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Virtual reality and its impact on B2B marketing: A value-in-use perspective

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ABSTRACT

The opportunities virtual reality provides for B2B marketing are increasingly recognized by the trade press in discussions of interesting examples from early adopters like GE, Siemens and Airbus. However, while there is growing recognition of its promise and potential, the specific impact of virtual reality on B2B marketing remains an unexplored research area. This paper provides an early theoretical consideration of the topic by developing a framework and offering propositions that describe the impact of virtual reality on B2B buyer perceptions of value-in-use during the post-purchase stage of the buyer's purchase journey. The paper also considers the moderating impact of several aspects of buyer-supplier relationships, including knowledge complexity, social complexity and task complexity, on virtual reality's contribution to value-in-use perceptions. The discussion provides B2B marketing scholars with several directions for future research and makes several recommendations for B2B marketers interested in leveraging the opportunities presented by virtual reality.

1. Introduction

The recent development and penetration of new media fundamentally changed the way we think about products, brands, partnerships and buyer relationship management (Batra & Keller, 2016). In response to these trends, many companies have developed substantially enhanced digital capabilities, skills and practices, in order to remain relevant and competitive in the market. For instance, firms nowadays are expected to establish and maintain their presence on social networking sites (SNSs) in order to enhance buyer engagement and interaction with their products and brands (Barreda, Bilgihan, Nusair, & Okumus, 2015). Yet according to a recent report based on in-depth interviews with marketing leaders, success in the future will require even more aggressive moves and profound digital transformations if firms are to remain competitive (Schwartz, Burgess, & Rousselet, 2017). One of these key transformations will entail harnessing the marketing opportunities presented by virtual reality, hereafter referred to as VR (Silverberg, 2016).

Imagine being a construction company and being able to provide healthcare professionals with the ability to walk through a future hospital before construction even begins. Or being a manufacturer of medical equipment and providing physicians with the ability to access a realistic recreation of the human body or any organ within it using any desirable scale in preparation for using your product. Or being a member of a team of engineers and being able to visit and provide key services to a power plant buyer in Libya during the Civil War from your secure Berlin-based expert center location. Perhaps unimaginable a few decades ago, these examples are nowadays very real and contemporary. Hospitals are being designed based on early stakeholder input via an effective collaboration between software companies and construction agencies (DIRTT Environmental Solutions Ltd, 2017; Maddox, 2015). Thanks to a pair of talented and imaginative GE Healthcare designers, combining VR tools and other gaming software, and leveraging information from a large set of CT and MRI body scans, it is now possible for physicians to walk into a virtual room that could resemble a patient's brain (Kloberdanz, 2017). Finally, the power plant example comes from Siemens, who – after having developed the prototype used for the purposes of a Libyan power plant – has made substantial advancements and is now using the technology to establish efficient cooperation remotely between its engineering centers and its buyers' offshore power plant control rooms (Siemens, 2018).

Although the above instances draw on organizations that can be viewed as early adopters and thus leading the way in terms of exploiting VR technology, projections about the impact of VR in B2B markets are quite optimistic, and many organizations at different stages of diffusion are expected to follow suit. For instance, a report commissioned by The Goldman Sachs Group (2016) estimates the combined VR and augmented reality (AR) market to reach between $80B to

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$182B in market size by 2025, with sales distributed across both B2C and B2B sectors. In fact, in a recent assessment commissioned by the global network ABI Research to examine the VR technology penetration in a group of US-based companies, results revealed that 85% of firms were considering adoption of virtual reality (Deans, 2017).

These examples clearly illustrate the growing importance of VR to B2B marketing. Yet while most marketing experts look forward to the next 10 years of VR evolution with high hopes and anticipation, there are no clear guidelines as to how organizations may successfully integrate VR into their marketing mix, nor is there a collective understanding as to how VR technology may help B2B companies deliver value to their buyers. A key reason for the lack of B2B insight is that the extant literature has focused on VR in marketing from a largely B2C rather than B2B perspective (Piyathasanan, Mathies, Wetzels, Patterson, & de Ruyter, 2015; Wang, Ting, & Wu, 2013; Yoo, Peña, & Drumwright, 2015). The extent to which this body of existing VR research may be applied to a B2B context may be limited given important differences that exist between B2B and B2C markets in relation to factors like technology adoption (Vakeel, Das, Udo, & Bagchi, 2017) and methods of engagement (Moore, Hopkins, & Raymond, 2013; Swani, Brown, & Milne, 2014).

The purpose of this paper is to fill this gap in the literature by expanding marketing researchers' and managers' understanding of the potential of VR in B2B marketing, and consequently provide scholars with directions for future research and assist B2B marketers in their efforts to embrace this innovative technology. Our aim is to contribute to this discourse by approaching VR from the perspective of value within a buyer-supplier relationship context. Buyers hold different expectations about value depending on their position in the purchase journey. During the pre-purchase stage, when potential suppliers and their products are being considered, buyers hold perceptions about the desired value they seek from a supplier based on expectations related to possible outcomes and the supplier's potential contribution to the desired outcomes (Flint, Woodruff, & Gardial, 2002). Alternatively, at the purchase stage, when contracts are being negotiated, buyers focus heavily on technical and legal issues related to terms of the contract and the financial costs associated with purchasing a supplier's product (Geiger, 2017). During the post-purchase stage, the buyer develops perceptions of the value-in-use associated with a supplier's product/service, which reflects upon the extent to which the product/service enables the buying firm and its employees to achieve goals related to the business and a specific task, respectively (Blut, Evanschitzky, Backhaus, Rudd, & Marck, 2016).

This paper focuses on studying VR in the context of value-in-use emerging during the post-purchase phase for several reasons. First, buyers' value-in-use experiences are often the source of more effective product promotion campaigns in B2B markets (Ruokolainen & Aarikka-Stenroos, 2016) and can positively impact B2B buyer satisfaction (Raja, Bourne, Goffin, Çakkol, & Martinez, 2013). As such, considering value-in-use will provide insight into an important means by which VR potentially will impact B2B marketing success – particularly during the initial period of increasing yet still relatively low levels of penetration. Second, the integration of buyer and supplier resources underlying value-in-use perceptions reflects a co-creation process that is not as prevalent in determining other forms of value in B2B markets, and this allows the paper to expand marketers' understanding of VR in a nascent but emerging area of marketing research (Merz, Zarantonello, & Grappi, 2018; Ranjan & Read, 2016). Third, the value-in-use buyers experience provides an important form of social proof that can be used by B2B marketers as references when acquiring new buyers (Kumar, Petersen, & Leone, 2013). This point is particularly important during the early stages of VR penetration when many buying firms have limited prior exposure to and understanding of what the technology can do for them. Fourth, through the co-creation process associated with value-in-use, relational ties between a buyer and a supplier develop that can serve as an important switching cost limiting turnover (Blut et al., 2016).

The paper begins with a discussion of VR and identifies certain key characteristics that are relevant from a B2B marketing standpoint. The paper then discusses value-in-use, building on recent research suggesting that a key driver underlying value-in-use perceptions in B2B markets comes from the quality of the process by which supplier and buyer resource integration is coordinated and assets are managed during the buyer's adoption and usage of a supplier's solution (i.e., product/service) (Macdonald, Kleinaltenkamp, & Wilson, 2016; Macdonald, Wilson, Martinez, & Toossi, 2011). The paper draws on this conceptual discussion to develop several propositions relating VR to B2B value-in-use and identifies relational factors expected to moderate the impact of VR. The article concludes by discussing the implications of the proposed framework to inform future research and marketing practice.

2. VR and its relevance for B2B marketing

Organizations have witnessed substantial changes in recent decades due to the extent of digitalization and increase in innovative potential. While most firms have a strategy that incorporates Web 2.0 platforms into their marketing mix (Batra & Keller, 2016), practices regarding the use of VR are not as crystallized. In the past, the infrastructural and computational demands presented potential entrants with severe limitations (Brooks, 1999; Nazir & Lui, 2016). With substantial recent technological advancements, together with the launch of several commercial VR head-mounted devices, such as Google Cardboard, Microsoft HoloLens and Oculus Rift, these limitations are increasingly phasing out, enabling businesses to exploit and embrace the creative potential underlying this innovative technology (Carr, 2016; Scroxton, 2016).

Early work by Sutherland (1970) envisioned VR as a model of the real world that is maintained in real-time, sounds and feels real, and which the user can manipulate directly and realistically. During the past two decades, VR conceptualizations evolved from being overly technical and focusing predominantly on hardware and software requirements (Gold, 1993; Greenbaum, 1992), moving toward adopting a more experiential perspective that emphasizes the user and the interactive environment (Biocca, 1992; Brooks, 1999; Schuemie, van der Straaten, Krijn, & van der Mast, 2001). There are several important features that not only distinguish VR-enhanced applications from other technologies like social media platforms and augmented reality, but also underpin their relevance for purposes of buyer-supplier relationship management (Shabbir, Ghazi, & Mehmood, 2016; Zhang, Trusov, Stephen, & Jamal, 2017).

In general, VR applications capture three-dimensional, computer-generated spaces that enable vivid and multi-sensory experiences within rich media settings (Coyle & Thorson, 2001; Klein, 2003; Whyte, 2003). While these features are essential to ensure a certain type of engagement, they serve more of a background role to differentiate VR-based solutions from other innovative technologies. At the same time, there are certain characteristics of VR applications that are particularly prevalent from a B2B marketing perspective; including immersion, interactivity, and the ability to enact real-time engagements. These attributes will be illustrated throughout the manuscript using various examples. Although these characteristics tend to co-exist and in combination deliver optimal technological solutions, in the following section we present a brief overview and illustrate each one with examples that emphasize the importance of the given attribute to B2B marketing. Furthermore, we argue that companies are likely to vary in the extent to which they leverage the interactive, immersive and real-time features of VR and will use the examples to support a model that assists organizations in identifying their own needs and reasons for engagement in VR-enhanced endeavors.

2.1. VR applications as immersive platforms

Brooks (1999) described VR experience as an encounter in which "the user is effectively immersed in a responsive virtual world" (p.16) in a way that allows a dynamic control over his or her viewpoint. Berg and Vance (2016) expanded upon this by positioning VR – also referred to as immersive computing technology (ICT) – as a "set of technologies that enable people to immersively experience a world beyond reality" (p.1) and engage in human encounters that mimic their own interpretation of the world around them. Immersive platforms are important in that they elicit greater enjoyment (Hershfield, 2011), higher psychological ownership (Y. Lee & Chen, 2011), enhanced experience of presence and flow (Nah, Eschenbrenner, & DeWester, 2011), heightened attention and concentration (Sacks, Perlman, & Barak, 2013), and – particularly in comparison to simpler forms of 2D media – a greater sense of *realness* (Sun Joo & Bailenson, 2011). Often referred to by the technical term *telepresence* (Coyle & Thorson, 2001), users of VR applications can bring upon a "simulated perception of direct experience" (p. 66).

In numerous B2B relationships, immersion is particularly important to re-create engagements that mimic reality to the greatest possible extent. Neha Prajapat, leader of a team of engineers at GE, emphasizes the benefits of VR with respect to immersion in the following manner: "If you had a model of the room you're in right now on your computer screen and were somewhere else, do you think you would be able to understand the nuances, subtleties and even general characteristics better from looking on the computer screen than you would being in the room itself?" (Wheeler, 2016). Another GE representative, Katrina Craigwell, Director of global content and programming elaborates on her views regarding VR-enhanced solutions: "VR is another part of the puzzle for us in terms of opening up the world of GE and doing it through visual storytelling. […] The more we can show rather than tell, the better we do" (Maddox, 2015). By using immersive platforms, buyers can learn about relevant product and service solutions in a way that enables suppliers to communicate their value differentiation, overcoming a frequent challenge for B2B marketers (Finn, 2018).

As a concrete example, Honeywell introduced a cloud-based simulation 'Honeywell Connected Plant's Skills Insight Immersive Competency tool', in response to their anticipated upcoming shortage of trained staff due to their foreseeable retirement (Honewell International Inc, 2018). This initiative combined different VR solutions to train plant personnel in a contemporary and sustainable fashion. Without the technology it would be more difficult to support buyers during the post-purchase phase of the B2B buying journey when Honeywell uses its employees to assist buyers adopt its products into their operations.

Similar training-based and educational uses of VR technology can be found in the pharmaceutical industry, where buyers and company representatives can use these media to gain first-hand exposure to specialized and complex medical procedures like spinal fusion or hip fracture surgery via shared live VR-enhanced applications (Pacira Pharmaceuticals Inc., 2017a, 2017b). Another illustrative example comes from the hospital design scenario mentioned above, where doctors, nurses and other key stakeholders are given the opportunity to walk through the future hospital and comment on its layout and logistical realities while modifications are still feasible (Maddox, 2015). As Mogens Falk Smed, Co-founder, CEO and Director of DIRTT Environmental Solutions, Inc. emphasized during an interview: "Well, they're here now walking through their whole space. They see exactly what it is. It completely changes the experience for the contractor, the architect and the client. So we're continuing to invest in that area" (DIRTT Environmental Solutions Ltd, 2017).

Along these lines, Airbus has invested extensively in VR solutions to inform various aspects of cabin design by leveraging buyers' virtual experience, and to use flight simulators to train future pilots (Marcellin, 2016). An insightful quote by Thomas Hirschmann, partner at the B2B-oriented virtual design studio *The Third Fate* explains: "Architecture isn't like procuring a photocopier. There are often multiple stakeholders across multiple departments, and even across the community. There is the ability with VR to help pass on your concept not only to the client, but to get stakeholder engagement. […] A render in architecture always looks a little fake – or a lot fake. Virtual reality allows people to have a better understanding of things like scale, movement and flows" (Maddox, 2015). This ability to support immersive experiences between multiple stakeholders is key in B2B markets where buyer-supplier engagement often occurs within and across groups and networks of stakeholders (Anderson, Håkansson, & Johanson, 1994; Johnston & Bonoma, 1981).

2.2. VR applications in support of interactive experiences

From the perspective of interactivity, it is important to emphasize that VR contexts are dynamic and responsive settings that give users a sense of control and incorporation of their viewpoint (Berg & Vance, 2016; Brooks, 1999), which in turn foster advanced cognitive responses (Kavanagh, Luxton-Reilly, Wuensche, & Plimmer, 2017; Klein, 2003). VR encounters entail two forms of interactivity. On the one hand, users interact with the environment in a way that provides immediate feedback, which is advantageous to reinforce connectivity (Bhatt, 2004) and prolonged user involvement (Bekkering & Rose, 2003). On the other hand, users have the ability to interact with other relevant stakeholders, which tends to foster information sharing, processing efficiency and collaborative learning (Coyle & Thorson, 2001; Mazursky & Vinitzky, 2005).

B2B exchange relationships can benefit from both types of interactivity in various ways. In their overview of best practices and pitfalls associated with virtual experimentation and simulation, Sommer and Moskowitz (2016) emphasize certain key advantages that enable new ways of working in R&D efforts, "in part by allowing faster and more thorough experimentation and testing, minimizing physical product test failure, enabling co-creation with buyers, and supporting cross-discipline integration" (p. 12). A good example comes from Kimberly-Clark's Innovation Design Studio with its integrated VR system, whose primary aim is to invite its retail buyers and their staff to collaboratively engage in innovation and new product development. As emphasized by company representatives, these initiatives are crucial in that they foster product innovation with buyers from the idea stage all the way through testing and execution, without having to invest time and resources to construct physical mock-ups (Kimberly-Clark, 2007).

Returning to the earlier example illustrating the use of VR-solutions to gain on-site experience with complex surgical procedures, Pacira Pharmaceuticals developed the product EXPAREL that provides an innovative alternative to non-opioid local analgesic to assist with post-surgical pain control, and also simultaneously launched a new virtual training engine to provide healthcare professionals guidance and experience with effectively administering the product. In order to gain advanced understanding of the post knee-replacement surgical context using the assistance of an application that can be accessed from the convenience of a smartphone or iPad, clinicians are able to manipulate "the exposure and angle of the knee, the angle of the syringe, the location of the injections, and the amount of volume distributed throughout the surgical site (Pacira Pharmaceuticals, 2016)." This demonstrates the form and extent of context-based interactive learning opportunity between supplier and buyer that would be impossible without this innovative technology (Kavanagh et al., 2017).

In general, the example of Pacira provides a good illustration for demonstrating several areas of uniqueness that are inherent in VR applications. First, VR applications can be beneficial at different stages of the buyer purchase journey, as evidenced by the pre-purchase educational and post-purchase surgical uses of the Pacira VR app. Furthermore, this example supports the notion that VR applications can simultaneously cater to a unique combination of stakeholders, which in

this case may include surgeons, clinicians, nurses, training personnel, and ultimately patients. Finally, this is a particularly good illustration to demonstrate the two types of interactions in VR settings. On the one hand, users may interact with other stakeholders, as would be the case during the surgery that is shared via live VR-enhanced solutions. On the other hand, users may interact with the environment when experimenting with the post-surgical analgesic administration in a way that helps their learning and overall proficiency in using Pacira's products.

2.3. VR applications foster real-time encounters

A particularly important characteristic of VR encounters is that they occur in real time and thus do not entail a delay in responsiveness. Users as well as relevant stakeholders receive immediate feedback, which is important for various reasons. As representatives at DIRTT Environmental Solutions Ltd. note (DIRTT Environmental Solutions Ltd, 2017), "the whole VR experience is so important for us because a lot of our clients […] they're in different parts of the world, you know what I mean? They can't all come into one place to experience what the space is like. And by being able to take these – wear these goggles […] they're able to, we're able to talk to them in real time of what their whole place is going to look like". Similar solutions are exploited by GE that enable their engineers to receive instantaneous feedback on design decisions. This is important not only to minimize work but also to reduce the costs associated with collaboration between buyer and supplier (Wheeler, 2016).

It is informative to revisit the Siemens example from above that illustrates the importance of the real-time feature well (Siemens, 2018). Recognizing the special needs of stakeholders, the primary aim for Siemens to incorporate VR was to optimize the maintenance programs made available to offshore platforms; platforms that often are subjected to extreme conditions and temperatures given their situation at great distance from the shoreline. The benefits include reduction in costs, personnel time and unnecessary and inconvenient delays. Traditionally, an expert would need to visit the site, should a problem arise, which may take two to three days without this technological solution. Using their special helmet, experts can be connected to the buyer site in a matter of minutes and engage in a real-time dialogue with offsite staff. As an additional advantage, training time using this technology can be reduced to 45 min from the two to three days that used to be common in the past, not to mention the logistical challenges of scheduling everyone in the same place at the same time. These examples demonstrate that the three key features of VR are beneficial for business marketers in supporting their exchange relationships with buying firms during the pre-purchase, purchase, and post-purchase stages of the buyer journey.

3. VR and value-in-use perceptions in B2B exchange relationships

The previous section outlined a series of examples demonstrating the use of VR-enhanced solutions throughout the buyer purchase journey. The remaining part of the paper will focus specifically on the post-purchase value-in-use aspects of B2B engagements and the contribution of applying VR-based solutions at this stage of the buyer purchase journey. During the post-purchase phase of the buyer purchase journey, the buyer develops perceptions of the value-in-use associated with a supplier's product/service, which reflects upon the extent to which the product/service enables the buying firm and/or its employees to achieve goals related to the business in general, and/or to the performance of a specific task (Blut et al., 2016). In their recent in-depth analysis of the value-in-use process, Macdonald et al. (2016) demonstrated that buyer value-in-use perceptions vary as a function of coordination and asset management effectiveness occurring between buyer and supplier in support of a buyer's use of a supplier's solution. As such, we focus attention on coordination and asset management effectiveness in developing propositions that capture the expected impact of VR on buyers' perceptions of value-in-use.

3.1. Coordination effectiveness

Coordination effectiveness represents the "extent to which the processes of supplier-buyer interaction act to integrate resources for the customer's benefit" (Macdonald et al., 2016, p. 106). Furthermore, this aspect of the buyer-supplier relationship depends upon how the flow of information is coordinated between buyer and supplier. An effective flow of information between buyer and supplier requires a collaborative approach to communication involving extensive information sharing between parties (Mohr, Fisher, & Nevin, 1996).

VR can support collaborative information sharing and contribute to more effective coordination at both a dyadic and network level in a buyer-supplier relationship. At a dyadic level, it can improve coordination between a buyer and supplier by allowing the firms to experiment and simulate possible approaches to coordination (Sommer & Moskowitz, 2016). Kimberly-Clarke (Kimberly-Clark, 2007), for instance, opened a design studio and used VR to help its retail buyers acquire insight into how retail customers would react to different display formats. This use of VR allowed Kimberly-Clarke and its buyers to visualize in ways not possible with previous technology and use these insights toward enhancing their collaboration, contributing to retailer success selling Kimberly-Clarke products. From a value-in-use perspective, this use of VR allows Kimberly-Clarke's buyers to save time and costs typically associated with creating physical mock-ups of store layouts and displays. According to Ramin Eivaz, Vice President of North Atlantic Insight, Strategy and Growth for K-C, "By engaging ourselves and our buyers in this virtual world, we can spark better ideas to improve the shopping experience and collaborate on new product concepts and innovations" (Kimberly-Clark, 2007). This type of customized deployment is important to buying firms as it represents an activity buyers expect from a supplier (Tuli, Kohli, & Bharadwaj, 2007).

B2B exchange relationships are also typically embedded within a network of exchange relationships that serve to support and enhance coordination between a buyer and supplier. For example, construction firms have their buyers for whom they are constructing a building, but their buyers also have third-party stakeholders like architects and building code inspectors who must be incorporated into decisions. VR can aid in managing the flow of information between architects and other stakeholders more effectively, by allowing them to create visualizations and rendering of buildings that can be shared with other stakeholders in acquiring their approval. As a specific example, Turner Construction Co. builds hospitals for its buyers. By employing VR technology, the company can assess usability with its buyers who can then use the results to get approval from doctors and nurses who will be working in the hospital (Maddox, 2015).

Based on VR's ability to support collaborative information sharing between a buyer and supplier and the network of stakeholders within which their exchange relationship is embedded, B2B marketers can expect VR to nurture more effective coordination, as shown in Fig. 1. The following proposition expresses this expectation more formally:

P1. *The post-purchase use of virtual reality in B2B exchange relationships enhances buyer-supplier coordination effectiveness, leading to higher buyer perceptions of value-in-use.*

3.2. Asset management effectiveness

A second feature of buyer-supplier exchange relationships that is critical to generating higher value-in-use is asset management effectiveness. Macdonald et al. (2016) define asset management effectiveness as the "extent to which the resource integration processes fulfill the tasks of purchasing, maintaining, using, and disposing of physical assets for the customer's benefit" (p. 107). VR can aid in the performance of several of these tasks in relation to goal achievement at both a collective and individual goal perspective. Collective goals refer to a firm's objectives while individual goals refer to the goals of the individuals

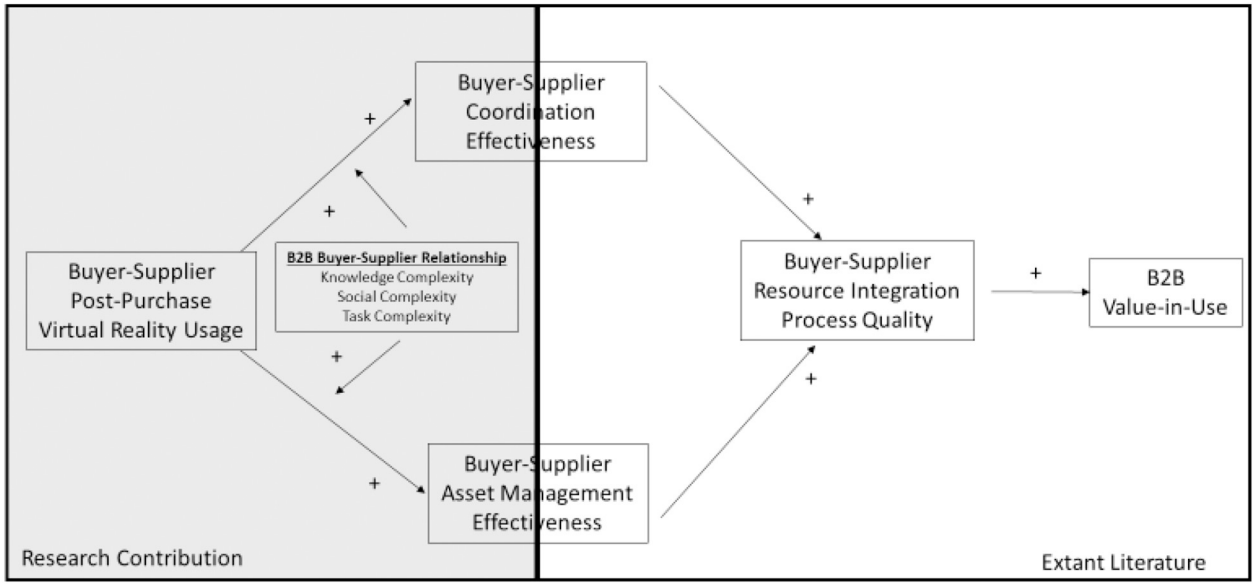

Fig. 1. Virtual reality and B2B value-in-use.

who are responsible for using a supplier's product in performing the tasks associated with asset management.

Purchasing tasks can include assessment and certification of suppliers and coordination of production plans (Rodríguez-Escobar & González-Benito, 2015). VR can aid in the performance of these purchasing-related tasks. As an example, Jen-Hsun Huang, President and CEO of Nvidia Corporation, described how an important use of VR by Nvidia involved "being able to see and experience a product in VR before you manufacture it. And so whether you're designing a building or designing a car or creating a showroom, the ability to be able to put it on VR and experience it before you build it is quite an extraordinary benefit" (NVIDIA Corp, 2015). Similarly, suppliers serving the pharmaceutical industry where massive machinery is sold are using VR to enable buying firms to assess machinery and experience how the machinery will be installed in the buying firm's plant prior to production (Maddox, 2015). The employment of VR in this way addresses buyers' expectations that supplier's will expend effort toward defining buyer requirements and incorporating them into the supplier's solution (Tuli et al., 2007).

VR can also aid buying firms in using a supplier's offering. Pacira Pharmaceuticals, for instance, uses VR to create training programs associated with its surgical product EXPAREL. The VR-based educational experiences ensure that their buyers' employees are kept current with best surgical practices related to the types of surgeries and to EXPAREL, including spinal fusion, hip fracture and shoulder arthroplasty surgery (Pacira Pharmaceuticals Inc., 2017a). There is also the example of Honeywell discussed earlier whereby the company is using VR to enhance the skills of its own engineering staff and that of buyers so that they can more effectively support buyer use of Honeywell products (Honewell International Inc, 2018). The paper also previously reviewed Kimberly Clarke's use of VR to help buyers implement store design changes that allow the buyer to more effectively sell Kimberly-Clarke products. Buyers expect these types of post-deployment support activities (Tuli et al., 2007), and VR provides one way of meeting these expectations.

The performance of maintenance tasks also impacts asset management effectiveness. Maintenance tasks involve limiting downtime and disruptions that can limit buyer usage of a supplier's solution (Alabdulkarim, Ball, & Tiwari, 2015). The Siemens case discussed earlier whereby it offers maintenance to buyers in war-torn countries provides an excellent example of how VR can enhance maintenance-related tasks.

As suggested by the previous discussion and as shown in the left-hand shaded portion of Fig. 1, VR usage can lead to higher asset management effectiveness. The combination of these above arguments and supportive examples provide the basis for the following proposition connecting post-purchase VR usage with B2B buyer-supplier asset management effectiveness:

P2. *The post-purchase use of virtual reality in B2B exchange relationships enhances buyer-supplier asset management effectiveness, leading to higher buyer perceptions of value-in-use.*

4. The moderating impact of buyer-supplier relationship complexity

B2B exchange relationships can vary significantly from being transaction-based exchange relationships involving limited and autonomous actions by buyer and supplier to being more complex relationships involving high levels of interaction and interdependence between buyer and supplier (Dwyer, Schurr, & Oh, 1987). We expect the contribution of VR toward value-in-use perceptions to be greater in B2B exchange relationships characterized as more complex because these types of relationships provide more opportunity for the relationship to benefit from the interactive, immersive, and real-time features of VR discussed earlier. The following discussion considers the potential impact of three aspects of buyer-supplier relationship complexity, along with their moderating effect over the influence of VR on coordination and asset management effectiveness underlying buyer perceptions of value-in-use. The three complexity factors considered include knowledge complexity, social complexity, and task complexity, and were chosen based on their relevance to B2B exchange relationships and potential impact of VR (Chao, Wu, Yau, Feng, & Tseng, 2017).

4.1. B2B buyer-supplier relationship task complexity

Task complexity describes the extent to which multiple actors perform interdependent actions in pursuit of a common goal (Haerem, Pentland, & Miller, 2015). Coordination and asset management between a buyer and supplier can vary in their degree of task complexity based on the number of individuals and interdependent nature of the work they perform in these two key areas associated with value-in-use. As discussed earlier, B2B exchange relationships often involve the use of VR to perform complex tasks incorporating different stakeholders,

skillsets and geographic locations. Pacira Pharmaceuticals' use of VR to train buyers on the use of its Exparel products provides a good example of VR's use in high task complexity situations. The training focuses on multiple types of surgery like spinal fusion, hip fracture and shoulder arthroplasty that bring individuals with multiple specialties together for training. The training also includes physicians and nurses who typically are positioned at different levels of hierarchy within a surgical team. In comparison, a low level of task complexity would involve a single individual autonomously completing a re-order purchasing task via a VR environment.

VR can be especially beneficial in buyer-supplier relationships characterized by high task complexity for several reasons. First, the more complex the task, the more sophisticated coordination and asset management tends to be, making standardization difficult in the buyer-supplier exchange relationship (Narayanan, Jayaraman, Luo, & Swaminathan, 2011). The low degree of standardization requires a high level of involvement between buyer and supplier when performing complex tasks. The high degree of immersion made possible by VR technology can be especially beneficial in this respect (Li-Ting, Chen-An, Kai, & Cheng-Kiang, 2011).

Second, the real-time nature of VR can also be important in exchange relationships involving high task complexity. The energy industry provides a good example for this, where facilities are dispersed offshore and have complicated infrastructures and equipment. VR-technology allows companies to overcome temporal and spatial constraints while also limiting risks and safety hazards to personnel as well as equipment (Blümel, Termath, & Haase, 2009). More specifically, technicians, who often have never visited the buyer's site, can use VR to explore the intricate workings of a buyer's equipment and facility layout to identify issues and create response plans that can be used by personnel at the buyer site in real-time without delays associated with travel and diagnosis (Harrison, 2017).

The following proposition communicates our expectation regarding the moderating effect of task complexity:

P3. *The positive effect of post-purchase virtual reality usage on (a) buyer-supplier coordination effectiveness and (b) buyer-supplier asset management effectiveness will be greater in buyer-supplier relationships characterized by higher task complexity*.

4.2. B2B buyer-supplier relationship social complexity

B2B exchange relationships can be described as socially complex to the extent that individuals within a buyer and supplier perform multiple roles and possess an array of personal relationships with others within and across each firm (Coff, 1997). Social complexity is an inherent characteristic of post-purchase product usage contributing to value-in-use perceptions. For instance, the usage center associated with using a product, and contributing to asset management effectiveness, will often consist of individuals from different functional areas and different hierarchical levels (Macdonald et al., 2016).

As social complexity increases, the interactive requirements associated with buyer-supplier coordination and asset management also increases to incorporate a variety of relevant parties. As an illustration, we can consider Kimberly Clarke's Innovation Design Studio, where the exchange relationship involved buyers and staff collaboratively producing innovative design options. The interactive nature of VR is seen as key to supporting this level of social complexity (Kimberly-Clark, 2007). The ability of VR to support higher social complexity can also be seen in cases like DIRTT's interactive design initiative (DIRTT Environmental Solutions Ltd, 2017) or Siemens' offshore platform maintenance system (Siemens, 2018), where users do not only interact with the VR environment but also with several stakeholders within and across both firms. Additionally, the real-time nature of VR is also important to supporting social complexity because it allows for more accurate prediction of performance and achieve decision outcomes that enhance the efficiency of coordination and asset management (Sommer & Moskowitz, 2016).

The immersive nature of VR is essential in socially complex situations. For instance, VR immersion can incorporate multiple sensorial channels (Berg & Vance, 2016) and elicit a sense of presence or “the feeling of actually being in another place” (p. 55) above and beyond what was made available in 2D and simpler 3D platforms (Gronstedt, 2016). Correspondingly, an increasing number of studies explore multisensory online experiences that capture heightened imagery and auditory elements along with olfactory and touch-based sensations (Carulli, Bordegoni, & Cugini, 2016; Li, Daugherty, & Biocca, 2002; Nelson & Bolia, 2002). Prior research also suggests the interpersonal interactions occurring within VR can further enhance the immersive nature of online experiences (Li-Ting et al., 2011). One possible explanation for the higher sense of immersion comes from research that establishes a positive connection between social interactions and arousal (Inderbitzin et al., 2013), which in turn may have a further positive impact on sensitivity to VR environments (Yeh, Wang, Li, & Lin, 2017).

Ultimately, VR and the opportunity it offers for interactivity, immersion and real-time should be more beneficial in B2B exchange relationships characterized by higher social complexity. The following proposition communicates our expectation regarding the moderating effect of social complexity:

P4. *The positive effect of post-purchase virtual reality usage on (a) buyer-supplier coordination effectiveness and (b) buyer-supplier asset management effectiveness will be greater in buyer-supplier relationships characterized by higher social complexity*.

4.3. B2B buyer-supplier relationship knowledge complexity

Knowledge complexity reflects the degree to which the information involved in a task is diverse (Kim, Im, & Slater, 2013). A buyer and supplier might, for instance, seek to share buyer, competitor, and technological knowledge in order to identify innovative uses and/or outcomes for a supplier's product/service (Pérez-Luño, Medina, Lavado, & Rodríguez, 2011). Alternatively, knowledge complexity may be high (low) because the information shared between buyer and supplier is more tacit (codified) (Pérez-Luño et al., 2011). Consider the case of a construction company like Turner Construction Co., builder of hospitals for its buyers. As mentioned previously, the company uses VR to allow stakeholders like hospital administrators, doctors, and nurses to experience a proposed hospital design as a means of allowing them to provide feedback on the proposed design (Maddox, 2015). Coordination and asset management in this situation can focus on a very limited set of information like hallway design alone, or it can focus on multiple aspects of design like hallways, patient facilities, and operating room designs. Additionally, it may focus on the sharing of more codified information like engineering specifications or more tacit information like past building experiences.

One challenge in situations characterized by higher knowledge complexity is the need for higher and longer interaction for knowledge to be effectively shared (Kogut & Zander, 2003). The interactive and immersive nature of VR aligns with these requirements, suggesting the technology can best be employed in B2B exchange relationships involving higher knowledge complexity. Prior research, for example, indicates that exposing users to a wider range of information cues in the VR environment enables them to experience a more pronounced sense of presence and immersion (E.-J. Lee & Park, 2014). Greater knowledge complexity in VR usage can also trigger positive attitudes and high levels of enjoyment (Li, Daugherty, & Biocca, 2001, 2003; Yoonhyuk & Pawlowski, 2014), which in turn is likely to encourage buyers to spend more time interacting with suppliers. Along the same lines, the aesthetically appealing and vivid settings that combine pertinent physical and virtual elements provide further benefits via encouraging buyer

involvement (Wikström, Carlell, & Frostling-Henningsson, 2002).

GE is one of the early pioneers to leverage the power of VR to support B2B exchange relationships involving higher knowledge complexity. Their activities include showcasing their deep sea research center (Torres-Valderas, 2017) or training young nuclear engineers in their VR power plant to assemble and dismantle turbines (Egan, 2017). These activities involve both technical aspects of training and also the sharing of more tacit experience possessed by more senior personnel. Furthermore, there is the sharing of information on multiple topics including engineering, nuclear science, and the environment, all of which add to knowledge complexity. GE's success in using VR in this type of situation combined with the earlier theoretical discussions provides the basis for the following proposition communicating our expectation regarding the moderating effect of knowledge complexity:

P5. *The positive effect of post-purchase virtual reality usage on (a) buyer-supplier coordination effectiveness and (b) buyer-supplier asset management effectiveness will be greater in buyer-supplier relationships characterized by higher knowledge complexity*.

5. Discussion and directions for future research

The B2B literature suggests that post-purchase value in B2B exchange relationships is a complicated process based on perceptions of coordination and asset management effectiveness (Lemon & Verhoef, 2016). The current paper has provided a roadmap describing the expected impact of VR on buyers' value-in-use perceptions through its influence over the flow of information between buyer-supplier and the larger network within which their exchange relationship exists in linking VR to coordination effectiveness. It also discussed how VR can enhance performance of tasks related to asset management including purchasing, using, and maintaining the solution a supplier provides to its buyers. Examples from practice were used to highlight specific ways VR affects aspects of coordination and asset management effectiveness. The paper also identified several moderators related to the complexity of B2B exchange relationships that are expected to influence the impact of VR on value-in-use perceptions. The moderators involved task, social, and knowledge complexity characterizing buyer-supplier coordination and asset management.

Providing the roadmap is admittedly easier than empirically testing the proposed relationships. However, prior literature offers guidance for measuring several constructs identified as important. Input for measures capturing value-in-use, resource integration process quality, coordination effectiveness and asset management effectiveness are available in Macdonald et al. (2016) and Macdonald et al. (2011). Although no measures exist for the moderating factors in a VR context, extant measures for knowledge complexity (Kim et al., 2013), social complexity (Tuli, Bharadwaj, & Kohli, 2010) and task complexity (Narayanan et al., 2011) can be modified and used in testing their proposed moderating effect. Research confirming the proposed model and developing a valid and reliable measure of buyer-supplier VR usage would make an important contribution to this emerging area of marketing research.

Considering future research directions, buyer perceptions of desired value and transactional value are important at the pre-purchase and purchase stages of the buying journey, respectively, and also deserve additional attention from researchers. Research at these different stages of buyers' purchase journey will be important for B2B marketers who have begun to use VR during pre-purchase and purchase stages. Furthermore, researchers such as Eggert, Ulaga, Frow, and Payne (2018) mention that value in use is not only a function of the resources possessed by suppliers and buyers but also the resources of their customers. Research is needed that considers these additional sources of resources in terms of VR usage. Similarly, the discussion provided examples of VR supporting coordination with a buyer's and supplier's network of stakeholders. Suppliers, for instance, are using VR during the pre-purchase stage to provide potential buyers an opportunity to witness operations at their facilities from all over the globe in order to ensure buyers that a supplier is operating in a socially responsible manner (Britt, 2016). Future research is needed that considers VR and its impact at these triadic and network levels of analysis.

Similarly, suppliers are using VR at trade shows to present buyers with the opportunity to experience their product/service while being transported away from the hectic and chaotic trade show floor (Sommerfield, 2016). How does the use of VR at primarily B2B marketing events like trade shows impact perceptions of desired value pre-purchase? And, how does the use of VR during pre-purchase impact value-related expectations at post-purchase? Tuli et al. (2007), for instance, suggest buyers form their perceptions of a solution's value based on a supplier's efforts toward defining buyer requirements, customizing and integrating a solution into a buyer's business, deploying the solution, and providing post-deployment support. Does the pre-purchase use of VR and the experiences of interactivity, immersion and/or real-time activity influence buyer expectations in these areas? Research in this vein will greatly expand B2B marketers' understanding of VR's impact across the entire purchase journey, and respond to calls in the literature for a greater understanding of buyers' multiple experiences and points of engagement with suppliers (Lemon & Verhoef, 2016).

B2B marketers must also remember that buyers and suppliers utilize an increasing number of technologies. These technologies include more traditional landline telephones and desktops and more emerging technologies like smartphones and social media networks available via the internet (Burkitt-Gray, 2016). In comparison to the low-immersive environments of social media settings that impose limitations in interactive capacity and sensory richness, the perceptual complexity and high-immersive nature of 3D VR interfaces enable users to experience a sense of *realness* while being completely shielded away from the physical world (Sun Joo & Bailenson, 2011). Low- versus high-immersive experiences are likely to present encounters that are qualitatively and categorically different from one another, which is an important point for marketers to consider. Consequently, VR engagements tend to be more impactful, more immersive in the content of the meaning, and more memorable as they build engagements that have a longer trace in memory (Mbryonic.Ltd, 2016).

After considering these important differences, an important issue that remains largely unclear concerns the implications of adding VR to the overall portfolio of technology supporting B2B exchanges, and in particular to how VR may best be incorporated so that buyers experience a seamless omni-channel engagement with suppliers. For instance, B2B marketers are increasingly adopting marketing automation systems for lead generation and lead nurturing activities (Järvinen & Taiminen, 2016). How can VR be integrated with marketing automation in support if its use toward these important B2B marketing activities? Or, is VR a potential replacement for systems like marketing automation? Research in these areas will advance scholars' and managers' understanding of VR from the perspective of several important B2B marketing topics, including technological opportunism (Srinivasan, Lilien, & Rangaswamy, 2002), return on engagement (Gill, Sridhar, & Grewal, 2017), and value creation (Lilien et al., 2010).

A discussion of directions for future research related to VR usage in B2B markets would be amiss if it didn't also recognize potential drawbacks to using the technology. Although research examining the impact of this technology is still in its infancy, an emerging body of research suggests that there can be downsides to VR experiences. According to recent research, one of these concerns relates to psychological stress, linking the immersive nature of VR with the level of workload stress experienced by VR participants (Alghamdi, Regenbrecht, Hoermann, & Swain, 2017). Research into the impact of VR on stress in buyer-supplier relationships will be important particularly in light of prior research suggesting that tension may damage buyer-supplier relationships (Fang, Chang, & Peng, 2011).

The use of avatars in VR can raise additional concerns. Building on

their experimental study, Yoon and Vargas (2014) revealed that the traits of individual avatars in virtual environments not only promoted but accentuated individual behaviors aligned with the avatar, both toward prosocial and antisocial manifestations, depending on pre-determined avatar traits. A particularly interesting characteristic to note here comes from the research of van Gelder, Hershfield, and Nordgren (2013), who find that creative manipulations in VR environments are able to curtail 'delinquency' in behaviors that entail delayed future consequences even in offline settings. In a B2B buyer-supplier context, this could mean modifying current behaviors to identify more positive and mutually advantageous alternatives in light of vivid and realistic future projections. Research is needed to explore the extent to which these same effects permeate into VR usage within buyer-supplier relationships and provide opportunities for the emergence of behaviors that may be detrimental to buyer-supplier relationships, such as opportunism (Grayson & Ambler, 1999) and loss of objectivity (Mooi & Frambach, 2012). Left unchecked, these negative effects could potentially outweigh the benefits of VR in B2B exchange relationships. However, only future research will be able to clarify this possibility and connection.

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