Overcoming Variance and Process Distinctions in Information Systems Research

Completed Research Paper

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Abstract

Most Information Systems research to date has been conducted from either a variance or a process perspective. On the one hand, some researchers argue that process and variance approaches should be kept separate, while others think they should be combined. In this paper, we argue that variance and process have more similarities than expected, and that combining them can have significant advantages for the field. We propose a ‘blended’ hybrid approach in which elements of both variance and process exist in a coherent whole, and offer a first-version tool box to start hybrid theorizing. Our paper ends with a discussion regarding the types of information systems research questions that can be appropriately approached from a hybrid standpoint.

Keywords: Research methods/methodology, theory building, information systems

Introduction

“...we do not have to accept the integrity of extant paradigms because their assumptions are always limited and, therefore, the subject of critique... Rather we need to develop new paradigms, with their own assumptions and commitments, which draw on the strengths and weaknesses of the current ones, recognizing the plurality and diversity of the world.” (Mingers 2001, p. 243)

Information Systems (IS) research has typically been conducted from variance (e.g., Davis 1989) or process (e.g., Lapointe and Rivard 2005) approaches (Gregor 2006; Paré et al. 2008; Rivard 2014). Since the explicit distinction between process and variance by Markus and Robey (1988) was introduced to the field, several researchers have argued for the necessity of keeping these approaches separate (Newman and Robey 1992; Seddon 1997). They argue that the two approaches have different ontological assumptions, different types of causality, and different theoretical explanations. At the same time, others propose that their separation can have detrimental effects: it unnecessarily limits the variety of theories constructed and research conducted (Langley 1999). Thus, some have called for a combination of the two

1 We use the term approach as an umbrella term to encompass a way of dealing with theory, research, or both. Theory is an explanation of phenomena whereas research can be thought of as an empirical study of phenomena. We thank an anonymous reviewer for this insight.
approaches (e.g., Sabherwal and Robey 1995). These researchers argue that social phenomena are intertwined and that variance and process models should be combined to better explain these phenomena (e.g., Langley 1999; Peterson 1998). They argue that the best theories are often hybrids that combine variance and process theorizing (DiMaggio 1995).

In this paper, we argue that the distinctions between the two approaches are more artificial than a real reflection of research practices in our field, and demonstrate how they already overlap to some extent in our theorizing and empirical research. Further, we propose that even more overlap should be encouraged because hybrid approaches are in a privileged position to address some of the toughest research questions of our field. We do so from a positivist standpoint: we believe, in an unorthodox way, that reality is to a certain extent objective, can be observed and analyzed, and exists beyond the researcher’s mind (Rivard 2014; Weber 2004). The rest of the paper is organized as follows. First, we provide a succinct review of the main process and variance distinctions and arguments for keeping them separate. Second, we demonstrate that much of our research in IS already demonstrates elements of both, suggesting that our researchers value hybrid approaches rather than keeping them separate. Third, we demonstrate how hybrid approaches can be carried out in future research, distinguishing between two main types of combinations, parallel and blended. Fourth, we provide arguments for why more hybrid approaches should be adopted. Finally, we discuss important research questions for the IS field that can be addressed with a hybrid approach.

**A Review of Process versus Variance Distinctions**

The distinctions between variance and process research were best described to IS researchers by Markus and Robey (1988) who drew on Mohr (1982) to explain their differences. That is, researchers generally use variance theories when making precise predictions (about ‘nouns’ such as organizations) that will be tested, while those drawing on process theories are concerned with explaining how situations and events unfold and develop (with verbs such as ‘organizing’) over time (Van de Ven and Poole 2005).

In general, process and variance approaches can be characterized in six main ways, as outlined in Table 1. The first distinguishing characteristic is ontology, or the theory elements. While variance approaches deal with fixed entities with varying attributes (variables), process approaches consider entities that participate in events (Mohr, 1982). That is, variance approaches deal with variables describing states while process approaches deal with events and process that unfold over time (Van de Ven 1992). The time ordering of entities represents the second characteristic: for the variance approach, time ordering of variables is not important, while for the process approach, time ordering is critical. The third characteristic concerns the change of meaning of entities over time (Mohr, 1982). That is, time is unimportant in linking independent variables to outcomes in variance approaches; in contrast, time is essential in explaining how processes unfold. Furthermore, the criticality of time has some importance for the third characteristics: causality. Thus in terms of causality, for the variance approach, explanation is based on establishing necessary and sufficient causality: “If more X, then more Y” (Mohr 1982, p. 39). For the process approach, explanation is based on establishing a necessary causality: the precursor (X) is a necessary condition for the outcome (Y) (Mohr, 1982). With respect to the fourth characteristic, change of meaning of entities over time, for variance approaches, entities have only one meaning over the course of time, whereas the meaning of entities may change in process approaches (Mohr 1982). The fourth characteristic is epistemology, or how to acquire knowledge. In this regard, most variance approaches have adopted quantitative methods in a cross-sectional way while most process approaches have employed qualitative ones with a longitudinal orientation (Mohr 1982). The final characteristic is the type of explanation provided by each approach. Variance approaches emphasize the what or the changes that independent variables infringe in a dependent one (Mohr 1982; Van de Ven and Poole 2005). In contrast, process approaches explain the how or an explanation of how events occur over time to produce an outcome (Mohr 1982; Van de Ven and Poole 2005).

With these distinctions in mind, some researchers have suggested that the two approaches be kept separate. Otherwise, the result would be “muddled thinking that is likely to be counter-productive for future IS research” (Seddon 1997, p. 242). For example, drawing on the different ontological assumptions, researchers suggest that the boxes and arrows represent different things in process and variance models: “Since the boxes in a process model represent discrete have-happened/have-not-happened events, and the arrows indicate sequence, not causality, it is not possible to adopt a variance model interpretation of one part of a box-and-arrow diagram, and a process model interpretation of another part. If one does,
there must be a slippage of meanings somewhere in between” (Seddon 1997, p. 242). Further, they argue that the two approaches have fundamentally different causal arguments that a “In process models, the outcome implies the preceding events, which is a fundamentally different causal argument than the ones offered by factor models” (Newman and Robey 1992, p. 251). Finally, they suggest that although variance and process models may be ‘mutually informative,’ their results may not be easy to combine (Mohr 1982; Newman and Robey 1992). Nevertheless, as we demonstrate next, the lines between variance and process approaches are not clear-cut.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Variance</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Theory elements (ontology)</td>
<td>Entities are a “system of interrelated variables describing the states of different constructs” (Sabherwal and Robey 1995, p. 307).</td>
<td>Entities are “no more than temporary instantiations of ongoing processes, continually in a state of becoming” (Langley 1999, p. 5).</td>
</tr>
<tr>
<td>2. Time ordering of entities</td>
<td>Time ordering among the variables is immaterial to the outcome (Langley 1999; Mohr 1982).</td>
<td>Time ordering among the entities is critical (Langley 1999; Mohr 1982).</td>
</tr>
<tr>
<td>3. Causality</td>
<td>Each variable, “whether standing alone as an additive contributor or combined multiplicatively with other causes, has a separable impact on the outcome; the extent of its impact is not lost in the intertwining of causes and conditions” (Mohr 1982, p. 41).</td>
<td>“Process theories focus on critical events and conjunctions of events to explain development and change, and hence they hinge on necessary causality. Each causal event imparts a particular direction and pushes the developing subject toward a certain outcome necessary for development and change to proceed down a particular path” (Poole et al. 2000, p. 41).</td>
</tr>
<tr>
<td>4. Change of meaning of entities over time</td>
<td>Variables have only one meaning over the course of time. That is, “regardless of when the measurement occurred, the assumption would be that the same thing is being measured – for example, that client service meant the same thing at time 3 as it did at time 1” (Poole et al. 2000, p. 31).</td>
<td>Process approaches address “questions about how and why things emerge, develop, grow, or terminate over time” (Langley 1999, p. 1). Therefore, an entity may change in meaning over time (Mohr 1982).</td>
</tr>
<tr>
<td>6. Type of Explanation</td>
<td>‘What’ or explanations in terms of independent variables causing changes in a dependent variable (Mohr 1982; Van de Ven and Poole 2005).</td>
<td>‘How’ or explanations as narratives or stories about how a sequence of events unfolds to produce a given outcome (Mohr 1982; Van de Ven and Poole 2005).</td>
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</table>
Table 1. Variance versus Process Approaches

**Blurring the Lines between Variance and Process Research**

We propose that pure variance and process approaches are actually quite very rare: in fact, most IS research has elements of both. Examining each of the six characteristics in Table 1 in turn, we demonstrate that overlap often exists between the two approaches, creating a start towards a hybrid approach.

**Theory Elements**

In reality, the same theory can be instantiated from a variance or a process perspective, or one that contains elements of both (e.g., coping theory: Liang and Xue 2009). In fact, both variance and process approaches hold a positivist ontology about the world: there is an objective reality that we can observe and represent independently of the researcher. Although process approaches use events and processes whereas variance approaches employ variables, a hybrid approach can build reality based on events, processes, and variables. That is, if the process approach constructs theory around events and processes - two different elements - then a hybrid approach can also incorporate additional elements such as variables. As a result, terms such as processes, events, and variables are more a matter of semantics than fundamentally separated phenomena. For example, Mohr (1982, p. 39), when explaining the variance approach, admits that X and Y can be values (variance) or events (process): it is “best to think of X and Y as defined states, events, or values (scores, quantities) and of not-X and not-Y as undefined states – simply as the absence or negation or complements of X Y”, and goes to say: “If X, then Y” is equivalent to saying “if more X, more Y” translating at that moment X and Y into quantifiable variables. Consequently, events and process have properties that can be operationalized in variables that have different levels. For a very simple example, the occurrence of events and processes can be operationalized as dummy (0/1) variables, as it is done in experimental research. As Poole et al. (2000, p. 17) put it: “the second and most frequently used meaning of process is as a category of concepts of individual and organizational actions ... In this usage, process refers to a category of concepts that can be distinguished from other categories of concepts... Like these other categories, process concepts are operationalized as constructs and measured as fixed entities (variables), the attributes of which can vary along numerical scales from low to high”. Thus, processes, such as job instrumental processes, have been operationalized as variables and depicted in variance models (e.g., Venkatesh and Davis 2000). The opposite also exists: variables have been identified as factors having an influence on the dynamics of a process (e.g., Newman and Sabherwal 1991, factors such as uncertainty influence the dynamics of the Information System development process).

**Time Ordering of Entities**

Time is undeniably an essential component of process approaches. However, we propose that the irrelevance of time for the variance approach is not always the case. There are situations in which time is of critical importance for the variance approach. For instance, a variance approach can capture time ordering with repeated measures (for an example, see D'Aubeterre et al. 2008). As another example, experiments - aimed at observing the effects of a given treatment (or manipulation) – contain elements that emphasize time. That is, the very essence of experiment design is to demonstrate that the treatment or manipulation (actually an event often operationalized as a variable, in event vs. no-event conditions) has an effect on a variable, and in order to do so, time is critical the measurement of the effect needs to be done after the treatment has taken place (Shadish et al. 2003). Another situation in which time is of importance occurs in variance approaches containing mediators. Mediators are variables aimed at capturing the underlying process by which an independent variable influences an outcome: “the central idea in this model is that effects of stimuli on behavior are mediated by various processes internal to the organism ... Theories as diverse as Hull, Tolman, and Lewin shared a belief in the importance of postulating entities or processes that intervene between input and output” (Baron and Kenny 1986, p. 1176). Thus, time has appeared in both process and variance approaches, suggesting a second type of overlap between the two approaches.
Causality

Mohr’s (1982) original assumptions concerning causality were based on necessary and sufficient conditions. Specifically, he proposed that the precursor (X) is a necessary and sufficient condition for the outcome (Y) for the variance approach, while the precursor (X) is a necessary condition for the outcome (Y) for the process approach. However, both Mohr and other researchers later revised these assertions, explaining that theories of social phenomena cannot meet these causality requirements. For example, Mohr now argues that “causation, which is certainly relevant in physics, is not so relevant in social science” (p. 8) because its requirements are “impossible to fulfill, that is, it is inherently impossible to specify the circumstances under which a particular behavior will always be determined by a given sent of variables or factors” (p. 9). Similarly, Shaw and Jarvenpaa (1997, p. 73) argue that Mohr’s (1982) earlier “ideas are based on assumptions of causality that are both abstract and philosophically debatable … we contend that the logical relationship between concepts as described by Mohr does not contribute significantly to our understanding”. The result is that “causality is rarely explicitly articulated” in IS research (Avgerou 2013, p. 402).

We argue that this is because most, if not all, social science deals with what can be considered INUS conditions: an insufficient but non-redundant part of an unnecessary but sufficient condition (Mackay 1974). That is, for each effect, there is a “plurality of causes” (Mackay 1974, p. 61). A certain effect can be brought about by a number of distinct clusters of factors: each of the clusters is sufficient to bring about the effect, but none of them is necessary. As experimentalists note, this explains “why a given causal relationship will occur under some conditions but not universally across time, space, human populations, or other kinds of treatments and outcomes that are more or less related to those studied” (Shadish et al. 2002, p. 5). Thus, we conclude that the earlier causality distinctions between variance and process approaches are not appropriate.

Change of Meaning of Entities over Time

The idea between the “changing of meaning” is that an entity’s (either a variable, an event, or an attribute) meaning – not its value – is static, and thus, does not change in the case of variance approach. In the case of the process approach, the meaning of an entity may or may not change.

We posit that, in most studies taking a process approach from a positivist standpoint, the meaning of an entity actually remains the same (Weber 2004). That is, from a positivist standpoint -- regardless of whether the research is carried out from a variance or process approach -- meaning does not change. What might change, however, is the interpretation of an entity by participants. For example, in Lapointe and Rivard (2005), the perceptions of the meaning of the introduced information system for physicians and nurses changed as time passed. And this change in participants’ interpretations of meaning could have alternatively been measured with different variables that contained references to different relevant dimensions. Of course, in a quantitative approach, the richness of the data would certainly be inferior to that of a qualitative approach, but this matter concerns the advantages and disadvantages of each method, not a property of the (variance or process) approach itself.

Method

The traditional view posits that the variance approach uses mostly quantitative methods, while the process approach mostly employs qualitative methods. However, there is no one-to-one correspondence between theoretical approach and method (Burton-Jones et al. 2013): there is no reason why variance theories could not be tested with qualitative methods or process theories with quantitative methods. For example, longitudinal research, time series analysis, and repeated measures are just a few examples of how to test change and processes with quantitative tools (for examples, see Elie-Dit-Cosaque et al. (2011) and Bhattacharjee et al. (2006)). Thus, it is possible to detach methods from the approaches within which

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2 If the meaning of an entity changes, this is due to the scientific paradigm within which the research is conducted. That is, if one is doing research anchored in interpretivism, the meaning of entities might evolve and change, not because of using a process approach, but because the overall scientific assumptions that guide the research allow it to do so.
they have been traditionally employed, and use them within other approaches that may make different assumptions (Mingers 2001).

Type of Explanation

Finally, and perhaps most importantly, a pure variance approach cannot meet the theoretical demands of explaining the critical “why” of a theory (Sutton and Staw 1995; Whetten 1989). Because both variance and process approaches require a theoretical explanation, they both resort to “process thinking” for theoretically justifying the relationships between the variables and the sequences of events (Poole et al. 2000). That is, although variance models are constructed by specifying relations between sets of variables, they rely upon “process logic” dynamics to explain and justify such relations (please see Table 2 for some examples). Again, we see overlap between the two approaches.

<table>
<thead>
<tr>
<th>Quotes</th>
<th>Authors</th>
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<tbody>
<tr>
<td>“As noted earlier, two theoretical processes explain the relationships between perceived usefulness and its determinants: social influence and cognitive instrumental processes.”</td>
<td>(Venkatesh and Bala 2008, p. 279)</td>
</tr>
<tr>
<td>“ Whereas the direct relationship between subjective norm and intention in TRA and TPB is based on compliance, TAM2 encompasses two additional theoretical mechanisms by which subjective norm can influence intention indirectly through perceived usefulness: internalization and identification. Internalization (Kelman 1958, Warshaw 1980) refers to the process by which, when one perceives that an important referent thinks one should use a system, one incorporates the referent’s belief into one’s own belief structure.”</td>
<td>(Venkatesh and Davis 2000, p. 188-189)</td>
</tr>
<tr>
<td>“Greater consistency with prior experiences should facilitate the learning process, thereby rendering a new technology easier to use. By contrast, when the new technology is significantly different from experiences the user has had, prior experiences constrain rather than facilitate learning about it.”</td>
<td>(Karahanna et al. 2006, p. 788)</td>
</tr>
<tr>
<td>“TRA theorists suggest that reasoned behaviors are preceded by a deliberate process that culminates in the decision or intention to act, but, even after an individual decides to act, barriers can prevent individuals from completing the behavior (Fishbein and Azjen 1975).”</td>
<td>(Ahuja and Thatcher 2005, p. 430)</td>
</tr>
</tbody>
</table>

Table 2. Evidence of ‘Process’ Logic in Variance Approaches

We conclude from our review that the variance and process approaches share more than first thought. Our analysis shows how they are more compatible than they are traditionally viewed. Given their overlap, the next two critical questions to address are: how can they be combined? and why should they be combined?

Hybrid Approaches: How Can Variance and Process Be Combined?

Although we demonstrated that variance and process approaches overlap somewhat, few studies combine them to a great extent. We propose that those combining them take either a parallel or a blended approach. In the ‘parallel’ hybrid approach, both variance and process approaches are used independently in the same or different studies (e.g., Liang and Xue 2009; Sabherwal and Robey 1995). That is, the two approaches are separate in terms of models and analyses, but their results are compared and discussed. For example, Liang and Xue (2009) built two theoretical models – one variance and one process - concerning how users avoid IT threats. The objective was for the process and variance approaches to mutually inform each other. Likewise, Trauth³ (2000) used a variance approach and then a process approach to study computer-mediated discussions, followed by a discussion of how each approach

³ Trauth (2000) not only adopted variance and process approaches, she did so from a positivist paradigm for the variance approach and from an interpretivist one for the process approach.
conveyed something new that the other could not. The idea of this parallel hybrid approach is to use both a variance and a process approach to analyze and theorize about the same phenomenon: both sets of results are presented in order to obtain a more complete picture of the phenomenon under investigation (Sabherwal and Robey 1995).

In the ‘blended’ hybrid approach, researchers combine both variance and process approaches in the same study. This approach builds one model that combines both variance and process elements to theorize about a phenomenon in a coherent way. This combination of the two approaches may be more or less blended. We suggest that much of the present research that blurs the lines between variance and process could be viewed as the less blended approach. The most common examples are studies that use variables and relations from the variance approach and the time element from the process approach, that is, longitudinal studies that test relations between variables. For example, Bhattacherjee and Prekumar (2004) studied changes in beliefs and attitudes longitudinally in different contexts (computer training software usage and rapid application development tool usage). They stated that usefulness and attitudes at t1 would influence disconfirmation, satisfaction, usefulness, attitude, and intention to use at t2 (see their model in Figure 1, which incorporates variables, relations, and time). Although they use theoretical elements that belong to variance entities and relations, they also incorporate time, and time becomes important in the ordering of the different variables in the model. The entities in their model do not change in meaning over time. Their causality approach meets the requirements for INUS conditions. The method used to test their model is quantitative: a longitudinal survey. And the type of explanation provided in the text follows a process logic. This less blended approach is quite common (for another example, see Limayem et al. 2007) and encompasses what Van de Ven and Poole (2005) have called ‘weak’ variance and ‘weak’ process approaches. In this regard, it is important to acknowledge that some researchers might characterize this ‘weak hybrid approach’ as just longitudinal research taken from a variance standpoint; whereas others have categorized it as a process approach (Paré et al. 2008). We take this ambivalence of categorization as a further evidence of how the two approaches are blurred, and therefore we categorize this as a weakly blended hybrid approach.

Figure 1. A Weakly Blended Hybrid Research Model
(adapted from Bhattacherjee and Prekumar 2004)

In a highly blended hybrid approach, however, additional elements are employed. For example, a study by Ortiz de Guinea and Webster (2013) employed several elements of both approaches: discrete events, continuous events, time, variables, processes, and relations. They conceptualized IS use patterns as a “configuration of an individual’s emotions, cognitions, and behaviors when interacting with IT to accomplish a task” (p. 1166). Figure 2 portrays this: on the horizontal axis, one can see how events

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4 We thank an anonymous reviewer for this insight.
(expected or discrepant) may occur over time, with their resulting IS use patterns composed of emotional, cognitive, and behavioral processes. As demonstrated, the theoretical elements of both process and variance approaches – processes, events, variables, relations - are blended and combined into a coherent theory and then into a coherent research model. Furthermore, time has a critical role in theory, in ordering the different elements into the research model, in their empirical measurement, and in the calculation of their effects. The entities in the model (drawn from a positivist paradigm) do not change in meaning over time; that is, the cognitive, emotional, and behavioral processes, as well as the rest of events and variables, might change in value but not in meaning over time. The implicit causality in the model (and in their theory throughout their article) meets the requirements for INUS conditions; that is the events are seen as INUS conditions that bring different IS use patterns into life. Furthermore, both qualitative and quantitative methods were intertwined in order to test the model, in which think-aloud techniques, pop-up questions, heart-rate monitoring, and videos were employed and coded in order to operationalize cognitive, emotional, and behavioral processes over time. Hypotheses regarding events triggering different patterns and patterns fading away over time were tested via overall trend analyses through repeated measures ANOVA. Furthermore, the relation between behaviors and performance was tested through path analysis. Finally, the explanation addressing the why behind the hypotheses followed a process logic.

In order to build coherent blended hybrid models that convey a parsimonious understanding, we suggest that standard icons be used for different theoretical elements. Drawing on symbols used in past variance

Figure 2. A Highly Blended Hybrid Research Model
(adapted from Ortiz de Guinea and Webster 2013)
and process studies, we provide a starting point for future researchers on such a hybrid tool box (see Table 3: the previous Figures 1 and 2 were adopted from the original studies by employing this hybrid tool box). It proposes icons to use for different theoretical elements: events, processes, variables, time, and relations. Events can be further divided into discrete (that is, they happen at a distinct point of time with a well-defined beginning and end) or continuous (they persist over time) ones. Processes are illustrated by a continuous line that, if flat, indicates no change over time, and, if fluctuating, indicates change over time. Variables are represented by an oval form for latent variables and by a box for manifest variables. Time is represented by a dotted arrow that indicates the direction of time in the research model. Relations, or the linking between variables, are illustrated by a straight arrow that indicates the influence of one variable on another variable.

<table>
<thead>
<tr>
<th>Element</th>
<th>Icons for Hybrid Approaches</th>
<th>Original Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Events</td>
<td><img src="image" alt="Discrete Events" /></td>
<td>Process</td>
</tr>
<tr>
<td>Continuous</td>
<td><img src="image" alt="Continuous Events" /></td>
<td>Process</td>
</tr>
<tr>
<td>Processes</td>
<td><img src="image" alt="Fluctuating Line" /> to show change</td>
<td>Process</td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="Straight Line" /> to show no change</td>
<td>Process</td>
</tr>
<tr>
<td>Variables</td>
<td><img src="image" alt="Latent Variables" /></td>
<td>Variance</td>
</tr>
<tr>
<td>Time</td>
<td><img src="image" alt="Dotted Arrow" /></td>
<td>Process</td>
</tr>
<tr>
<td>Relations</td>
<td><img src="image" alt="Straight Arrow" /></td>
<td>Variance</td>
</tr>
</tbody>
</table>

Table 3. Hybrid Tool Box

We suggest that the more elements from the table that come from both variance and process approaches, the more blended the combination; likewise, fewer elements from the table suggest a less blended combination. We hope that this initial tool box will spur others to develop it further, creating other standard symbols to add to the tool box. By developing creative models using accepted symbols, we hope that future researchers will create more blended hybrids that combine both process and variance approaches into a coherent whole.

**Why Should Variance and Process Approaches be Combined?**

We believe that there are several compelling reasons for combining process and variance approaches. Perhaps the most important reason is that the phenomena we want to understand and explain in the IS field – such as IS use – fundamentally share the characteristics of both approaches. In fact, what is difficult to do is to actually separate variance and process theories. As we demonstrated above, the
approaches are blurred, and in practice phenomena of different kinds are intertwined (Langley 1999). For example, IS use can be thought of as a process or a pattern that occurs over time from the moment at which a system is introduced in the workplace until its lifecycle ends, or as a variable that captures the breadth or frequency of use of a given technology. Many factors can influence the decision to first use a system (Davis 1989), and various events can trigger different ways or patterns in which individuals use a system over time (Beaudry and Pinsonneault 2005). In turn, system use can enable other processes such as speedy production of different products and the efficiency and efficacy for which work is carried out by individuals and groups. Thus, we can see how IS use – one of the most important subject areas in our field - contains both process and variance characteristics.

As Peterson (1998, p. 27) states: “Process and variance theories are inherently interwoven when things are viewed as chunks of process.” Accordingly, exclusively pursuing research that uses one approach or the other has detrimental effects for the advance of science: it unnecessarily limits the variety of theories constructed and research conducted. As Langley (1999, p. 693) puts it:

> it may be important to understand the effect of events on the state of an entity (a variable) or to identify the effect of a contextual variable on the state of an entity on the evolution of events. Process research may also deal with the evolution of relationships between people or with the cognitions and emotions of individuals as they interpret and react to events.

Eminent theorists agree and explain that the best theories are often hybrids between variance and process (DiMaggio 1995). Accordingly, if the phenomenon of interest has elements of both variance and process, it follows that great value can be gained by combining them. This provides the “ability to address different, and more complex, research questions that those posed earlier” (Sabherwal and Robey 1995, p. 38). The promise is that these research questions, by containing elements of both approaches, would be practically relevant, and if so, could help lessen the existing gap between IS-related practices and academic research (Benbasat and Zmud 1999).

Another reason for combining both approaches is that such combination can bring collaboration to IS research across different approaches and researchers. Such research would benefit from collaborations from variance and quantitative method experts as well as from process and qualitative experts. Furthermore, recent advances in and introduction of new neuroscientific tools to the field necessitate hybrid approaches. Most neuroscientific tools - such as electroencephalograms (EEG), electrocardiograms (EKG), galvanic skin response (GSR), facial expression recognition software, and eye-tracking – have the capability of capturing phenomena (ex., neural activity within the cerebral cortex) over time in the range of milliseconds (Dimoka et al. 2012). With this type of research, we use tools that address the time dimension in a quantitative way and thus we need to deal with this time dimension using a hybrid approach.

Finally, the flexibility of hybrid approaches to conduct studies that combine different sources of data and methods has an additional benefit for research: the reduction of the likelihood of mono-method bias, priming, and consistency artifacts (Podsakoff et al. 2003; Salancik 1984). Furthermore, the combination of different methods has synergistic properties and thus, different methods complement each other by compensating for the weakness of one with the strengths of the other (Jick 1979).

**Discussion and Conclusion**

While the discussion above explains the reasons behind adopting blended hybrid approaches, an approach is only useful if it is capable of valuably addressing important research questions. Given the fact that phenomena in the IS field have characteristics of both variance and process approaches, we believe that hybrid approaches hold promise for addressing important and complex research questions in our field.

Hybrids are particularly suited for addressing research questions that tackle notions of change (Van de Ven and Poole 2005). Thus, hybrids can address research questions that include the study of processes over time along with their impacts on a given outcome. Or, efforts can be aimed at investigating events that trigger certain changes in states or outcomes. Researchers can also follow time series where states are seeing as processes that change as a result of particular interventions. Or, they can focus on explaining the processes that are involved in transforming antecedents into outcomes. Overall, research questions that
include time, as well as elements of antecedents, impacts, events, and processes, can be better approached from a hybrid perspective.

Many recent calls for research arising from different domains of IS contain fundamentally hybrid ideas. At the individual level, researchers have urged studies on how users attain an effective use of a system over time and how such evolution affects their work-related task performance (Burton-Jones and Grange 2013). Others have suggested that efforts are needed to investigate how and when users employ IT in reflective and non-reflective ways as well as the situations and events capable of triggering periods of reflective use that disrupt non-reflective use states (Jasperson et al. 2005). Researchers have also encouraged studies of hidden or unconscious processes that relate to system adoption and use, including the evolution of emotional states and habits (Dimoka et al. 2012; Dimoka et al. 2011). Others have proposed investigating how technological events (e.g., receiving emails, use of new features) trigger different neural processes (Léger et al. forthcoming).

With respect to the group level, there are numerous avenues for hybrid research into virtual teams. For example, there have been calls for research into the identification of the socio-economic and task-related processes involved in mediating virtual teams' inputs into outputs (Martins 2004; Powell et al. 2004). Research is also needed to study how geographic dispersion - conceived as a multidimensional construct - impacts coordination processes in virtual teams (O’Leary and Cummings 2007). Research has also highlighted the importance of time in virtual teams’ development and outcomes (Ortiz de Guinea et al. 2012), with calls for research focusing on investigating the impact of knowledge coordination processes on virtual teams’ performance over time (Kanawatthanachai and Yoo 2008).

At the organizational level, research questions could be addressed in a number of different topics. With respect to governance, researchers have called for more investigations on the new organization logic that comes with pervasive digitization (Yoo et al. 2010). For example, researchers could study how firms strategically control their digital products, how such controls evolve over time, and whether such controls are effective (Yoo et al. 2010). In terms of the emerging and critical area of green IT (Mines 2008), hybrid approaches are in a privileged position to advance our knowledge on how “information systems [can] be used to change social norms to increase energy efficiency” p. 30 (Watson et al. 2010) and how organizational green IT strategies can initiate the process of adopting and implementing more green IT (Jenkin et al. 2011). In the strategy area, research could focus on how technological and business characteristics influence the process of value creation (Pagani 2013).

Hybrid approaches can also be useful in addressing research questions implying a mixed-level approach. One promising area of study is the linking of micro processes that occur for individual-level IT use and macro outcomes at the organizational level (Jasperson et al. 2005). Such research would address a long-suspected reason for the productivity paradox (Brynjolfsson 1993): that low-level processes, such as employees’ everyday behaviors with IT, are critical in linking organizational IS investments with organizational performance (Barua et al. 1995; Barua and Mukhopadhyay 2000). Other possibilities exist, such as studying how IT affects organizational sensing of rapidly changing environments and thus, organizations’ overall strategies (Drnevich and Croson 2013).

One of the difficulties we can foresee with ‘blended’ hybrids, however, is that the approach may become more difficult to apply for multi-level research (for example, groups, departments, and organizations). For instance, when researching organizational entities and concepts we may need to specify their compositional or compilational characteristics in order to differentiate them from lower level entities and concepts (Rousseau 1985). As more high-level elements become part of a multi-level research study, the causality can become more complex and the operationalizations of entities become more challenging (Klein et al. 1994).

We should clarify that we do not advocate for the exclusive application of ‘blended’ hybrid approaches. Rather, the research questions should drive which approach to adopt. In contrast, our objectives are more humble: a) to point to the fact that variance and process approaches share certain similarities, b) to provide a first tool box to start building coherent blended hybrid models, and c) to call attention to hybrid approaches that hold the promise to address some critical research questions that each approach alone (variance or process) cannot.
All in all, although some researchers advocate for the separation of variance and process approaches for IS research, our paper provides arguments for why variance and process are more similar than might be expected. More importantly, we provide a first toolkit for combining the approaches into 'blended' hybrids. Our hope is that this paper sparks future research efforts that will contribute to the IS field by answering critical research questions that could not be addressed by either approach alone.

References


