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Paper:

Kapoor, K., Dwivedi, Y. & Williams, M. (2014). Innovation adoption attributes: a review and synthesis of research findings. *European Journal of Innovation Management*, 17(3), 327-348.

<http://dx.doi.org/10.1108/EJIM-08-2012-0083>

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Innovation Adoption Attributes: A Review and Synthesis of Research Findings

Abstract

Purpose - Rogers' diffusion of innovations theory typically concerns attributes that steer the process of inducing new ideas through various communication channels, which essentially diffuse different types of innovations into different systems. After Rogers, Tornatzky and Klein presented 30 such attributes (five of which were Rogers') that steered the process of innovation diffusion. This paper aims to use a systematic approach in reviewing the literature pertaining to these thirty attributes, followed by the meta-analysis of the articles collated in relevance to these attributes.

Design/methodology/approach - Publications in the time frame of 1996 - mid 2011 in this field of literature have been shortlisted for this review. A total of 223 innovation articles are studied in detail to collate the relevant data needed to reflect on the various informative trends exhibited by the shortlisted innovation attributes.

Findings - An analysis of these trends will be carried out across three different categories – [I] Subjective Analysis [II] Seven features of an ideal innovation attribute study (Approach, Dependent Variable, Study Type, Instrument, Measure, Number of attributes, Number of innovations, Adopting unit) [III] Antecedents and descendants of the innovation attributes, which altogether will be used deduce findings, limitations and suggestions for future research from this review.

Originality/value - No recent study has analysed existing research on less explored innovation adoption attributes. Therefore, analysis and findings presented in this research is original and will make adequate contribution to the existing research on this topic. Findings presented in this submission would be helpful for researchers, authors, reviewers, and editors.

Keywords: Attributes, Innovation, Meta-Analysis, Systematic Review

Submission Classification: Literature Review

1. Introduction

Everett M. Rogers is regarded as the inventor of the *Diffusion of Innovations* theory, which first sought recognition in 1962. He described diffusion as a process of communicating an innovation over time, through certain channels, amongst the members of a social system (Rogers, 2003). To help in assessing the different rates of adoption, Rogers identified – *Relative advantage, Compatibility, Complexity, Trialability, and Observability* as the five attributes of innovations. After Rogers, Tornatzky and Klein's work in 1982 was marked significant in this literary field of innovation diffusion. They examined IT innovations with reference to the use of Rogers' innovation attributes. In addition to the five attributes listed by Rogers, they identified twenty five other innovation attributes. These other 25 attributes were deemed important and marked to be studied under this review. Tornatzky and Klein (1982, p28) state that “innovation characteristics research describes the relationship between the attributes or characteristics of an innovation and the adoption or implementation”. Therefore, there exists a need for achieving a better understanding of the effects of such attributes, as they increasingly influence the adoption decision of an innovation. Tornatzky and Klein (1982) also proposed a conceptual yardstick, whereby they listed seven features that together represent an *ideal innovation-attribute study*.

After Tornatzky and Klein, Moore and Benbasat performed a significant study in this area in 1991, during which they developed an instrument to measure individual perceptions of adopting an IT innovation. They discussed attributes both from *Rogers* and *Tornatzky and Klein*. They studied eight attributes, five out of which were studied either by Rogers, or by Tornatzky and Klein. The remaining three newly identified attributes – Image, Voluntariness, and Result Demonstrability were essentially found to have their basis on Rogers' attributes. Therefore, a decision was made to also incorporate these three attributes in this study. The existing literature in the field of innovations is a proof of the many studies using one or more of Rogers' innovation attributes for analysis in their respective works (Kapoor et al., 2014). For instance, Hester and Scott (2008) study the literature to emphasize the need for implementations of the Wiki technology to carefully consider the user perceptions of Wiki organizational compatibility, relative advantage and complexity; Greenhalgh et al. (2004) in a systematic review address the diffusion and sustenance of innovations in the health service delivery industry by delving into each of Rogers' five attributes; Legare et al. (2008) address Rogers' innovation attributes as the facilitators and barriers in the implementation of the decision making process in their updated systematic review on health professionals' perceptions in clinical practice.

Owing to the fact that Rogers' theory holds the highest position and is well established in the world of innovations, it can be concluded that there have been many studies concentrating on Rogers' innovation attributes. However, there are also other attributes that have been used, studied, and reviewed as innovation attributes in the past, a classic example of which is the Tornatzky and Klein review (1982). Evidently, Rogers' innovation attributes have been periodically reviewed both, in the revised editions of his books that came out until 2003, and also in the other reviews published in this area. This elucidates the fact that the other innovation attributes have not received as much attention as the Rogers' attributes. Therefore a decision was made to study the other innovation attributes apart from the five Rogers' attributes. Thus, the other 25 attributes from Tornatzky and Klein, and the three attributes from Moore and Benbasat made up the 28 relevant innovation attributes chosen to be reviewed under our study. The aim of this paper is (a) to undertake a systematic review of these chosen innovation attributes to reflect upon how the use of these attributes have changed

and progressed in the last 15 years, and (b) to carry out a meta-analysis for the evaluation of the role of these innovation attributes in the adoption process. To achieve this aim, four objectives have been laid out - (i) to perform a subjective analysis of chosen attributes (ii) to provide for a longitudinal view by identifying and comparing the different trends across these attributes over time, (iii) to identify the antecedents and descendants of all of the attributes, (iv) use conservative averaging for the estimation of effect size and significances.

This paper will proceed with a detailing on the methodology adopted for this review process, and revelations of the findings in the forthcoming section. The progression will continue with discussions, followed by recommendations, limitations, and the derived conclusions from this review.

2. Methodology

When it comes to the synthesis of research findings, numerous research methods exist, like the systematic review, the bibliometric analysis, content analysis, meta-analysis and many more (Weerakkody et al., 2009; Dwivedi and Kuljis, 2008; Dwivedi et al., 2011; Williams et al., 2009). Our study however chose a combination of literature review and meta-analysis. Meta-analysis is basically combining quantitative findings from existing research, while literature review is the subjective discussion on the combined results using appropriate supporting citations. Therefore, both meta-analysis and literature review have been used here in conjunction. The same set of studies has been considered for undertaking both, the literature review, and the meta-analysis, and therefore no discrepancy exists between these two research methods in terms of the studies used. The literature review was undertaken to discuss the existing literature on the innovation attributes and their influences on the adoption and diffusion of different innovations. Since one of the identified aims of this study was to pursue an analysis that extends a longitudinal view on the behaviour of different innovation attributes over time, a meta-analysis approach was adopted. While meta-analysis can be pursued in many different ways, given the aims of our study, an averaging method of meta-analysis was employed, since Tornatzky and Klein (1982) followed such an approach in their meta-analysis. Given that the findings from this study's meta-analysis would be compared with the findings by Tornatzky and Klein (1982), we duplicated their approach in our study to allow for the comparison.

The fifth edition of Rogers' book on Diffusion of Innovations (2003) was chosen to be the base point for our review. Although the attributes identified by *tornatzky and Klein*, and *Moore and Benbasat* were shortlisted as the relevant attributes for our study, the data collection was primarily concentrated only on studies citing Rogers' Diffusion of Innovations theory, as our study is wholly and essentially dedicated to the *Diffusion of Innovations* theory. The conceptual idea was to search and analyse the usage and worth of the all the attributes identified by *Tornatzky and Klein* and *Moore and Benbasat* in all the studies citing Rogers' Diffusion of Innovations theory. Hence, it was considered appropriate to collate all the studies citing the latest edition of this book, but it was found that many publications continued to cite the fourth edition of the book even after the release of the fifth. Considering this, a decision was made to extract all publications from the year 1996 onwards. All publications made until the mid of the year 2011 were extracted. *ISI web of knowledge* and *Google Scholar* were the two search engines used, which fetched 2073 publications in total.

In the *preliminary screening* the retrieved publications were sorted according to their type – journals, articles, conference proceedings, papers, books, HTML, theses, and citations. For the review purposes, it was necessary to create a database housing all publications available.

Only 1365 articles were available for download. In the *secondary screening*, it was important to segregate publications that had mentioned one or more of the 28 innovation attributes of our interest in their respective works. This filtering fetched 104 articles from 74 journals, and 25 proceedings from 13 conferences, resulting in a total of 129 relevant publications to be studied under this review. Finally, the *tertiary screening* focussed on identifying the exact number of studies in which each of these 28 attributes had been used as innovation attributes. The frequency for each of these attributes is as shown table 1.

<Table 1. Here>

Tornatzky and Klein used the attributes, *cost* and *initial cost* in total conjunction. They analysed both attributes under a single category, *cost*. The same will be followed for this study. There were typically 27 studies under cost, and two studies under initial cost, which were both clubbed to arrive at a total of 29 cost studies. Of the total 28 attributes, it was found that 17 attributes (association with major enterprise, flexibility, pervasiveness, radicalness, saving of time, reliability, scientific status, clarity of results, continuing costs, profitability, importance, mechanical attraction, regularity of reward, payoff, rate of cost recovery, saving of discomfort, specificity of evaluation) had not been used as innovation attributes in any of the 129 publications. Out of the remaining 11, three attributes - *divisibility*, *communicability*, and *initial cost* were found to be in less than ten studies. To arrive at a substantial discussion and a meaningful analysis, a decision was made to eliminate attributes with less than 10 studies. Since initial cost was already suitably combined with cost, divisibility and communicability were discarded from our analysis. This led to a total of eight innovation attributes to be studied under this review – *Ease of Operation*, *Image*, *Cost*, *Riskiness*, *Visibility*, *Voluntariness*, *Result Demonstrability*, and *Social Approval*.

3. Findings

This review will follow a meta-analytic approach to synthesize the findings. Egger (1997) suggests - meta-analysis is that statistical procedure that integrates the findings from various independent studies, to provide for an objective appraisal of the available evidences, while helping explain the heterogeneity between the findings from those independent studies. The analysis for the current study is based on the method adopted by Tornatzky and Klein (1982). The findings will be marked against all seven features of an ideal innovation study for each of the eight innovation attributes. This will help establish a longitudinal view across these attributes. An attempt of identifying, whether or not the suggestions made by their study were followed in all these years will also be made. *Study type* is the eighth feature that was considered appropriate and added to the current body of work. Our study will also calculate the binomial probabilities of the beta values to establish a positive/negative correlation between the innovation-attributes and the dependent variables (adoption/implementation). The studies with no beta values were eliminated from the calculations for this category. From the total eight, the findings only for cost and social approval will be compared and analysed with the findings of the Tornatzky and Klein study, as these are the only two attributes in common. These two attributes were also analysed in detail by their study. The other six of our shortlisted attributes will be individually analysed across the seven ideal features with no element of comparison involved.

The coding procedure was adopted from Tornatzky & Klein's meta-analysis (1982). The individual studies were scored under each of these categories, which essentially make up the seven features of an ideal innovation study - (a) *Approach: Predictive*: effects of innovation attributes were measured before the targeted population's adoption decision; *Retrospective*:

innovation attributes were measured post the adoption decision of an innovation; *Literature Review*: discussed and analysed on the basis of prior studies; *In-Progress*: only the abstract and methodology were available, and the study had not reached completion. (b) *Nature of dependent variable*: *Adoption*: the dependent variable was either accepted or rejected; *Adoption and Implementation*: measured both, adoption and post implementation parameters. (c) *Study Type*: *Descriptive*: followed a model with no data construction; *Qualitative*: gathered in-depth understanding of the respondents through interviews, observations/comments; *Quantitative*: tested theoretical models with statistical or computational techniques; (d) *Instrument*: eight subcategories – Survey, Questionnaire, Secondary Data, Case Study, Theory, Interview, Experiments. Most studies chose to deploy a combination of the here listed instruments. (e) *Measure*: *Decision Makers*: the attributes were assessed by the decisive authorities; *Expert Judges*: the assessment was made by the area experts; *Cost and Profit*: secondary data used to assess innovation attributes; *Inferred*: authors used their discretion to arrive at suitable conclusions; *Employees*: employees of an organization rated attributes; *Consumers/Users*: the users rated attributes. (f) *Number of Attribute/Innovations*: used in a study. (g) *Adopting Unit*: Whether the adopters were individuals or organizations. (h) *Innovation Type*: The field to which an innovation belonged (education, healthcare).

Alongside meta-analysis, this section will also statistically analyse the usage of the antecedents and descendants for each innovation attribute. The notation ‘C’ is used to represent the count of the studies using that boxed attribute as an antecedent or descendant. In addition, from the *theoretical issues and contributions of the examined innovation attributes* perspective, this section individually considers the eight shortlisted attributes to delve deeper into both, the attributes they are affected by, and the effect they have on the adoption of an innovation. Technology/domain specific trends, if any, have also been highlighted in this section.

3.1. Ease of Operation

Ease of operation was regarded as an equivalent of perceived ease of use, and papers using either terminology were listed under this specific category. According to Fred (1986, p82) it is the degree to which an individual believes that using a particular system is free of physical and mental effort. Teo and Lim (1996) mention that previous research regards ease of use to be the opposite of complexity. Thus, this attribute introduces an element of ease in dealing with a particular innovation in question, and so is positively related to adoption. There were 71 *ease of operation* studies in total. These were mostly retrospective studies (90.14%) focussing mainly on the adoption (97.18%) aspect of an innovation. 64.78% studies showed statistical results. Aggregated at 0.04, the p-value was significant.

The 46 ease of operation studies with statistical findings fetched 13 antecedents (figure 1). Except two, *communication* and *exposure*, all others were found to be statistically significant. There were only five antecedents that had been used by two or more studies. *Compatibility* stood out to be the most used antecedent with eight studies. It also had the highest β value of 0.694, and was statistically significant. Rogers (2003) refers to an aspect of compatibility to be a degree to which an innovation is consistent with past experiences. If an innovation is compatible, it reflects an adopter unit’s previous experience with something similar to the introduced innovation, hence lending the adopter unit a free hand to easily operate or use this newly introduced innovation. This in a way supports both, the high usage frequency and the high β value for *compatibility* as an antecedent of *ease of operation*. Ten descendants were found for this innovation attribute. The usage frequencies of four of these descendants

(Adoption, Adoption Intention, Attitude, and Perceived Usefulness) were found to be fairly higher, with them being used in 11 or more studies. All except adoption, which was nearly significant, were significant in terms of their p-values. While behavioural intention was found to have the highest β value (0.62), it was reuse intention that was found to have the lowest at -0.066. Adoption being nearly significant for ease of operation showcases a positive β value of 0.498, making the association of this attribute to adoption a positive one.

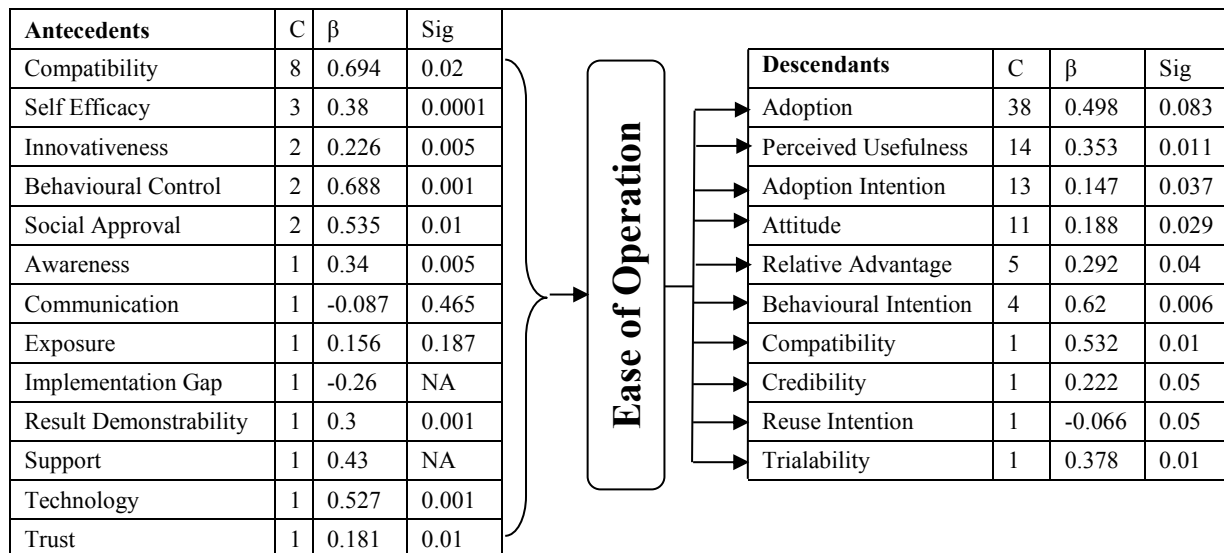


Figure 1. The antecedents and descendants for Ease of Operation

In this review the studies discussing the *ease of operation of using an innovation* as an innovation-attribute mostly found this attribute to be sharing a positive significant relationship with the adoption of an innovation being considered ($p=0.04$). Our review revealed that most studies considered compatibility and self efficacy as the antecedents to ease of operation. In studying the diffusion of the World Wide Web, Achjari and Quaddus (2002) conclude that users with high self efficacy tend to perceive internet as an easy to use technology leading to higher internet usage; they also suggest that a more compatible technology is often perceived as easy to use, as it means lesser efforts and changes are needed in one's current job. Likewise, adoption and perceived usefulness were the most used descendants of perceived ease of operation. It is worthy of mentioning that perceived usefulness and relative advantage are terms that are used interchangeably (Moore and Benbasat, 1991). While some studies like Davis et al. (1989) showed that ease of use indirectly influenced adoption through its influence on the perceived usefulness, other studies like Compeau et al. (2007) confirmed its exclusive direct significant impacts on both, adoption and perceived usefulness. In extension to this argument, out of the 46 studies that reported statistical data, while most of the reviewed studies reported a significant influence of ease of operation on the use intentions and adoption of an innovation, there were studies that showed its insignificance – Carter and Belanger (2004) in their study on the adoption of e-government initiatives reported this non-significant relationship, and reasoned ease of use to be a dynamic construct that behaves differently depending upon intrinsic or extrinsic use; they also confirmed that for their study, ease of use was a significant antecedent of usefulness that was a direct determinant of adoption of e-government services. Rokhman (2011), also studying the e-government adoption encountered the same non-significant relationship between ease of use and adoption; they reasoned it for internet being a part of the everyday life, which made the users well acquainted with using the internet making them ready to use e-government services nullifying the evaluation of the ease of use aspect. Therefore, our review mostly witnessed the e-government studies reporting an insignificant influence of ease of use on adoption.

3.2. Image

Moore and Benbasat (1991; pg 195) define image as “the degree to which, use of an innovation is perceived to enhance one’s image or status in one’s social system”. 37 articles used image as an innovation attribute in their studies. In investigating the drivers of internet banking adoption, Gounaris and Koritos (2008) show that consumers were more likely to adopt internet banking if doing so enhanced their image. Image is a social element. Any decision made in favour of enhancing one’s social image is greatly appealing from a user perspective. This attribute is assumed to be positively related to adoption (Moore and Benbasat, 1991). There were 15 studies presenting statistical findings. Nine calculated the R square values and the p-value was significant at 0.016. Figure 2 is descriptive of the antecedents and descendants for *image* as an innovation attribute.

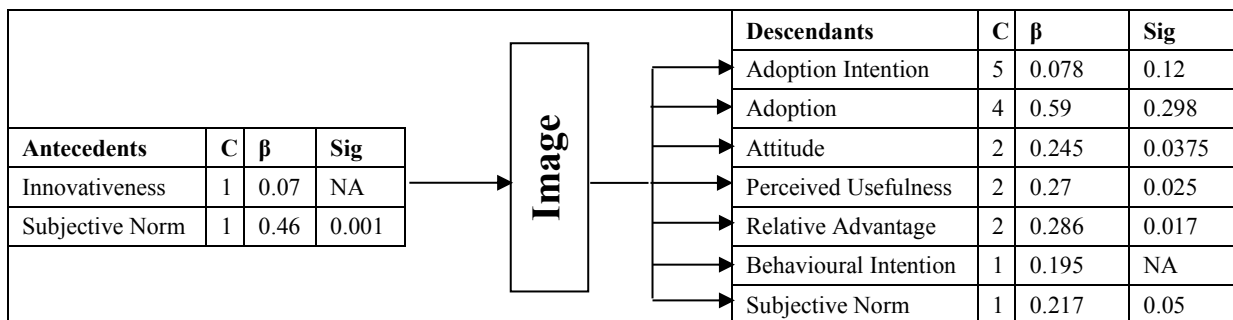


Figure 2. The antecedents and descendants for Image

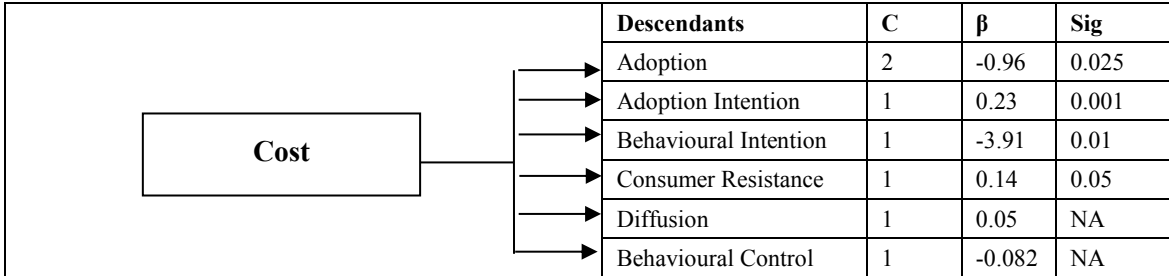
This attribute had only two antecedents, both of which had been used by one study each. One out of the two, *innovativeness* had no p-value available, and *subjective norm* along with being statistically significant was found to have the highest β value out of the two. However no constructive conclusion can be made on the basis of only one study recorded per head. There were seven descendants - *Adoption intention* was most frequently used, closely followed by *adoption*. While *adoption* was found to have highest β value at 0.59, it was the only descendant with a non-significant p-value.

As illustrated in figure 2, most studies used adoption intention and adoption as the descendants for image, and image was found to be making a significant impact on these two attributes (Slyke et al., 2004a; Hsu et al., 2007; Mourad and Ahmed, 2012). In the publications reviewed by our study, not many chose to have antecedents for image as an innovation attribute. Only one study chose to use innovativeness and subjective norm as the two antecedents for image, where subjective norm positively influenced image, but innovativeness had an insignificant effect on it – Yi et al. (2006) in studying IT acceptance by healthcare professionals established the aforementioned relationships; this study concluded that technologies were already well established and socially well positioned individuals are being targeted as users for an innovation, image does not play a significant role in acting as an incentive for adopting an innovation, as the targeted consumers are already having a well built social status, and adopting a technology that may only help better their image does not seem very attractive to them. Of all the 15 studies reporting statistical data on Image, another study by Slyke et al. (2010) on the adoption of e-commerce discovered a non-significant relationship between image and adoption. Overall, as mentioned above, image was found to have a significant and positive effect on the use intentions and adoption of an innovation.

3.3. Cost

Tornatzky and Klein (1982) discuss this attribute with an assumption for it to be negatively related to the adoption and implementation of an innovation. They elaborate that an inexpensive innovation will have a greater likelihood of being immediately adopted and implemented. Their study showed that the cost studies used better characteristics to measure, i.e. they were mostly assessed by decision makers or inferred. However, this study did not have any publication using decision makers to rate the attributes. The percentage of the inferred studies also was just 24.13%. It was the consumers/users group that scored the highest in this category with 37.93% studies having them to rate the innovation attributes. Tornatzky and Klein also mentioned that such cost studies preferred more innovation attributes and more innovations, which is contrary to the findings from this study. This study had publications mostly using six to nine attributes (55.17%), and concentrating on a single innovation (93.10%). Seven studies reported statistical data, and five out of these showed adjusted R square values. The significance level for the cost studies was aggregated at 0.026, and hence concluded to be statistically significant, which again contrasted with the Tornatzky and Klein study as their significance level for this group of studies was concluded to be non-significant.

Out of the seven cost studies with statistical results, none provided for any antecedent for cost. However, there were six descendants all with one study each, except *adoption* which was used by two studies. With no p-values available for two descendants, the rest were all significant. Also, there were three attributes with negative β values (*Adoption*, *Behavioural Intention*, and *Perceived Behavioural Control*). This negative β for adoption made cost negatively associated to it. It would not be appropriate to conclude on a single study basis, but the highest β value for *adoption intention* indicates that lower cost will encourage the adopters to say yes to an innovation in question.



Descendants	C	β	Sig
Adoption	2	-0.96	0.025
Adoption Intention	1	0.23	0.001
Behavioural Intention	1	-3.91	0.01
Consumer Resistance	1	0.14	0.05
Diffusion	1	0.05	NA
Behavioural Control	1	-0.082	NA

Figure 3. The antecedents and descendants for Cost

None of the 29 reviewed cost studies used any antecedent to it (figure 3). On the other hand, most used adoption and adoption intention as its descendants. It was found that only five of the 223 reviewed studies presented statistical findings related to cost as an innovation attribute. Out of these five studies, two studies, one on the post adoption stages of innovation diffusion by Zhu et al. (2006), and the other on the adoption of best practice in manufacturing by Ungan (2004), in their respective studies concluded that cost has a significant, but negative impact on the adoption of an innovation. Tornatzky and Klein (1982) also in their meta-analysis posit for this negative significant impact, where high costs associated to an innovation's use tend to act as barrier to its adoption. Other studies on innovation adoption in public organizations (Damanpour and Schneider, 2008) and on the adoption of mobile virtual network operator services (Shin, 2010) vouched for a positive significant effect of switching cost on adoption. One study on the adoption of application service provider, however, found cost to have an insignificant effect on adoption; they reasoned it as different users attach different values to cost savings, and in a technology as their other factors like risk and

competitive advantage take more importance than the cost and hence the insignificance (Daylami et al., 2005).

3.4. Riskiness

Rijsdijk and Hultnik (2003) cite Jacoby and Kaplan (1972) to describe perceived risk as a multidimensional concept consisting of six different components – performance risk, financial risk, social risk, physical risk, psychological risk and risk of time loss. Teo and Pok (2003) view perceived risk to be negatively associated with attitude. They cite Bauer (1960) in describing perceived risk as either the psychological or the general risks that are associated to a product and its performance. To illustrate further - Hansen (2006) conceptualize perceived risk in an online context as the consumer’s perception of the possibility of having a negative outcome or suffering from harm or losses associated with e-commerce. Tanakinjal et al. (2010) concentrated on the security and privacy risks faced by mobile phone users in m-marketing. Also, Tan and Teo (2000) discuss lack of security and privacy over the internet as its negative effects on the adoption decision. Thus, perceived risk is generally hypothesized to negatively affect an innovation adoption decision. Most riskiness studies were found to be theoretical (32%), mostly concentrated on individuals as adopting units. Only nine provided for statistical data, and the significance value of 0.083 rendered this attribute to be marginally significant.

Riskiness had five antecedents to it, the usage frequency of each continuing to be one study each. Only *credibility*, *innovativeness* and *trust* had valid p-values, all of which were significant. These three had negative β values, and *security concerns* secured the highest position with a β of 0.55. Seven descendants of riskiness were identified. *Attitude* was the most used; although significant it had a negative β value. Following close was *adoption intention* with the highest β value, but with no specified significance level. The inherent nature of *riskiness* has a negative effect on the adoption decision. Therefore, lower the associated risks of an innovation, higher is the adoption intention towards that innovation. Risk with a negative β for *adoption* was concluded to be negatively associated with adoption.

Antecedents				Riskiness	Descendants			
	C	β	Sig			C	β	Sig
Credibility	1	-0.478	0.001	Riskiness	Attitude	3	-0.238	0.031
Innovativeness	1	-0.146	0		Adoption Intention	2	0.15	NA
Primary Concerns	1	0.17	NA		Adoption	1	-0.109	0.383
Security Concerns	1	0.55	NA		Behaviour	1	0.038	0.01
Trust	1	-0.226	0.05		Behavioural Intention	1	0.145	0
					Consumer Satisfaction	1	-0.2	0.05
					Reuse Intention	1	-0.169	NA

Figure 5. The antecedents and descendants for Riskiness

While significant influences of riskiness was exhibited in the findings from studies on the acceptance of IS use (Huang and Chuang, 2007) and mobile payment adoption (Chen, 2008) where a negative relationship between risk and adoption intention and adoption was recognized, and studies on mobile ticketing adoption (Mallat et al., 2008) found that risk positively and significantly influenced adoption, there were also studies that accounted for the non-significant influence of this attribute on adoption. For instance, Crespo and Rodriguez (2008) in studying the acceptance of e-commerce discovered this insignificant relationship; they argued that some aspects of risk might have been incorporated or covered by the other innovation attributes used in their model, or there could be an internal methodological element in their research setting that could have eased the feeling of risk in their respondents. An internet banking adoption study (Suki, 2010) also supported this insignificant relationship. Overall, amongst the reviewed riskiness studies, the non-significant effect of this attribute on

adoption mostly prevailed. In terms of antecedents, three studies proposed different antecedents that were only used once, i.e. were not repeated in any other riskiness studies. All of these antecedents, credibility and trust (Koenig-Lewis et al., 2010) security and privacy concerns (Chen, 2008), and innovativeness (Chen, 2008) were seen exerting significant impact on risk.

3.5. Visibility

Visibility is the degree to which the use of a particular innovation is apparent (Slyke et al, 2005). A study on the mobile internet adoption showed that visibility considerations were important for the late majority groups to take time to observe and increase their likelihood of adopting that innovation (Hsu et al, 2007). Rogers (2003) in their explanation on observability show that greater visibility of that innovation to its potential adopters increases the probability of adopting that innovation. Thus this attribute is positively related to the rate of adoption. Only 22.72% of the studies represented their data statistically, with only three studies having an R square value. All of the five studies with statistical findings had significant p-values, which were averaged to arrive at p-value of 0.004.

Figure 4. shows that visibility had no antecedents to its account. However, five descendants were identified, all of which accounted only for one study each. They were all also found to be statistically significant. *Subjective Norm* was with the highest β value of 0.508. Adoption's positive β value of 0.154 and a very satisfactory p-value rendered visibility to be significant, and positively associated to adoption.

Descendants	C	β	Sig
Adoption	1	0.154	0.0005
Adoption Intention	1	0.115	NA
Attitude	1	0.3	0.005
Behavioural Intention	1	0.143	0.0025
Subjective Norm	1	0.508	0.001

Figure 4. The antecedents and descendants for Visibility

This attribute found no antecedents being used in any of the reviewed studies. With only five of the reviewed studies recording statistical data for this attribute, adoption intention and adoption were the favoured descendants. Being studied for adoption of different technologies such as mobile internet (Hsu et al., 2007), e-commerce (Slyke et al., 2005), and so on, the visibility of an innovation was found to have exerted a significant, positive effect on the adoption of those innovations.

3.6. Voluntariness

It is defined as “the degree to which use of an innovation is perceived as being voluntary or of free will” (Moore and Benbasat, 1991; pg 195). Aubert and Hamel (2001) state that innovations introduced on a voluntary basis are adopted more easily by individuals, and forcing adoption only introduces resistance. Thus, voluntariness is assumed to be positively related to adoption. Only six studies provided the statistical data, and five gave the R square values indicating the variance in the voluntariness-adoption relationship. The p-value remained significant at 0.0036.

Figure 6. illustrates that *voluntariness* has zero antecedents and three descendants, two out of which have negative β values. *Adoption* is the descendant with the highest β of 0.728, and a satisfactory significance level. This leaves voluntariness to be positively related to the adoption rate. *Voluntariness* in itself dictates the free will exhibited towards the *adoption* of an innovation.

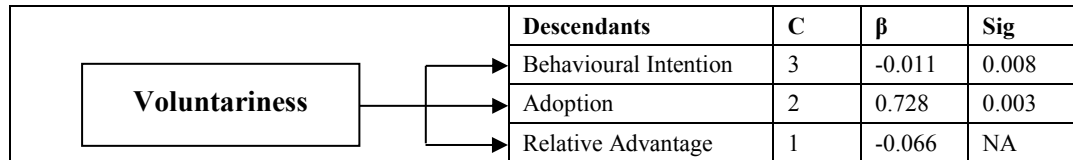


Figure 6. The antecedents and descendants for Voluntariness

Voluntariness mostly has adoption intention and adoption as its descendants. Exhibiting both positive and negative impacts, some instances for this attribute are as follows - a study on software reuse infusion found that voluntariness had a significant negative effect on the infusion behaviour (Kishore and McLean, 2007). Another study on IT adoption regards voluntariness as a form of social influence and also concludes for its significant negative impact on adoption. On the other hand, in studying the acceptance of multimedia messaging service, Hsu et al. (2007) reported a significant positive effect of this attribute on adoption. Overall, this attribute was seen having both negative and positive influences on innovation adoption.

3.7. Result Demonstrability

Moore and Benbasat (1991) explain result demonstrability as a dimension of tangibility of the results of using an innovation, including their observability and communicability. The more observable and clearly communicable an innovation is, more are its chances of being readily adopted, and hence this attribute is considered to be in positive association with the adoption aspect of an innovation. These were mostly retrospective studies, focussing more on only one adoption and were increasingly based on the organizational innovations. Six studies had both statistical findings and adjusted R square values. The p-value was found to be significant at 0.0032.

Result Demonstrability had one antecedent and six descendants. *Innovativeness* was its only antecedent with a β of 0.55, and was also significant. *Adoption Intention* was the only descendant used in more than just one study. All descendants were also significant, and *ease of operation* had the highest β at 0.3. With a positive β value for *adoption*, result demonstrability does seek a positive association to adoption, but no significance levels were available for adoption in this case.

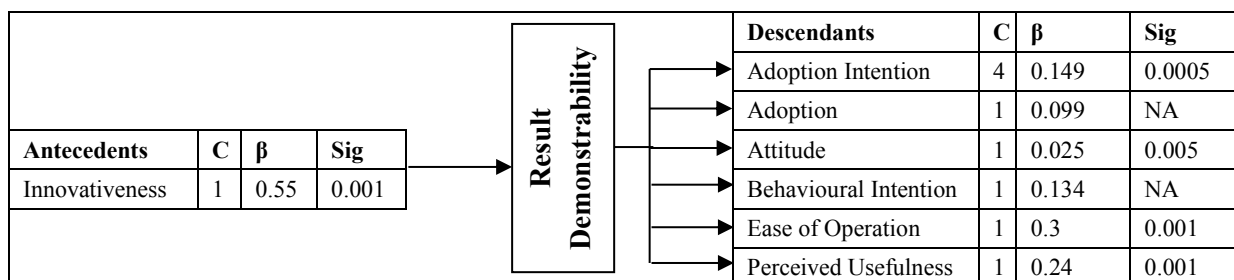


Figure 7. The antecedents and descendants for Result Demonstrability

With only 17 studies, result demonstrability was clearly not a very popular attribute in the studies reviewed by us. Making its presence across innovations such as mobile internet (Hsu

et al., 2007) and e-commerce (Slyke et al., 2004b; 2005), this attribute was seen having a positive and significant influence on the adoption of an innovation.

3.8. Social Approval

Social approval refers to status gained in one's reference group, "a nonfinancial aspect of reward" (Fliegel et al., 1968, p.445) as a function of adopting a particular innovation. Thus this attribute is assumed to positively influence adoption. Mallat et al. (2008) show how social approval or influence, as other people's recommendations or perception of an approved behavioural pattern plays as a strong determinant of adoption. These studies in both, the Tornatzky and Klein study and our review used better design of instruments for measuring innovation attributes, and considered more number of attributes in their studies. While in the Tornatzky and Klein review, most attributes were rated by the decision makers, only a single study in the current review used the decision makers to rate for them. Also, the current review had all of the studies using only one innovation, as opposed to the Tornatzky and Klein review, which had a majority of studies considering multiple, i.e. ten or more innovations. Three social approval studies were found to have provided statistical references, out of which two had calculated the adjusted R square values. A significant p-value of 0.01 was available for these studies.

Figure 8 reveals that *social approval* has no antecedents and four descendants. Out of the three studies that provided statistical data for this innovation attribute, *behavioural intention* was found to be present in all. All descendants were statistically significant, and *ease of operation* was found to have the highest β value at 0.53. Adoption's positive β value of 0.17 makes social approval's association to it a positive one.

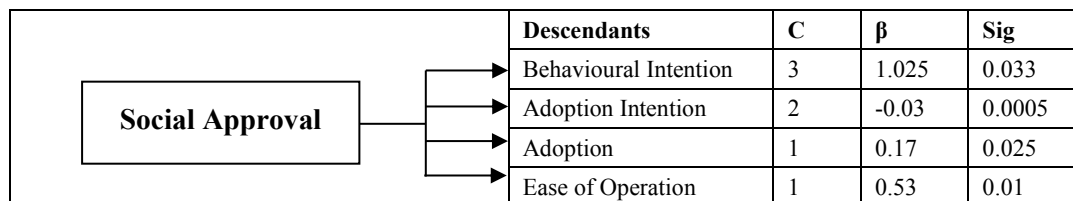


Figure 8. The antecedents and descendants for Social Approval

Social approval being the least used innovation attribute out of the eight shortlisted for our study, had adoption intention and adoption as the most used descendants to it. Yang and Choi (2001) in revisiting the technology acceptance model conclude that depending on the characteristics of information technology, social influence is seen to have different influences on IS use. Studies on mobile ticketing adoption (Mallat et al., 2008), mobile virtual network adoption (Shin, 2010), internet stock trading adoption (Lee-Partridge and Ho, 2003) were all found to have influencing the adoption intention significantly.

4. Discussions

For *approach*, all of these eight attributes were used mostly in studies that followed a retrospective approach in comparison to the predictive approach. Same was the case with the studies considered under the Tornatzky & Klein review. For this study - the *cost* studies ranked the highest with 93.10% retrospective studies. For Tornatzky and Klein study - the *communicability* studies had the highest percentage of retrospective studies. According to them, an ideal study should be predictive in order to prevent the perceptions of innovation attributes from being based on an innovation's adoption or rejection decision. They suggest for the measurement of these attributes to be done before the adoption. The findings from this

review suggest that a majority of the shortlisted studies do not meet this criterion of an ideal innovation study, as they were mostly *retrospective*. For the *dependent variable*, *adoption* was the most preferred dependent variable, with percentages all above 90% across all of the innovation attributes. Two attributes *social approval*, and *voluntariness* had 100% of their studies concentrating only on adoption. Striking similarity once again with the Tornatzky and Klein study was *social approval* which in their review also had all of their studies attributed to adoption. They state that an ideal study should make a consideration for both adoption and implementation as dependent variables. They reason that the evaluation of the degree of implementation aids in assessing the variability in the behaviour after the actual adoption. Much evidently, our findings indicate that the shortlisted studies failed to comply with this criterion as well, as most studies focus only on *adoption*.

In order to provide more statistical clarity, our review added a sub feature to *instrument*, which was *study type*. A greater percentage of the studies were *quantitative* by nature across all the attributes. However *cost* studies varied here, as they were majorly a mix of qualitative and quantitative studies. The second largest group across all was of studies which used a *descriptive* approach. Tornatzky and Klein suggest for an ideal study to be made up of quantitative data as this type of data contributes significantly as opposed to the qualitative data or theoretical studies. Both *Questionnaires* and *theoretical* data accumulation instruments were the most commonly used across all attributes. Overall, most publications under this study were found to have utilized quantitative methods. Thus the findings from our review are in line with this criterion of an ideal innovation study. For *measure*, seven out of the eight attributes had *consumers/users* to rate the study variables for them. Voluntariness was the only attribute which had mostly inferred the influence of these attributes on an innovation. According to Tornatzky and Klein, replicable measures of innovation attributes and the data directly collected from the participants were considered more accountable than restricting to only inferring these innovation attributes. Thus our findings do not meet this criterion of an ideal innovation study.

For the *number of attributes*, most studies included six to nine attributes. Tornatzky and Klein claim that in order to gain a thorough understanding of an innovation, and to allow for a comparison of the included attributes, an ideal study should essentially incorporate more than one attribute. This review had none of the studies across any attribute using one attribute, thus rendering this category to be in a complete fit with criterion of an ideal study. For the *number of innovations*, more than 75% of the studies across all attributes studied a single innovation. Contrary to which Tornatzky and Klein suggested that to permit for generalization across multiple innovations, an ideal study should study different innovations at once. Therefore this category failed to meet the requirements of an ideal study. For the *adopting unit*, most of our shortlisted studies aimed at organizations as the adopting units of an innovation. This was in accordance with Tornatzky and Klein's idea, which was for an ideal study to be developed in an organizational context, in order to enable the inference of implications for the organizational innovation processes.

From the above comparison on the seven features proposed by Tornatzky and Klein (1982) with the findings of our study, this discussion can be further extended to suggest that the upcoming publications on innovations should be particularly considerate of the following three features that were found to have not been followed by most of the recent studies – (a) It will be more favourable for the studies to follow a more predictive approach to allow for more unbiased consumer perceptions; (b) Also, it is essential that such studies on innovation adoption lay focus on not just adoption, but also the implementation aspect to better

understand the consumers' adoption behaviour; (c) Giving consideration to the fact that it might not always be possible, but would be worthwhile, if in studying the innovation attributes, more than one innovation at once are considered to allow for generalization.

Our study calculated the binomial probabilities to arrive at the significance of the gathered findings across each of these attributes. All attributes were found to be statistically significant except for *risk* (0.083) that was found to be nearly statistically significant. *Result Demonstrability* had the most significant aggregated p-value at 0.0032. There were four attributes with zero antecedents (cost, visibility, voluntariness, and social approval). Out of all the eight attributes, *ease of operation* had the highest number of antecedents (13) and descendants (10). It was found that there were two antecedents that sought repetition – innovativeness and trust. In case of descendants, 9 were repeated across the eight innovation attributes – adoption, adoption intention, attitude, behavioural intention, ease of operation, perceived usefulness, relative advantage, reuse intention, and subjective norm.

The results from the conducted meta-analysis revealed that out of the eight shortlisted attributes for this study, except riskiness, the remaining seven attributes were found to consistently exert significant influences on the innovation adoption decisions. Also, out of these eight attributes, only two attributes, cost and social approval were the common attributes in our and Tornatzky and Klein's meta-analysis. While, in our review both these attributes showed significant impacts on adoption, Tornatzky and Klein saw only cost making such significant impacts. Moreover, both the meta-analyses confirmed for cost to be exerting a significant, but negative impact on adoption. Interestingly, while our meta-analysis focussed on the ease of operation, Tornatzky and Klein had reviewed for complexity as an innovation attribute. Essentially, ease of operation can be considered as an exact opposite of complexity. This explains the significant negative effect of complexity, and a significant positive effect of ease of operation in the two meta-analyses. While increased ease of operating an innovation attracts more consumers towards its use, increased complexity will act against the consumers' adoption decisions. Although, named differently, both these attributes, as highlighted by Tornatzky and Klein (1982), lack the very essential specificity. It is very critical that the studies on innovation adoption research answer these questions of which particular aspect is defining the ease or complexity involved in using an innovation under consideration.

As rightfully mention by Tornatzky and Klein (1982), with newer studies, the effect of other different innovation characteristics are studied, and some of these are found to have a significant effect on adoption. Our study is an example of one such study that has reviewed the recent studies to learn the effects of a totally different set of innovation attributes, and showed how they can considerably and significantly affect adoption decisions. Lastly, Tornatzky and Klein mentioned how their meta-analysis suffered a small N for the reviewed studies, and that there were very few studies reporting the correlational data being reviewed in their study. The case has not been very different for our meta-analysis. While seven attributes had ten or less studies with statistical values, only ease of operation had 15 studies with the statistical values being reviewed in our study. To more constructively elaborate on the relationship between innovation attributes and the adoption of an innovation, it is important that the innovation related studies also focus their attention on these statistical deductions that extend more reliable explanations on the behaviour of different innovation attributes.

5. Conclusions

This paper is a contributory effort providing a *systematic review* of the literature available on the eight shortlisted attributes since 1996 until mid of 2011. Based on the seven features of an ideal innovation study presented by Tornatzky and Klein's meta-analysis in 1982, a *meta-analysis* of the 223 publications shortlisted for the current review has been carried out. Some key conclusions from this review are - ease of operation (71 studies), alongside being the most frequently used innovation attribute in the publications reviewed by this study, was also the attribute that was found to have a non-significant influence on the adoption of e-government innovations. Studies mostly used a retrospective approach and concentrated focus on only adoption of an innovation, with no follow up on implementation or the post adoption behavior. Most studies used quantitative data, much through *surveys* and questionnaires, with consumers/users being the highly targeted population for rating the effects and influences of the innovation attributes. Almost all studies choose to utilize multiple attributes, with an increasing proportion of studies studying only one innovation at a time, mostly in an organizational context. The binomial probabilities revealed that seven of the eight shortlisted attributes were statistically significant on innovation adoption, with one attribute, riskiness showing a non-significant affect on adoption. While, ease of use, image, visibility, result demonstrability, and social approval made positive impacts on adoption, voluntariness and riskiness were seen making both positive and negative impacts on an innovation's adoption decisions. Cost, on the other hand, although statistically significant exerted only a negative impact on the adoption of an innovation. Ease of operation had the maximum number of antecedents and descendants. Innovativeness was the most used antecedents with four attributes, and all eight attributes were dependent on adoption and behavioural intention as their descendants. Lastly, while this study failed to comply with three ideal features - approach, dependent variable, and number of innovations, it successfully complied with four ideal features - instrument, measure, number of attributes, and adopting unit.

5.1. Practical Implications of the Examined Innovation Attributes

In terms of practical implications, the managers and implementers of innovative technologies can bank on the following significant insights that have been derived from reviewing the findings of various studies investigating the influences of the innovation attributes shortlisted to be reviewed in our study. Very interestingly, out of all the reviewed studies, it was found that ease of use was found to be non-significant towards adoption and adoption intention in most e-government studies (Carter and Belanger, 2004; Lee and Lei, 2007; Rokhman, 2011). Ease of use has been proposed to have extreme behaviour in different situations. An e-government study, upon discovering an insignificant impact of this attribute on acceptance suggested for future studies to clearly demarcate ease of use, in terms of ease in gathering information from the e-government bodies, or ease in completing a transaction using e-government initiatives (Carter and Belanger, 2004). Gumussoy and Calisir (2009) in their e-reverse auction study suggested that ease of use may be enhanced by some factors related to compatibility, which in turn may significantly influence the behavioural intention. With respect to this attribute, the most often offered implication is that an easy to use innovation and the cultivation of an environment that would foster this are important to increase the adoption rate of the innovations being introduced (Chau, 1996).

In an e-government study by Carter and Belanger (2004), the authors interpret the significant influence of image as the need for implementing organizations to promote the use of that technology as a status symbol, and also have local celebs and well respected citizens to endorse the use of the technology to promote its usage. It was observed that most mobile commerce studies used image and concluded for its significant impact on the adoption of mobile commerce related technologies (Allen, 2003; Teo and Pok, 2003; Hsu et al., 2007).

Therefore, mobile related innovations should pay attention towards projecting their innovations as image enhancing technologies which will help increase their adopter population. On the other hand, in evaluating cost as an innovation attribute, studies often suggest for most economic resource allocations which in turn are assumed to leverage increased sales and reduced costs associated to an innovation, which in return attract more consumers towards its usage (Zhu et al., 2006; Damanpour and Scheider, 2009; Shin, 2010). At the same time, the cost of using an innovation should be equal to or lesser than the system it is superseding to attract more customers towards its use (Vrechopoulos et al., 2001). Riskiness is an attribute which is much recommended to be broken down into specific risk aspects to be evaluated, and not to be considered just as a general risk construct. Tanakinjal et al. (2010) suggest breaking risk into security and privacy risks, the perceptions of which are seen as an active engagement in the process of adoption. Many consumers view misuse of personal information associated to using an innovation as a risk. An interesting suggestion in this regard comes from a mobile payment study where consumers view unauthorised use of personal information as a risk affecting adoption, that regulations prohibiting companies from excessive information collection and to control company's opportunistic behaviours must be enforced to ease consumers' privacy concerns (Chen, 2008). In addition, incorporating latest certified and reputed security technologies would also to a great deal ease consumers' privacy and security risk concerns (Lee-Partridge and Ho, 2003, Heimonen, 2012). Visibility is seen as an essential attribute in targeting consumers of the late majority type, wherein observing others use an innovation influences them to adopt that innovation (Hsu et al., 2007). Also, advertising the positives of using an innovation to increase its visibility acts as an attractor of more adopters (Slyke et al., 2005). Voluntariness, on the other hand is assumed to operate via compliance processes (Karahanna et al., 1999). Positive influences from social groups and indirect social pressures tend to greatly impact adoption intentions (Lee-Partridge and Ho, 2003; Bernstein and Singh, 2008).

5.2. Limitations and Future Lines of Research

The initial part of this section will provide an insight into a brief collection of future research suggestions made by the reviewed publications, whilst, the latter part will present future lines of research deduced by this study.

Haggman (2009) in explaining the perception of different actors towards different innovation attributes suggest that case study methodologies should be chosen over quantitative research designs, and that the practitioners should delve into understanding how the involvement of innovation providers can influence the perceptions of the actors. Vaugh and Schiavone (2010) integrate theoretical explanations for innovation diffusion across the marketing, innovation and sociology research domains, and suggest an investigation on the extent to which different conditions/domains matter in making an old product redundant to encourage acceptance of a new one, and at the same time, also explore the probable interdependencies and regularities between different model variables and domains. It is suggested that surveys should rely on multiple informants, and also that larger survey size is preferable over small expert panels (Damanpour and Schneider, 2009). Instead of placing focus on exploring the relationships between dependent and independent variables only, importance should also be given to learn about the interrelationships between the different independent/predictor variables (Wang et al., 2010; Arts et al., 2011).

The number of antecedents and descendants suggest an increased number of attributes being used in the innovation diffusion studies. Also, different studies tend to use different terminologies for the same attributes. Although they describe these terminologies, there is an

element of redundancy and confusion introduced. It is therefore necessary to have a standard nomenclature set for this field of research, which in effect should make the review and understanding of the utilized innovation attributes much easier. Also, in order to better learn these innovation attributes, it could be of worth to break them down according to their subjective perceptions. Introduction of a degree of specificity should assist in justifying the direction of measurement of these attributes. Delving more into the sense of usage of these attributes should essentially succeed in establishing a more meaningful relationship between the effects of these attributes and the adoption of an innovation.

A total of 2073 publications for Rogers' diffusion of innovations theory were retrieved and only 1365 articles were downloadable. There could be a handful studies out of these remaining 708, which could possibly be relevant to the current review but their unavailability prevented them from being studied. The future research should target all of the potentially relevant studies by overcoming the accessibility barriers. This review effectively focused only on eight innovation attributes across the 129 collated studies. The future research should concentrate on identifying and studying the other new attributes used in this field of innovation. Increasing the scope beyond these attributes will also provide for a remarkable increase in the number of studies. Performing a meta-analysis on such extensive literature should positively aid in acquiring a broader insight into the varied level of influences that different innovation attributes have on the target population's adoption decisions.

This review attempts to serve as a quick reference reflecting the prevailing trends of the shortlisted attributes which have been essentially discussed across seven demographic aspects, seven ideal features, binomial probabilities, and their respective antecedents and descendants. The statistical deductions should provide future researchers with a well constructed estimate of the past behavior of these innovation attributes, and also with a direction to arrive at a predictive estimate of their probable behavior in the future.

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