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MODELS OF TECHNOLOGY ADOPTION: AN INTEGRATIVE APPROACH

Theoretical Article

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Abstract

The interdisciplinary study of information technology adoption has developed rapidly over the last 30 years. Various theoretical models have been developed and applied such as: the Technology Acceptance Model (TAM), Innovation Diffusion Theory (IDT), Theory of Planned Behavior (TPB), etc. The result of these many years of research is thousands of contributions to the field, which, however, remain highly fragmented.

This paper develops a theoretical model of technology adoption by integrating major theories in the field: primarily IDT, TAM, and TPB. To do so while avoiding mess, an approach that goes back to basics in independent variable type's development is proposed; emphasizing: 1) the logic of classification, and 2) psychological mechanisms behind variable types. Once developed these types are then populated with variables originating in empirical research. Conclusions are developed on which types are underpopulated and present potential for future research. I end with a set of methodological recommendations for future application of the model.

Introduction

The interdisciplinary study of information technology adoption has developed rapidly over the last decades. Since the 1980s an abundance of research articles on the adoption of information technology by individuals has been produced, with contributions from researchers in various disciplines: management, information systems, sociology, psychology, education, public administration, etc. However, the very success of this research area of technology adoption may have turned in one of its weaknesses. That is because various theories and research traditions do not necessarily fully communicate to one another and because the research results are rather fragmented while research models have tended to remain rather simple and idiosyncratic. There are no unified theoretical frameworks to unite and integrate prior findings or to give enough theoretically grounded impetus to future research.

This paper makes some attempts to integrate prior theoretical and empirical work into a broad theoretical framework based on a typology of independent variables. The next section, presents a review of literature focused on a (rather brief) description of main theories and theoretical contributions in the field. The third section represents the main body of this paper and develops an integrative theoretical framework for the research of technology adoption. The final section concludes the paper by emphasizing the possible usefulness of the theoretical framework and typology of variables developed for further theoretical and empirical research.

Main Theories and Theoretical Contributions

Theory of Reasoned Action (TRA)

The Theory of Reasoned Action (TRA), introduced by Ajzen and Fishbein in late 1970s and early 1980s, is a social psychological theory with a rather wide area of applicability in different areas of human behavior(Ajzen & Fishbein, 1980). True to its name, TRA attempts to explain human behaviors that are intentional and "reasoned" as opposed to spontaneous, accidental or emotional behaviors. TRA establishes first a relationship between intention and behaviors, asserting the rather intuitive claim, that behaviors are generally determined by the *behavioral intention* of subjects. While this correlation is not claimed to be perfect (not all intentions manifesting themselves in behavior) it is generally expected that reasoned behaviors are preceded and determined by individual intentions to perform such behavior. TRA further proposes two broad antecedents of behavioral intentions. The first of these is the*attitude* (or attitudes) toward that specific behavior, especially outcome attitudes such as the extent to which a behavior is good, useful, etc. or the opposite for the subject. The second determinant (or set of determinants) of behavioral intention is made of the *subjective norm(s)* concerning that behavior. The subjective norm refers to the individual perception of what is the desirable, preferred, recommended behavior of relevant others regarding the situation/behavior in question. It is subjective in that it represents the subjective perception regarding that norm and not necessarily an objectively identifiable norm. See Figure 1 for a graphical depiction of TRA.

The determinant variables attitudes and subjective norms are rather broadly specified in TRA, and intentionally so, since it is conceived as a broad theory of human behavior. In order to be applied to specific contexts and behaviors, its authors recommend a process by which the attitudes and subjective norms of relevance are identified first by the researcher before being subjected to empirical tests. TRA has been applied to the psychological study of many behaviors, from consumer behavior to heath behaviors, academic achievement etc. In particular, TRA has also been used in empirical research concerning technology adoption by individuals, although probably in relatively fewer studies than other theories. Thus, several studies have produced statistical evidence supporting the role of attitudes and subjective norms in the adoption of information systems (Davis, Bagozzi, & Warshaw, 1989; Mishra, Akman, & Mishra, 2014; G.C. Moore & Benbasat, 1996). Probably more relevant is the indirect influence of TRA in the study of technology adoption. Thus, two more widely used theories the Theory of Planned Behavior and the Technology Acceptance Model, discussed below, have their origins in TRA.

Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB),developed in the 1980s by Ajzen, one of the authors of TRA, is an extension of TRA through the addition of one more variable, *perceived behavioral control*, and its corresponding causal mechanisms by which it affects behavioral intentions and the actual behavior of individuals(Ajzen, 1985, 1991). Figure 2 for a graphical description of TPB.

TPB proceeds from the observation of the imperfect correlation between behavioral intention and actual behavior for planned, longer term behaviors. Thus, often times, individuals may have the intention of performing certain behaviors however such behaviors fail to materialize or stop before they can achieve effects. This may be the case either because the individuals change their minds concerning the desirability of the said behavior, or because they cannot manage to perform the behavior. This second possibility raises

the issue whether the individual has enough *control* over their actions.

To account for this, Ajzen, based on previous work in psychology, particularly by Bandura (1977, 1982), introduces the extra variable of *perceived behavioral control* which refers to the extent to which the individual perceives a certain behavior to be under his control (previously named by Bandura *self-efficacy*). This variable, as intended by the author of TPB, includes both internal factors related to the individual (skills, knowledge, strength of volition, etc.) but also external factors (hindrances, other people's preferences and actions, etc.) that may help or hinder the individual in performing that behavior.

The claim is that the perceived behavioral control influences directly not only the actual behavior but also the process of forming the intention to perform the behavior. Thus, individuals who are uncertain of their ability to perform a behavior, even if they find it desirable or useful at the level of attitudes, may still not intend to perform it if they think it is not within their control to do so.

Once again, it should be mentioned, TPB, like TRA, is a broad psychological theory about human behavior having been applied and verified in various areas and social sciences. It has also been one of the theoretical models to be applied in the area of (information) technology adoption. Various studies have shown that TPB has good explanatory power in accounting for variations of intention to use or actual use of information technology by individuals (e.g. Czerniak, Lumpe, Haney, & Judy Beck, 1999; Mathieson, 1991; Taylor & Todd, 1995). TPB is thus one of the contending theories in explaining technology adoption.

Innovation Diffusion Theory (IDT)

The Innovation Diffusion Theory (IDT) was developed in the 1960s by Everett M. Rogers, American sociologist and communication scientist. Building on previous work from early sociology(particularly the French sociologist Gabriel Tarde), anthropology, and rural sociology, IDT is a refinement of older contributions in a comprehensive new theory. While IDT's concern is not so broad as TPB and TRA with all kinds of human behavior, it is specifically concerned with the phenomenon of diffusion (at social/group level) and the behavior of adoption of innovations (usually seen at individual level). It primarily focuses on technological innovations not necessarily information technology (which was still at its beginnings in the 1960s and not yet a mass phenomenon) (Rogers, 1983, 2003).

IDT is a highly complex theory proposing explicitly or implicitly a series of variables that act as determinants of individuals' behavior of adopting new technology. A first group of such variables is made of what Rogers termed *Perceived attributes of innovation*. Such relevant attributes advanced by IDT are: 1) the *relative advantage*– defined as "the degree to which an innovation is perceived as being better than the idea it supersedes (…) often expressed in economic profitability, in status giving, or in other ways"(Rogers, 1983, p. 213); 2) *compatibility* – "the degree to which an innovation is perceived as consistent with the existent values, past experiences, and needs of potential adopters (p. 223); 3) *complexity*, "the degree to which an innovation is perceived as relatively difficult to understand and use"(p. 230); 4) *trialability*, "the degree to which an innovation may be experimented with on a limited basis" (p. 231); and 5) *observability*, "the degree to which the results of an innovation are visible to others" (p. 232).

Aside from these I. *perceived attributes of innovations* there are other factors external to the individual and more related to the relevant social milieu that are discussed throughout Rogers' book: these are influences of: II. *the type of innovation decision* whether optional at the individual level, *collective* or imposed by some *authority*; III.*communication channels* (whether mass media or interpersonal); IV. *nature of the social system* (its norms, degree of interconnectedness, etc.); and V) the *extent of change agents promotion efforts*.Figure 4 summarizes IDT's variables and relations among them.

In addition one more variable is implicit in Rogers' discussion of the *innovativeness* of individuals understood by him as a classification of adopter categories based on how early or late they adopt the innovation. While Rogers defined innovativeness as a classification based on the time of adoption (therefore based on the dependent variable) many researchers making use of IDT have redefined innovativeness to refer to a personal characteristic/ propensity of individuals which, therefore, can become an independent variable, determinant of adoption(e.g. Agarwal & Prasad, 1998; Flynn & Goldsmith, 1993).

Rogers distinguished in the 1983 edition of his book, between a number of nine social science traditions that have made use of the IDT. We can safely say that, since then, at least a tenth one was added with the advent of information technology adoption studies. Some such studies have used IDT variables in the study of communication channels and of leadership in influencing the adoption of innovations decisions of individuals (e.g. Burkhardt & Brass, 1990; Gharavi, Love, & Cheng, 2004; Leonard-Barton & Deschamps, 1988; Nilakanta & Scamell, 1990; Zmud, 1983). Others have focused on the role of *perceived attributes of innovations*in determining individual decisions to adopt technology (Agarwal & Prasad, 1997, 1998; Chang

& Tung, 2008; Corrocher, 2011; Gary C. Moore & Benbasat, 1991; Tarofder, Marthandan, Mohan, & Tarofder, 2013; Wu & Wang, 2005; Zhao & Frank, 2003). Finally another category of studies have focused on the role of *personal innovativeness* in leading to technology adoption decisions and behaviors, whether they studies this variable in conjunction with other variables suggested by IDT or other theories (Agarwal & Prasad, 1998; Braak, 2001; Lewis, Agarwal, & Sambamurthy, 2003; Liu, Li, & Carlsson, 2010; Raaij & Schepers, 2008; Robinson, Marshall, & Stamps, 2005). In general, all of these studies have lent empirical backing to a multitude of variables advanced by IDT, supporting IDT as a viable theory in the study of information technology adoption.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) was developed by Davis and colleagues in the 1980s as a theoretical model with a narrow and dedicated focus on information technology adoption behavior(Davis, 1985, 1989; Davis et al., 1989).TAM is an application and simplification of TRA in the area of information technology adoption. It applies TRA in the sense that it focuses primarily on the first component, that of *attitudes* and did not include (at least initially) the component of *subjective norms*. In refining what attitudes are relevant in the context of technology adoption, Davis and colleagues processed a number of research traditions including IDT. They refine and diminish the relevant determinant variables of the behavioral intention to use technology to two: *perceived usefulness* defined as "the prospective user's subjective probability that using a specific application system will increase his or her job performance within the organizational context" (Davis et al., 1989, p. 985)and *perceived ease of use* defined as "the degree to which the prospective user expects the target system to be free of effort".All other possible influences on technology use intention, or actual use, are presumed to be antecedent to the main two TAM variables.(See Figure 3).

TAM has become an extremely widely used theoretical model in the study of technology adoption (or "acceptance" as it authors termed it). Some early studies have been focused more on the psychometric characteristics of TAM variables (e.g. Adams, Nelson, & Todd, 1992; Davis, 1989; Hendrickson, Massey, & Cronan, 1993; Gary C. Moore & Benbasat, 1991; Segars & Grover, 1993; Subramanian, 1994). Others have applied TAM in various technological or cultural contexts staying rather true to the original model (Igbaria & Iivari, 1995; Igbaria, Iivari, & Maragahh, 1995; Szajna, 1994). Still many others, have used TAM in conjunction with other variables suggested by other theoretical developments (e.g. Gefen & Straub, 1997; Koufaris, 2002; Lin & Lu, 2000; Selim, 2003)

TAM has now become the go to theoretical model of reference in the area of technology adoption. There are now thousands of academic research papers citing the original article introducing TAM by Davis and colleagues. And indeed most articles have provided the TAM variables, overall, with strong empirical support. Nevertheless, more recently TAM has come under some criticism, for becoming the victim of its own success and oversimplifying the explanation of technology adoption (Bagozzi, 2007; Benbasat & Barki, 2007).

Other theoretical contributions

Another relevant contribution for this article is a rather simple yet useful distinction made by Vallerand concerning types of motivations animating people's actions. He distinguished between *intrinsic* and *extrinsicmotivations*. *Intrinsic motivations* refer to the motivation people feel in performing the activity itself usually expressed through the pleasure or enjoyment of performing that activity/behavior. *Extrinsic motivations* refer to the desirable (or undesirable) results to be obtained following the performance of the activity. Such motivations relate to various goals people may have and the extent to which actions may fulfill such goals (Guay, Vallerand, & Blanchard, 2000; Vallerand, 1997).

The distinction has been successfully applied to technology adoption studies often in conjunction with, and as an extension to TAM (Davis, Bagozzi, & Warshaw, 1992; Teo, Lim, & Lai, 1999; Venkatesh, 1999, 2000). These studies have usually integrated the variable *enjoyment* as an intrinsic motivation. Note that the TAM variable perceived usefulness clearly relates to an ulterior benefit, therefore an extrinsic motivation (the classification of perceived ease of use on this scale will be discussed below).

The distinction and the introduction of *intrinsic motivations* in the study of technology adoption opened the door for more affective motivations. Aside from the enjoyment of technology use, a relevant group of studies has also considered the role of *computer (related) anxiety,* often these studies linking the concept also to Bandura's Social Cognitive Theory (Igbaria & Iivari, 1995; Saadé & Kira, 2007; Simonson, Maurer, Montag-Torardi, & Whitaker, 1987).

General considerations on theoretical developments

After decades of theoretical developments and an abundance of empirical research a lot of progress through various contributions has been made in understanding the phenomenon of technology adoption.However, it is hard not to

observe that their utility has been diminishing. This situation has developed partly because of the very success of TAM. While TAM has proven to be a robust model, it is also a rather simple one, due to its proposition of only two explanatory variables. Its influence on research has been rather simplifying; many studies usually including the two TAM variables plus a few other variables suggested by other theoretical developments. At the same timelacking broader theoretical frameworks, many studies have been rather idiosyncratic new variable proposals (Bagozzi, 2007; Benbasat & Barki, 2007). The result is that after these many years of study of technology adoption we lack comprehensive theoretical frameworks as well as comprehensive studies that would allow for simultaneous testing of many variables' influences.

While prior attempts to create broader theoretical models have been made (Venkatesh & Davis, 1996, 2000; Venkatesh, Morris, Davis, & Davis, 2003) they have not exhausted the space of possible expansion and integration of theory and have been rather quick to focus on statistical reliability and validity issues of the variables before further exploring the logical and theoretical relations among them.

Toward an integrative approach
Some methodological considerations

This paper attempts to integrate contributions of various theoretical developments into a unified theoretical framework. In approaching this task it proposes that the discussion about variables themselves be preceded by a discussion of types of variables. Such types are classified based primarily on social and psychological causal mechanisms (Elster, 1989)allegedly at work in making these variables a determinant of technology adoption intentions, or actual behavior. This discussion will therefore be informed by the main theoretical social and psychological developments already presented, the challenge being to identify the main dimensions of variation and cut points between types.

In building such typology, of great importance are not just social scientific considerations, but more broadly logical ones; particularly with regard to the logic of classification. The basics of the logic of classification boil down to two principles: classes have to be mutually exclusive (variables should ideally fall into one or another) and their entirety exhaustive (the set of all classes should cover the entire universe of interest). Clearly, while these principles of logic are useful, in the case of variables they may prove to be a bit overly ambitious. That is because social science variables are not exactly pure concepts, but concepts designed to capture variations in the real world (Hoover & Donovan, 2011, pp. 15–23). The principle of mutual exclusiveness may be too ambitious because social and psychological variables may not easily fall into one single type given that such social scientific measurement may "capture" more or less than what is desired. The principle of exhaustiveness of classifications is also rather ambitious, especially at the level of variables, since it is rather impossible to every say that all relevant variables have been identified. However, at the level of categories and classes, in principle exhaustiveness or at least further completeness could be achieved as long as one makes sure (to the extent that is possible) that each classification made proceeds from rather binary A and non A distinctions or alternatively if broad theoretical contributions are integrated to produce those classes. Once such typology and such classes of variables are identified they can serve as useful tools for theoretical expansion towards greater completeness.

Classifying determinant variables of technology adoption

A first broad and maybe deceptively simple distinctioncan be drawn between *internalpsychological*and *external* variables. This distinction attempts to separate variables describingthe internal subjective world of the individual psyche versus variables about the external world, be it natural, technological or social. However, the psychological world can also be divided into *individual variables or characteristics* (not immediately relational to the world of the behavior under study) and relational variables represent the external world of interest in the psyche. Table 1, below, presents the entire typology of variables which is described in more detail in the following.

Relational psychological variables.

This description begins with this category, because it contains the variables that are logically, psychologically and arguably causally most closely related to the intention of behavior (in our case of interest is the technology adoption behavior). *Relational variables* are variables that measure aspects of the internal psyche of individual as it relates to the external world. They are relational and somewhat intermediary between purely internal characteristics variables and external (world) variables in that they consist of mental (cognitive and affective) representations of the external world of interest. We can include here: *beliefs* and *attitudes*, on the one hand, which are cognitive and affective ways of relating between the subject are expressions of favor/positivity or disfavor/negativity vis-à-vis various objects. As such, they are not strictly speaking internal traits of the individual, but relational traits linking the subject to an object of the attitude.

Beliefs are mental representations of objects in reality. *Attitudes* are positive or negative evaluations of such objects. They have in common the fact that both are assigning traits to objects by means of cognitive affective attribution; that is objects are assigned certain attributes that have both a cognitive and affective component. While in more broader psychological theory the two are somewhat differentiated, when it comes to behavior theory and in particular related to technology adoption behavior, it is difficult to empirically separate the two. That is because, pertinent beliefs about technology and related objects also involve some degree of evaluation.

When beliefs and attitudes are related to behavior they also capture certain kind of *motivations* involved in behavioral intention formation. That is, beliefs or attitudes are relevant to behavior if and only if they are beliefs and attitudes that capture certain kind of motivations. Therefore, in this context of behavioral theory, beliefs and attitudes and motivations are to some extent interchangeable concepts: not because more broadly they are identical concepts (which they are not), but because they are partially overlapping concepts and it so happens that behavioral theory is interested in the area of overlap. Moreover, some social scientific theories have used the word "perceptions" to refer to such beliefs or attitudes or motivations (it is the case of *perceived usefulness* and *perceived ease of use* advanced by TAM as well as all of the *perceived attributes of innovation* advanced by IDT). Such use is clearly contrary to strict psychological understanding of the term (as organization and interpretation of sensory input) but is in accordance with a broader use of the term. Perceived/or perception in this case emphasizes that they are subjective mental representations that may have a greater or lesser correspondence to an objective reality.

Within this class of variables: *attitudes/ beliefs/ motivations/ perceptionsrelated to the object of behavior* we can distinguish, following Vallerand and colleagues, between *extrinsic motivations* and *intrinsic motivations*. *Extrinsic motivations* refer to motivations/ beliefs/ attitudes pertaining to ulterior benefits, goals that can be achieved by means of performing a certain behavior. It is here that we can place variables like perceived usefulness of (perceived relative advantage). Such variables denote motivations for behavior that are pursued for to the extent they lead to goals or benefits following the actual behavior as the result of the behavior.

Intrinsic motivations refer to beliefs/ attitudes pertaining to motivations that are intrinsic in the activity or behavior in question. Usually they refer to certain cognitive - emotional states, pleasant or unpleasant, elicited by the said behavior. In other words, they are about the component of behavior to pursue pleasant feelings and avoid unpleasant ones. Such states and variables capturing them are: *(computer) anxiety*(e..g. Simonson et al., 1987), *computer enjoyment*(Yi & Hwang, 2003), *cognitive absorption*(or *flow*)(Agarwal & Karahanna, 2000), etc. Although the assignment to this class has usually not been made by prior studies, because it refers to a measure of cognitive affective effort experienced during behavior performance, *perceived ease of use* also belongs to this class.

*Norm, value compliance/expression attitudes*are a third set of attitudes / beliefs that act as motivators toward performing behaviors, in our case technology adoption behavior. Following TRA and TPB we include this set of motivations but unlike them include it as a class of*attitudes or beliefs*and not as distinct from attitudes. Compliance attitudes are distinct though from, intrinsic and from intrinsic motivations in that a different psychological mechanism is at work. They are mainly neither about obtaining ulterior benefits (expressed in terms of utility), nor about intrinsic benefits (pleasure or avoiding negative emotions), but they are about *compliance with certain norms and values* the person holds. That being said, it is to be observed that compliance or noncompliance behavior can lead to satisfaction (or dissatisfaction) both while performing behavior or afterwards (which suggest that there may also be an indirect effect of compliance attitudes besides the direct one). The category of (norm/values) *compliance variables* is somewhat distinct from subjective norms (in TRA and TAM) in that we are looking at the norms/ values as internal (internalized) norms/ values and the extent to which the individual sees the behavior in question (technology adoption) as being congruent or not with them. This class is not concerned with observed external norms (i.e. the extent to which relevant others are perceived to prefer, find desirable a certain behavior). The second way this category is different is than TRA's and TPB's *subjective norm* is that in includes to mechanisms of positive value/norm expression as well as that of negative compliance and avoidance of noncompliance.

Internal, individual psychological traitvariables. *Internal individual psychological trait variables*refer to individual psychological characteristics, predispositions or personality traits that may be linked logically and psychologically to technology adoption intentions and behavior.The means or mechanism by which they influence behavior is through the fact that they express certain individual dispositions toward certain motivations to perform the behavior. However in being expressions of dispositions or capability they are not the motivations themselves (which are

essentially relational concepts) and therefore their effect will tend to be mediated by *relational attitudes/beliefs/motivations*. Within these internal variables we can further distinguish between *individual psychological traits* more or less permanent (be they stable *personality* traits or less stable passing *moods*, *emotional states*, etc.) and *attitudes.* Individual *traits* refer to characteristics of the individual that can be longer term, stable (for example personality characteristics as measured on various personality tests, generalized self-confidence or self-efficacy,cognitive characteristics such as IQ, etc.) or shorter term, less stable (related to mood or emotional state at a time or for a period). Such traits reveal general individual propensities (whether cognitive or emotional) that may become relevant in the context of the behavior of interest:in our case technology adoption). Most notably in the case of technology or innovation adoption, a personality trait of openness to innovation (*personal innovativeness*).

External variables

If the previous variables referred to psychological characteristics of individuals or measured relational aspects in attitudes and beliefs about the external world, external variables refer to the world external to the individual as it may impact the intention and behavior of technology adoption. These variables are external to the extent that they refer to objects external to the considered unit of behavior and to the extent that the locus of measurement is external (and not a perception of the individual about the external world).

We can distinguish within this broad category between technological/ material, at one end, and social variables at the other end, with the intermediary class of socio-technical.

Technological characteristics refer to the feature of the technology of interest that may lead to the adoption or non-adoption of technology. Technical characteristics should not be expected to have an immediate influence on adoption or intention of adoption, but one that is mediated by core attitudes toward object of behavior or by social influences. Thus the various features may make a technology more or less: useful, easy to use, enjoyable, norm or value compliant, etc.*Complexity*, when seen as a feature of the technology, measured independently from subject's perception, fits into this category.

Social variables or influences refer to characteristics of the relevant social actors or social system that may influence an individual's attitudes and intention to use technology. Once again the mechanism of influence is rather indirect and can be diverse, via either: the process of internalizing norms followed by norm compliance; the process of instrumental goal/preference imitation followed by extrinsic motivation or intrinsic motivation. We can include here: measures of *observability* or *pervasiveness* or *market penetration* (measured as external and independently from individual perceptions); *voluntariness* measured as social system's feature, i.e. locus of decision making; physical exposure to channels of communication (number of visits, clicks, time of exposure etc.); effort by change agents; etc.

Socio-technical characteristics refer to characteristics that may belong to both the technology itself and to the social context of its use. For example *trialability* or (as it has been named in other works) *result demonstrability* can be seen as both a material/technological feature of the technology, and a social one as made possible (or not) by the organization selling the specific technology. Clearly a set of technical characteristics, organizational policy, legal aspects, etc. make one technology in one social context more *trialable* than others. Similarly the availability of help and *technical support* can be a social availability but also dependent of technical characteristics (e.g. help menu, help functions, etc.).

Conclusions

This paper has developed a theoretical framework integrating various contributions and theories of technology adoption. It has done so by providing a complex and multidimensional typology of variables that act as determinants of technology adoption intentions and behavior. The main dimension of variation (establishing the main broad categories) is that of internal psychological variables vs. relational psychological variables vs. external variables. Within each category we discussed several classes or groups of variables. By grouping variables in this way we are able to identify commonalities and differences among variables at the level of causal mechanism by which they influence the dependent variable. Such classification opens the way toward more logically rigorous and comprehensive theoretical models.

Moreover, by creating groups/classes of variables based on the causal mechanisms by which they allegedly work one is able to expand theory and the available set of determinant variables by asking within each class: *what other variables might be relevant within that class?* Once the broader class(es) and mechanisms at work are clear then the effort of identifying new variables that may or may not be relevant in various research/ behavioral contexts can be identified. For example in the main category of attitudes toward behavior and object of behavior, the class of extrinsic motivations we can ask what other possible (ulterior) benefits or costs might be incurred by technology users that may determine their behavior? We can see for example that most studies of technology adoption at work do not take into

account the financial cost as one factor (that may be because most of the times in these contexts the users are not the buyers). However in the context of consumer research where users are also the buyers then this factor may prove to be relevant. A second example, in the class of *normative traits*, one may ask what other norms/ values may be relevant for technology adoption. One possible candidate could be *religiosity*. One can argue that religious people are more or less likely (probably less) inclined to have overall positive views about technology and science in general and about information technology in particular (although in various specific contexts say an application on religious themes religiosity may act in the opposite direction.

In conclusion it is the author's hope that such typology of variables could support theory development and empirical research in providing an underlying typology for all/most variables that would allow various research articles to "talk to each other", and constitute a working tool for theory and research model expansion.

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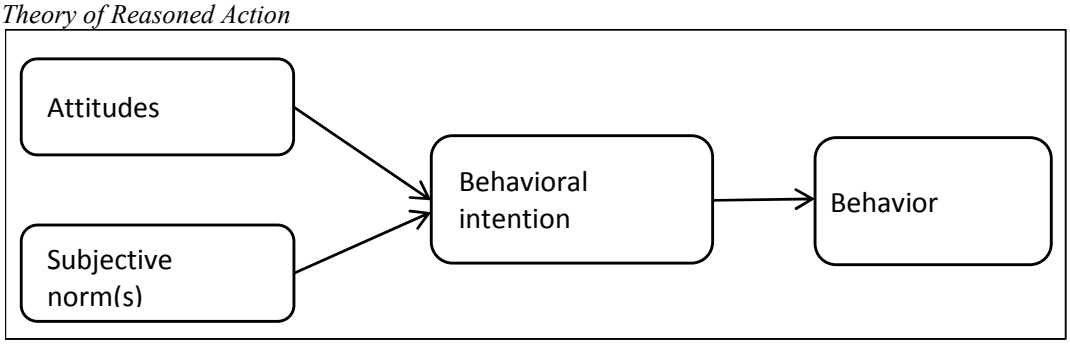
Appendices

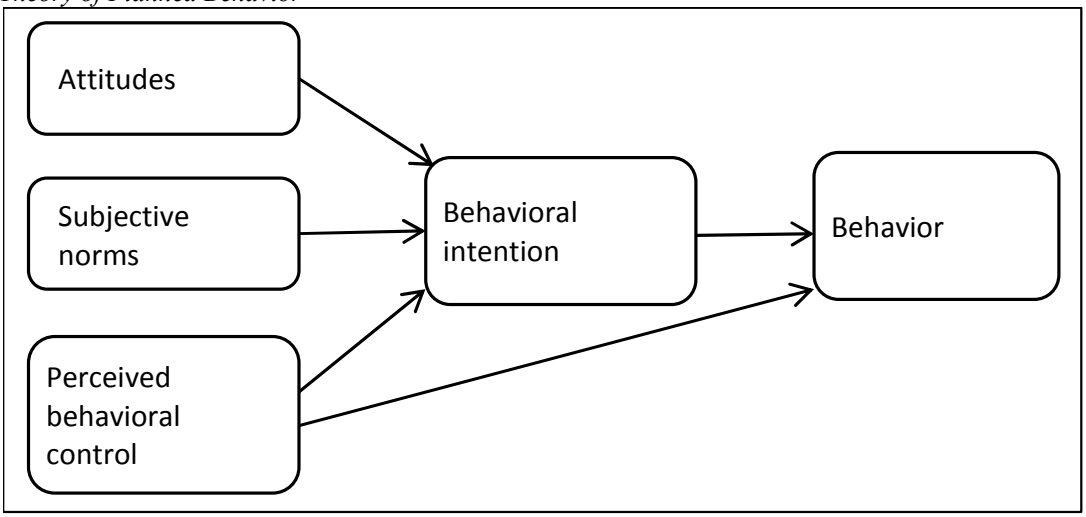
Appendix A

Figure 1
Theory of Reasoned Action



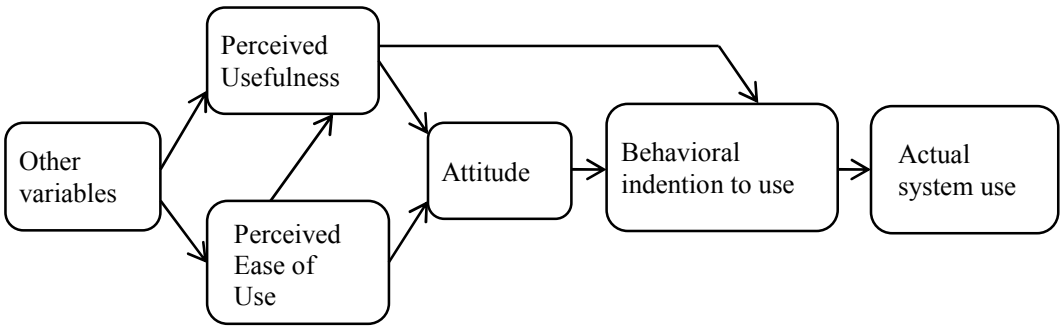
Based on Ajzen and Fishbein 1980, simplified.

Figure 2
Theory of Planned Behavior



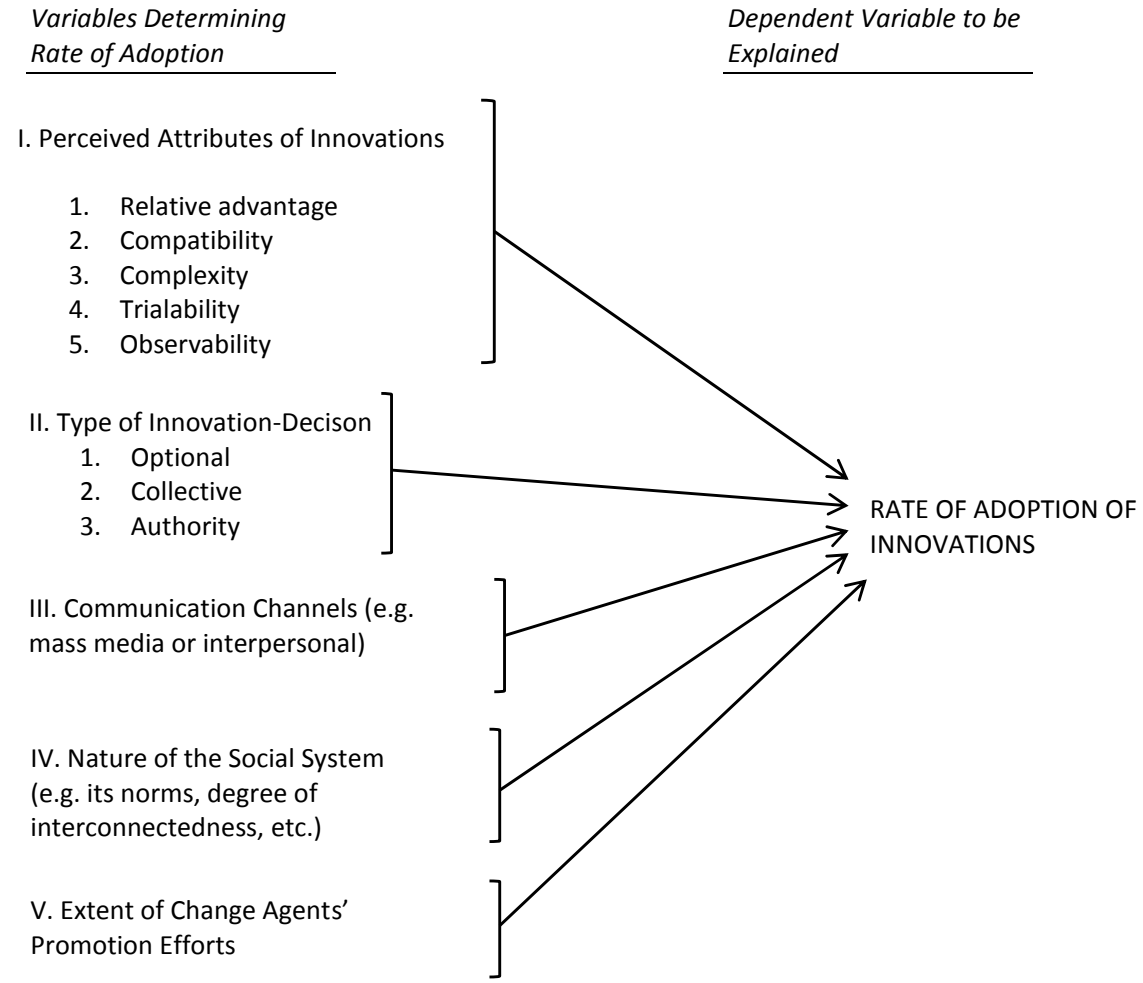
Based on Ajzen 1985, simplified

Figure 3
Technology Acceptance Model



Based on Davis et al. 1989, p. 985

Figure 4
Innovation Diffusion Theory: Variables detemining rate of adoption of innovations



Reproduced from Rogers 1983, p. 233.

Appendix B

Table 1
Typology of Determinant Variables of Technology Adoption

Individual psychological variables	**Relational variables: Attitudes/ beliefs**	**External variables**
Stable, long term traits	**Attitudes toward behavior or object of behavior**	
Cognitive traits	Extrinsic motivations	Technological characteristics
- IQ (cognitive capability); - Cognitive style; - Knowledge/ skills	- *Perceived usefulness;* - *Relative advantage;* - *Perceptions of risk/ trust related to technology* (ulterior risk related to potential losses following use of technology); - *Financial cost?*	- *Technological characteristics (features)* - *Complexity* (mesured as technology characteristic not as subject's perception)
Cognitive-affective traits	Intrinsic motivations	Socio-technical variables
- Personality traits; - *Innovativeness;*	- *Perceived ease of use* - *Computer anxiety*; - *Computer enjoyment*; - *Cognitive absorption/ flow*;	- *Trialability/ Result demonstrability;* - *Tech support availability*;
Normative traits	Normative compliance beliefs	Social influences
- Subjective norms/values (measured the extent to which norms/values are held); - Religiosity?;	- Subjective norms (measured as extent of compatibility of norms with behavior); - *Compatibility.*	- *Observability* or *technology pervasiveness* or *market penetration (measured as social measure of spread/ use of technology)* - *Voluntariness* (measured as external measure of social system's features, locus of decision, hierarchical nature, etc.) - Exposure to various *channels of communication* (mass media or interpersonal) (measured as phisical/behavioral exposure, e.g. frequency of reading certain media) - Effort by change agents;
Unstable, short term traits	**Attitudes/ beliefs about related objects**	
Affective:	Attitudes/ beliefs about social context	
- Mood	- *Perceived observability;* - *Perceived voluntaryness*; - *Subjective exposure to communication channels(measured as cognitive affective openness or trust in those channels);*	
	Attitudes/ beliefs about related objects	
	- Broader attitudes/ beliefs related to technologies (e.g. not only related to the technology in question for example a computer program but information technology in general); - Attitude toward science;	