical affordances of collaborative environments suggested by Sutcliffe [44], which outlines functions within an architecture as the key element of supporting collaborative task.

2.4. CoIN platform affordances

CoINs platforms are designed to integrate functional affordances for innovation tasks. The functional affordance of a CoIN environment is defined as a design feature that helps actors accomplish work, and therefore it could exist regardless they are perceived or realized by actors. As in all collaborative environments, CoIN functional affordances have interactional properties facilitating co-innovation tasks through communal or social interactions in a relatively complex co-innovation network.

Sutcliffe et al. suggested three functional dimensions of task support, communication support, and social and group support [44]. These functional dimensions can be aligned with three main functions of CoIN suggested by Gloor: Ideation, collaboration, and communication [11]. In a CoIN, ideation affordances are associated with specific task functions the interface allows participants to perform (e.g., submit new ideas and revise ideas). Collaboration affordances relate to social and group support functions such as group formation, role allocation, collaboration, recommendation, and voting. Communication affordances relate to communication tasks such as messaging, chatting, developing and sharing personal profiles, and networking.

To summarize, we conceptualize the functional affordances of CoIN platforms as socio-technical properties enabling co-innovation tasks: ideation, collaboration, and communication. This conceptualization is the basis of our proposed measurement instrument.

3. Instrument development process

Development of the instrument was carried out in six phases illustrated in Figure 1. The first phase was item creation with the goal of creating pools of items by identifying items from existing scales, and by creating additional items based on two case studies. Following the case studies, the initial items were selected and the sub-scales were developed.

In the second and third phase, the new items and then the questionnaire were pre-tested for face validity and content validity. First, we had panels of judges sort the items from the first study into separate affordance categories, based on the similarities and differences among items. Based on their placement, the items could then be examined and any inappropriately worded or ambiguous items were modified or eliminated. The various sub-scales were then combined into an overall instrument for a second pre-testing using two independent expert panels. The pre-tests helped ensure that the items of the new measures are valid in the social product CoIN context.

In the fourth phase, the instrument was distributed to a small sample of respondents and an analysis of the responses was conducted to get an initial indication of the scales’ reliability. Items that did not contribute to the reliability were culled for phase five, which was a full-scale pilot test with a larger number of subjects. The full-scale pilot test was carried to further examine the instrument validity and reliability within the CoIN context. Sub-scales were further refined and a field test of the instrument was carried out in the last phase. This phase also explored the instrument’s predictive (nomological) validity.

3.1. Item development

The initial construct of platform affordances (i.e. ideation affordances, collaboration affordance, and communication affordances) was conceptualized in light of the recent research on sociotechnical affordances of virtual workspaces and collaborative
technologies, especially the recent studies on collaborative and social virtual environments [21,44,50,52] and was further improved based on the results of our case studies and card-sorting practice.

To create the initial pool of items for each dimension, measurements of concepts such as ‘social media affordances’ [45], ‘interactivity’ [24], ‘sociability’ [21], ‘collaboration affordance’ (in open source community) [41], ‘sociotechnical affordances’ [46], and ‘communication affordance’ [30] were considered. Since these concepts were not initially developed to address functional affordances of co-innovation platforms, the items needed to be adapted and adjusted for the context of social co-innovation.

To do so, we conducted a case study of CoINs to better understand the tasks and actions of members. Studying the construct attributes in a natural setting supported measurement development [2,4] by providing supplementary sources of evidence for the development of the measurement model [51]. First, a broad array of co-innovation platforms was reviewed to identify the differences and the similarities in co-innovation tasks. Twenty-two CoIN were assessed to validate the three pre-identified dimensions of co-innovation platform functional affordances. Then, four CoINs were selected for further examinations. Each case was representative of a type of CoIN business model identified by earlier research: competitive (open) innovation market, co-innovation community, virtual customer environment, competitive innovation community. Our examination showed that these different business models utilized similar mechanisms to engage external innovators in ideation, collaboration and communication actions.

A second case study identified more details of the social model of CoIN platform characteristics. The case data were collected from Quirky.com for the following reasons: (1) co-innovation in Quirky includes more socially-enabled interactions and accordingly provides more opportunities for external actors to collaborate or to be engaged. (2) The Quirky business model is more comprehensive than other networks because of higher levels of actor involvement and the variety of co-innovation processes and social engagements. (3) The numerous co-innovation opportunities in this network provide a rich phenomenon. In addition, (4) the various sources of data (user and product profiles and forum discussions) were publicly available to study.

Different data sources were used in the case review. The first data source was email interviews with the active members of the Quirky community. Fifty active and relatively successful Quirky members were invited to participate in an interview. The member forum discussion was the second source of data. The third source of data was the researcher’s participatory and non-participatory observations of actors’ contribution, interactions, and relationships across the platform. The fourth resource was published materials by the company such as reports, blog posts, and press release that directly or indirectly specify the CoIN’s co-innovation processes. The last set of data are published case studies of Quirky in books, academic journals, and managerial reviews.

Quirky demonstrated a prototypical and at the same time a comprehensive model of socially-enabled co-innovation. As part of the ideation process, prospective inventors can usually submit their ideas for community evaluation. The submitted ideas, if selected, are collaboratively designed, developed, and commercialized by network members including the company’s employees. The developed product ideas are then put to production by the company and finally distributed. We used this so-called social product development process to expand the initial list of items. Table 1 provides examples of measurement items developed from the case studies.

### Table 1. Examples of action possibilities afforded by CoIN platforms emerged from case studies

<table>
<thead>
<tr>
<th>Ideation Affordances</th>
<th>Collaboration Affordances</th>
<th>Communication Affordances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submit new idea</td>
<td>Find new project</td>
<td>Exchange knowledge</td>
</tr>
<tr>
<td>Present new idea</td>
<td>Review new project</td>
<td>Exchange comments</td>
</tr>
<tr>
<td>Monitor the evaluation of one’s own idea</td>
<td>Share &amp; exchange knowledge</td>
<td>Exchange votes</td>
</tr>
<tr>
<td>Revise idea</td>
<td>Contribute to new project development /improvement</td>
<td>Discuss new idea/project</td>
</tr>
<tr>
<td>Resubmit revised idea</td>
<td>Contribute to new project marketing /commercialization</td>
<td>Add/share profile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Network internally/ externally</td>
</tr>
</tbody>
</table>

### 3.2. Instrument refinement

The items generated through the literature review and empirical case studies were refined into the measurement instrument through two processes: the pretest of the new and adjusted measurement items, and the pretest of the entire questionnaire. These tests were conducted to identify problems in item selection and comprehension, so as to improve the validity and reliability of the instrument.
3.2.1. Pre-test of scale items

Measurement items and their categorization were examined through two rounds of card-sorting. Card-sorting (using ConceptCodify, a web-based card sorting tool) was conducted in accordance with established guidelines [31]. The two sequential card-sorting exercises were conducted by 32 and 30 judges respectively. The card-sorting process was repeated with several judges until we reached the required level of inter-judge agreement measured by inter-rater reliability and hierarchical cluster analysis. This technique helped test the initial classification and relationships between different proposed items. This method was also the initial attempt to test convergent and discriminant validity by grouping items into different categories, thus confirming the conceptualization of platform as ideation, collaboration and communication affordances.

In both card-sorting exercises, the randomly listed items along with the names and definition of the constructs were distributed to the judges. The judges separately (1) sorted each item to a most proper construct, (2) marked it as ‘Does not fit any category’, or (3) marked it as ‘Does not make sense or is confusing.’ The judges could also suggest new categories for the items that did not fit any category.

After the first card sorting, inter-rater reliabilities (Cohen’s Kappa) were calculated and hierarchical cluster analysis was conducted for the items to identify the problematic items. The Kappa scores met the acceptable level of 0.65. The hierarchical cluster analysis then helped to identify relatively homogeneous groups of items based on selected groups. In the first round, the judges sorted 23 items with the flexibility of adding new groups to the initial three groups. Five misplaced items were reworded based on the judges’ feedback. After the refinement, the same procedure was followed for the second card-sorting but with judges from the target population. Thirty CoIN members were invited to sort 20 items to three categories. This second phase of card-sorting indicated four low performing items flagged as confusing. These items were rephrased before the questionnaire pre-test.

3.2.2 Pre-test of scales in questionnaire

The newly developed items were included in a comprehensive questionnaire that examined individual motivations and outcomes of co-innovation in addition to platform affordances. The pretest used the general guidelines of Creswell [4]. The most applicable method for the questionnaire assessment, ‘expert panel technique’, helps with identifying the possible weaknesses in the construction of the questions, and figuring out possible sources of bias (e.g. possible order effects). Ten experts were thus asked to identify flaws associated with the questionnaire construction. Experts reviewed the questionnaire and shared their opinion with the researcher directly. All items were constructed as 7-point Likert-type scaled questions [17] to avoid collapsed variance and maintain the consistency of responses. The questions in each group were ordered randomly. The questionnaire was evaluated in terms of respondent issues (e.g. comprehension, burden), as well as format issues (e.g. flow, typographical errors, and order effects).

The follow-up probes technique was employed to identify difficulties in the questionnaire completion after revising the first draft based on expert feedback. In this stage, 20 individuals from four different CoIN were asked to complete the questionnaire and comment on potential problems or improvement. Written and oral comments on the questionnaire were aggregated to improve the questionnaire. Five reviewers were also nominated from the Quirky community for follow-up probes. Quirky members provided insights on the entire co-innovation process as well as terminology used in the co-innovation community, facilitating further refinement.

4. Pilot studies

We conducted two pilot studies. The first test was conducted to ensure that the scales demonstrated the appropriate levels of reliability. The second pilot study was a full-scale pilot test of the questionnaire using respondents from the target population. The sample for the pilot study was drawn from the Quirky community and data were collected online using the Qualtrics platform. More than 650 Quirky users were randomly selected and invited to participate in the pilot tests. The respondents were also asked to provide feedback on the items, format and scaling.

The respondents were all active member with at least one-month experience with co-innovation. A total of 36 and 72 complete and usable questionnaires were returned respectively for each round of pilot test. Since data were normally distributed, this sample size is a reasonable size for multivariate analysis with SEM-PLS [12]. The sample was relatively balanced according to all known demographic factors.

4.1. First pilot test

The purpose of this test was to make an initial reliability assessment of the sub-scales and improve the instrument to achieve the desired reliability levels. PLS standardized loadings along with Cronbach’s alpha with minimum of 0.7 were used in determining
poor items [14]. Before any item elimination, we checked the content validity to ensure that the domain coverage of the construct would not suffer. As a result, two items were dropped. The statistics were then recomputed to reconfirm the reliability test recommendation.

4.2. Second pilot test

We modeled platform affordances as a second-order formative construct comprising of three first-order reflective constructs, namely platform ideation affordances, platform collaboration affordances, and platform communication affordances (see, Figure 2). Our case studies indicated that the three first-order constructs could exist independently of one another. Therefore, we assumed and then tested if the underlying second-order components can exist independently of one another without generating common variance [5,37]. Unlike in the case of reflective constructs (where the indicators are caused by the constructs), we proposed and tested whether the first-order affordance constructs variance occurs in the platform affordance construct [5].

![Figure 2. Reflective first-order, formative second-order platform affordances construct](image)

The measurement model was pilot tested in two steps using the techniques (see, Table 2) recommended by Hair and his colleagues [13,14]. The first step was for first-order reflective construct examination and the latent variables estimation, and step-2 was for formative second-order constructs.

**First-order.** Table 3 presents the overall quality of reflective measures. Cronbach’s alpha and composite reliability were calculated to test the reliability of data. In this stage, PIDA5 was the only indicator removed from the initial model with a factor loading less than 0.5. The PIDA reliability was improved, after removing PIDA5 (i.e. the platform enables me to improve my own product ideas), from 0.867 to 0.909. The rest of reflective constructs met the reliability criteria.

Convergent validity of reflective constructs was tested by examining Average variance extracted (AVE). All construct met the threshold of 0.5. Discriminant validity was tested by Fornell–Larcker criterion and the examination of cross-loadings. Comparing the loadings indicated that an item’s loadings on its own construct are in all cases higher than all of its cross loadings with other constructs. Moreover, the AVE of each reflective construct, was higher than the construct’s highest squared correlation with any other construct. These tests indicated that there is discriminant validity between all the dimensions of platform affordances. In addition, the evaluation of factor loading identified no cross-loading issues.

![Table 3. Reflective measures reliability](image)

**Second-order.** The second-order formative construct was assessed following a guide recommended by Hair and his colleagues [13,14]. Indicator validity was of interest for the test of second-order construct of platform affordances. Indicator validity refers to the importance of each indicator of the related formative construct. This indicator validity is concerned with the strength and significance of the path from the indicator to the construct. This estimation of this validity was performed using the PLS algorithm method with a bootstrapping of samples to calculate item weights and loading of each formative indicator. Each item’s weight (relative importance), loading (absolute importance), and associated t-value using bootstrapping were used to assess items’ significance. The t-value determines whether the path from the indicator to the construct is significant.

Then, the indicator validity results for the formative measures were calculated. All the second-order formative weights were significant except...
Platform Collaboration Affordance (PCLA). Since PCLA had significant loading value (0.75, p < 0.05), there is empirical support to retain the item with some consideration (i.e. theoretical relevancy) for the field study [49], [50].

Formative constructs should be also evaluated for multicollinearity. Multicollinearity tests showed that each indicator’s variance inflation factor (VIF) value was less than the cut-off value of 5. Redundancy analysis was then conducted to establish the convergent validity that can be achieved by correlating each formative construct with a global measure for that construct. For this test, the Platform Affordances construct was modeled as the independent variable and the global measures were the dependent variables. A path coefficient was above the threshold of 0.80, providing support for convergent validity of both formative constructs.

### Table 4. Final measurement items used in the field test

<table>
<thead>
<tr>
<th>Second-order formative construct</th>
<th>First-order reflective dimensions</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Platform Affordances</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platform Ideation Affordances</td>
<td><em>The platform enables me to ...</em></td>
<td>PIDA1: submit new product ideas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PIDA2: describe/present my product ideas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PIDA3: monitor my idea evaluation process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PIDA4: revise/submit my product ideas</td>
</tr>
<tr>
<td>Platform Collaboration Affordances</td>
<td><em>The platform enables me to ...</em></td>
<td>PCLA1: review different product ideas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PCLA2: vote for different product ideas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PCLA3: contribute to product design/development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PCLA4: contribute to product commercialization</td>
</tr>
<tr>
<td>Platform Communication Affordances</td>
<td><em>The platform enables me to ...</em></td>
<td>PCMA1: share my knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PCMA2: solicit votes/support</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PCMA3: discuss new ideas with community</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PCMA4: network with community</td>
</tr>
</tbody>
</table>

### 5. Field study

The final measurement items that were used in the field test are listed in Table 4. The data for the field survey were collected from a random sample of Quirky members. From 600,000 potential respondents, 1000 Quirky members were randomly invited to participate in an online survey. Of the 320 Quirky’s members who responded fifty-nine responses were removed due to the respondents’ lack of co-innovation experience or incomplete data, leaving a final sample of 261 usable responses for analysis. Demographic data analysis shows that all relevant types of respondent were included in the sample; therefore, the study obtained a productive sample contributing to the external validity.

The measurement models of different affordance constructs were tested as three different first-order reflective constructs. Then, the second-order construct of affordances was examined as a three-dimensional formative construct.

**First-order.** The evaluation of the reflective measurement model included the test of indicator reliability, internal consistency, convergent validity, and discrimination validity. The loadings of the reflective indicators were examined in order to assess the indicator reliability. As presented in Table 5, all constructs were found to have good to very good factor loading. Internal consistency reliability (construct reliability) was assessed by examining the Composite Reliability (CR) and Cronbach’s alpha of the constructs. Table 6 shows acceptable CR values and Cronbach’s alpha values for all the constructs, thus demonstrating acceptable internal consistency reliability for the first-order constructs.

### Table 5. Platform affordance factor loadings

<table>
<thead>
<tr>
<th>Items</th>
<th>PIDA</th>
<th>PCLA</th>
<th>PLCMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIDA1</td>
<td>0.898</td>
<td>0.546</td>
<td>0.421</td>
</tr>
<tr>
<td>PIDA2</td>
<td>0.913</td>
<td>0.551</td>
<td>0.384</td>
</tr>
<tr>
<td>PIDA3</td>
<td>0.829</td>
<td>0.501</td>
<td>0.363</td>
</tr>
<tr>
<td>PIDA4</td>
<td>0.856</td>
<td>0.474</td>
<td>0.410</td>
</tr>
<tr>
<td>PCLA1</td>
<td>0.544</td>
<td>0.818</td>
<td>0.422</td>
</tr>
<tr>
<td>PCLA2</td>
<td>0.468</td>
<td>0.842</td>
<td>0.475</td>
</tr>
<tr>
<td>PCLA3</td>
<td>0.492</td>
<td>0.845</td>
<td>0.395</td>
</tr>
<tr>
<td>PCLA4</td>
<td>0.454</td>
<td>0.800</td>
<td>0.413</td>
</tr>
<tr>
<td>PCMA1</td>
<td>0.375</td>
<td>0.512</td>
<td>0.883</td>
</tr>
<tr>
<td>PCMA2</td>
<td>0.368</td>
<td>0.460</td>
<td>0.881</td>
</tr>
<tr>
<td>PCMA3</td>
<td>0.447</td>
<td>0.441</td>
<td>0.897</td>
</tr>
<tr>
<td>PCMA4</td>
<td>0.408</td>
<td>0.416</td>
<td>0.879</td>
</tr>
</tbody>
</table>

Convergent validity of the model was again assessed using AVE. The acceptable standard is that the AVE of the constructs should exceed 0.5, which means the items share at least half of their variance with the construct. Table 6 shows that the AVE values of the reflective measurement model of the research
are greater than 0.5 with values ranging from 0.683 to 0.784. These values provided evidence that the convergent validity was achieved, and indicates that the measures used were robust. The discriminant validity of the model was evaluated by examining the cross loading for each indicator. It was found that the loading of each indicator with its own construct are all higher than its loading for other constructs. Discriminant validity was also examined using the Fornell–Larcker criterion. The second evidence of discriminant validity, the AVE of each reflective construct, was higher than the construct’s highest squared correlation with any other construct. Therefore, analysis of cross-loadings and Fornell–Larcker criterion showed that discriminant validity was perfectly established.

Table 6. Internal consistency reliability

<table>
<thead>
<tr>
<th></th>
<th>AVE</th>
<th>Composite Reliability</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCLA</td>
<td>0.683</td>
<td>0.896</td>
<td>0.845</td>
</tr>
<tr>
<td>PIDA</td>
<td>0.765</td>
<td>0.929</td>
<td>0.897</td>
</tr>
<tr>
<td>PCMA</td>
<td>0.784</td>
<td>0.935</td>
<td>0.908</td>
</tr>
</tbody>
</table>

Second-order. The evaluation of second-order construct of platform affordance as a formative construct included assessment of the formative indicators’ validity, multicollinearity, and convergent validity. The estimation of indicator validity was performed using the PLS algorithm method with a bootstrapping of samples to calculate item weights and loading of each formative indicator. Each item’s weight (relative importance), loading (absolute importance), and associated t-value using bootstrapping were used to assess item’s significance. The number of bootstrap samples was 5,000, and the number of cases was equal to the number of observations in the original sample. The weights and loadings of the formative indicators of the measurement model are given in Table 7.

Table 7. Weights and loadings

<table>
<thead>
<tr>
<th></th>
<th>Loading</th>
<th>t-value</th>
<th>Weight</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCLA → PA</td>
<td>0.828</td>
<td>16.440</td>
<td>0.316</td>
<td>2.908</td>
</tr>
<tr>
<td>PIDA → PA</td>
<td>0.893</td>
<td>27.814</td>
<td>0.545</td>
<td>6.804</td>
</tr>
<tr>
<td>PCMA → PA</td>
<td>0.749</td>
<td>12.584</td>
<td>0.327</td>
<td>3.525</td>
</tr>
</tbody>
</table>

Formative constructs were also evaluated for multicollinearity. Multicollinearity tests showed that each indicator’s VIF value was less than the cut-off value of 5 (see, Table 8). Following Hair’s et al. general guidelines, all formative indicators in this measurement model should be retained, as they were not highly correlated in the model [50].

Redundancy analysis was conducted to establish the convergent validity by correlating each formative construct with a global measure for that construct. A path coefficient for PA was above the threshold of 0.80 (p < .000), providing support for convergent validity (i.e. not redundant variable) of the formative construct. The off-diagonal values in

Table 9 are the square of correlations between the latent constructs. As the evidence of independency, the AVE of each reflective construct was higher than the construct’s highest squared correlation with any other construct.

Table 9: Latent variable squared correlation

<table>
<thead>
<tr>
<th></th>
<th>PCLA</th>
<th>PIDA</th>
<th>PCMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCLA</td>
<td>0.683</td>
<td>0.352</td>
<td>0.267</td>
</tr>
<tr>
<td>PIDA</td>
<td>0.352</td>
<td>0.765</td>
<td>0.204</td>
</tr>
<tr>
<td>PCMA</td>
<td>0.267</td>
<td>0.204</td>
<td>0.784</td>
</tr>
</tbody>
</table>

Lastly, we examined the nomological or predictive validity by testing the relationship between the platform affordance construct and its consequence: actor intention to co-innovation [21,49]. We tested the significance of the direct effect using bootstrapping procedures computed for each of 5,000 bootstrapped samples. The field study showed that the three constructs of platform affordances, PIDA, PCLA, and PCMA were positively associated with their respective construct, namely intention to ideate (b = 0.62, p < .001), intention to collaborate (b = 0.61, p < .001), and intention to communicate (b = 0.63, p < .001). Further test confirmed that the second-order construct of platform affordances also invokes the intention to contribute to co-innovation (see, Figure 3). Therefore, the predictive validity of the instrument was established.
7. Discussion and conclusion

The instrument development for co-innovation platform affordances offers several contributions to co-innovation research, most importantly a valid and general instrument to measure co-innovation functional affordances. The construct and measurements are drawn from theory as well as empirical studies. Through this process the functional affordances of co-innovation platform were shown to have three distinctive components related to ideation, collaboration and communication. As a result, platform affordances are operationalized as a second-order construct compromised of all three functions identified. This observation was confirmed during the card-sorting rounds. Later, it appeared the proposed first-order affordance sub-scales are conceptually distinct from each other given the relatively distinct factors, which emerged from the unconstrained factor analysis. The field test also confirmed all three affordances dimensions can be viewed as a single second-order formative construct. Thus, our method of developing the sub-scales provides a high degree of confidence in their both translation validity and criterion-related validity. The final result is a reliable and parsimonious with 12-item on 7-Likert scale.

The instrument can be used to investigate how perception of functional affordances affects actor intention to use co-innovation platforms. In addition to the solid results of validity of the factors, the predictive (nomological) validity of all the platform affordance was promising. It is believed that the final instrument, which was developed based on a model of general factors, can successfully contribute to the prediction of co-innovation behavior in terms of intention to co-innovation. Still more work, however, is needed to investigate the interaction between these three dimensions in driving co-innovation behavior. The results also call for more scholarly attention to the role CoIN platform affordances play in influencing the relationship between other motivational factors and intention to contribute to co-innovation process.

It is suggested that researchers employ the proposed instrument to develop new, more rigorous studies to further clarify the role of affordances. In recommending this instrument, we should also note its limitations. While the instrument is developed to be as general as possible, it was tested with respect to a particular type of CoIN. Following the results of first case study, we assume that most CoINs have all three functions of ideation, collaboration, and communication in some form. However, some CoINs, such as a customer virtual community, may limit actor participation to a single function such as communication. Although this instrument could be easily adapted for different CoIN business models, additional checks for validity and reliability would be prudent if removing a dimension. In addition, further investigation is needed with other open-innovation models such as innovation marketplace to investigate the generalizability of the scales.

9. References

[18] Kahert, D., Menez, R., and Blättel-Mink, B. Coordination and Motivation of Customer Contribution as


