Conceptualizing Circular Economy Performance with Non-Traditional Valuation Methods: Lessons for a Post-Pandemic Recovery

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Abstract

The circular economy (CE) has gained importance in the post-COVID-19 pandemic recovery. Businesses, while realizing the CE benefits, have challenges in justifying and evaluating the CE benefits using available performance measurement tools, specifically when considering sustainability and other non-traditional benefits. Given the rising institutional pressures for environmental and social sustainability, we argue that organizations can evaluate their CE implementation performance using non-market-based environmental goods valuation methods. Further, the effectiveness of the CE performance measurement model can be enhanced to support supply chain sustainability and resilience through an ecosystem of multi-stakeholder digital technologies that include a range of emerging technologies such as blockchain technology, the internet-of-things (IoT), artificial intelligence, remote sensing, and tracking technologies. Accordingly, a CE performance measurement model (CEPMM) is conceptualized and exemplified using seven COVID-19 disruption scenarios to provide insights that can be addressed through CE practices. Analyses and implications are presented along with areas for future research.

Keywords for Indexing: Sustainability, Circular Economy, Performance Measurement, Logistics, COVID-19, Digitization, Environmental Economics.

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1. Introduction

The COVID-19 pandemic of 2020-2021 caused many countries to temporarily shut down their economies. As countries reopened and plan for a post-COVID recovery, they are realizations that this recovery needs to address institutional concerns beyond jobs and economic issues. A key strategy is to make it a *green* recovery as espoused by international players including Europe, China and Japan, and the United States. For example, European nations believe climate change and environmental degradation are existential threats to Europe and also to the world. Europe's focus to overcome these recovery and sustainability challenges, entitled the European Green Deal, has goals to make the EU's recovery economy sustainable with no net emissions of greenhouse gases by 2050, economic growth decoupled from resource use, and no person or place left behind (European Commission, 2019). A keystone policy in the European Green Deal is to further support a circular economy (CE). Similarly, Japan launched a Circular Economy Collaboration with the World Economic Forum. The Japanese partnership brings business and government leaders together in a public-private partnership to identify focus areas, barriers, and strategies and actions to achieve a circular transition (World Economic Forum, 2021).

More recently, the United States under the Biden administration has a "build back better" transformative focus for the circular economy with a rescue plan for public health, the infrastructure, and the environment. The American Rescue Plan is a job creation plan to rebuild the US infrastructure, and improve areas including clean drinking water, create jobs, revitalize manufacturing, all in a focused approach (The American Jobs Plan, 2021). Correspondingly, the

Green New Deal (GND) in the United States calls for public policy to address climate change while improving social aims of reducing economic inequality (Friedman, 2019), an unofficial part of the post-COVID recovery.

These major recovery plans have explicitly included environmental measures to support economic improvements and focus on CE for a post-COVID-19 recovery. Similarly, justification can be made by organizations to embrace the circular economy to take advantage of these institutional shifts and can help build resiliency in organizations and their supply chains (Nandi et al., 2021a, b). Within this context, CE and its characteristics can be included within organizations and across their supply chains to better understand the institutional requirements of doing business in society (Brammer et al., 2020; Loi et al., 2021) and resource and capability pooling among firms during COVID-19 like crisis (Crick and Crick, 2020).

Although CE is gaining in popularity, not all its advantages can be justified and evaluated using standard performance measures and metrics—especially when considering various sustainability and non-traditional benefits it is afforded. Thus, a variety of environmental and multiple criteria decision tools have been used to evaluate CE (Sassanelli et al., 2019). In the green and sustainable supply chain literature, concerns have been raised about the incomplete, disparate, and many times, ineffective performance measurement systems. The consideration of non-traditional metrics and technology to support the field has been strongly recommended (Qorri et al., 2018). Similar criticisms exist for CE (Geng et al., 2019). Research is currently investigating how to integrate sustainability measures into CE as the need for new indicators has resonated with research and practitioner communities (e.g., see Alkhuzaim, et al., 2021; Kravchenko, et al., 2020). Digitization and big data elements have been recommended as important mechanisms that can contribute to the need for advancing performance measures in the CE environment (Cheng, et al., 2021). We contribute to this concern, discourse, and research.

The COVID crisis has made these issues even more prevalent as even basic accounting and performance information has been even more severely limited (Velayutham et al., 2021). Broadly, organizational processes and systems had come under great disruption during the pandemic, this issue also includes being able to gather and support traditional performance measurement, control, and accounting systems (Aidoo et al., 2021; Margherita et al., 2021). The issue of adjusting CE performance and accounting information during the COVID crisis has also extended to communities and cities (Droege et al., 2021; Parisi and Bekier, 2021).

This study provides a basic introduction to non-traditional approaches for the valuation of CE practices and provides several research directions for digitally supported performance measurement systems for sustainability in supply chains and logistics. The introduction of non-market-based valuation methods (NMVM) provides insights into the measurement of social and environmental sustainability, associated with supply chains. We expand on NMVM—the behavioral linkage approach—to help provide a more useful performance measurement perspective. To help advance the body of knowledge and practice in supply chain performance measurement, we argue that organizations can evaluate supply chain sustainability and resilience performance using a subset of environmental goods valuation techniques for their supply chains, namely NMVM. These new organizational performance evaluation methods for supply chain sustainability and resilience can be supported using multi-stakeholder digital technologies. These technologies may include a range of emerging technologies such as blockchain technology and complementary digital tools such as internet-of-things (IoT), artificial intelligence, remote sensing, and offline and online tracking technologies. We especially focus on an understudied area in organizational performance measurement which can provide a different and important perspective to value non-traditional sustainability dimensions. The underlying approaches to help develop performance measures that can be used by organizations and their supply chains for evaluating sustainability in a CE context. We will emphasize behavioral NMVM methods that may be grouped into revealed or stated preference approaches (Hervani, et al., 2017).

To exemplify and provide insights into the value of this approach and tools, we utilize actual scenarios from the COVID crisis that can be addressed through CE practices. Given that CE is still a relatively polysemous concept with contested definitions (Kirchher and Hekkert, 2017, Korhonen et al., 2018), we utilize the comprehensive ReSOLVE (REgenerate, Share, Optimise, Loop, Virtualise, and Exchange) model, that has been used in several other studies especially within the context of digitalization (Agrawal, et al., 2021; de Sousa Jabbour, 2018; Jabbour et al., 2019, Kouhizadeh, et al., 2020).

The next sections begin with a brief background on NMVM models, the ReSOLVE Model, multi-stakeholder technologies, and sustainability and performance measurement. Then we provide theoretical reasonings for integrating these tools and methods. A framework and methodological description of how the framework was formed is then be presented. We provide a populated framework that brings together the concepts. Analyses and implications are presented in the penultimate section, followed by conclusions.

2. Theoretical Background: Organizational Theories, Circular Economy, Non-Market-based Valuation Methods and Multi-Stakeholder Digital Ecosystem

A theoretical framework using well-rounded theoretical constructs can enhance our understandings of complex phenomena, such as the COVID-19 pandemic and its aftermath. A well-grounded theoretical framework can help scholars to develop valuable research for their communities and managerial practices (Meredith 1993; Dubey et al. 2019). In this section, we first provide an institutional theory-based logic and the resource-based view of firms' coexistences during and after the pandemic. Next, we briefly discuss the circular economy and ReSOLVE model for sustainability-driven production pathways. Further, we introduce the behaviorally revealed and stated non-market-based valuation methods for estimation of environmental goods utilization. Finally, we provide a brief overview of the ecosystem of multistakeholder digital technologies.

2.1. Institutional forces and firm resources

Organizational theories explain why and how firms behave, are designed, and are structured differently to match their internal and external environments (Sarkis et al., 2011). We apply two theoretical lenses, namely, the institutional theory to explain how firm manage their external environment and the resource-based view to describe how they apply their unique resources and capabilities to meet their short- and long-term goals. The two theoretical lenses are not only pertinent to the CE logic but to the multistakeholder digital ecosystem logic in our performance measurement framework–as they highlight the institutional and resource-based focus in the valuation of environmental goods, thus helping firms in a supply chain to shift to sustainable production practices. Both theories have been richly applied in the fields of sustainability, information management, and operations management (Touboulic and Walker, 2015). In the wake of COVID-19 disruptions, institutional theory has been applied to understand the reactions of governments and firms to establish new norms of doing business in society (Brammer et al., 2020; Loi et al., 2021). Similarly, resource-based view has been used to explain coopetition strategies to pool complementarities of firms needed to deter anticipated societal panics during COVID-19 (Crick and Crick, 2020).

Institutional theory. The institutional theory suggests that organization are motivated to change their internal structure and processes more for the need to gain organizational legitimacy from the external environment (such as regulations, laws, policies, social norms, and technological trends) and less for competition and efficiency reasons (DiMaggio and Powell, 1983; Shibin et al. 2020). To legitimize their strategic actions, processes, and structure, they resort to three types of institutional isomorphism–coercive, normative, and mimetic (DiMaggio and Powell, 1983). This motivation to gain organizational legitimacy promotes institutionalization, that is, they look alike in their forms and actions. The theory explains the role of the environment in the creation of regulatory, cognitive, and normative institutions, that are motivated by coercive, mimetic, and normative mechanisms, respectively (Scott, 2001). While coercive mechanisms indicate the role of influential institutions such as governments that coerce organizations to adopt certain practices through penalties and legal obligations, the normative mechanism puts pressure on organizations to adapt to certain practices to be socially acceptable to their customers and markets (Meherishi et al., 2019). The mimetic mechanism motivates organizations to imitate the actions of other successful companies from often within, related, and rarely unrelated industries in their quest for survival in the market (Dubey, 2019). Hence, during and after COVID-19, the application of institutional theory in sustainability-driven valuation research is important to theoretically validate the role of the external environment on organizations and firm choices to adopt CE transition practices in order to achieve a more sustainable, resilient, systemically-regenerated circular society (D'Adamo and Lupi, 2021; Rufino, 2021). Hence, the application of institutional theory in sustainability-driven valuation research is important to theoretically validate the role of the external environment on organizations in their CE transition practices and to qualify future research directions. Our research also supports the findings of Alnajem and Mostafa (2021) who agreed most studies on CE were limited to a specific region or specific CE-related application. Our work expands the CE research to the COVID-19 pandemic to include the CE and a multi-stakeholder digital ecosystems view.

Resource-based view. The resource-based view explains how resources and capabilities that a firm possesses could be directed toward building competitive advantages. Using a resource-based view, firms can how their resources and capabilities are aligned, and using those alignments they can outperform others to gain short- and long-term leverages (Barney, 1991). The theory argues that instead of merely competing with other organizations, firms should focus on developing “sticky” resources and capabilities that valuable, rare, inimitable, and difficult to transfer from them to another firm to sustain a competitive advantage for themselves (Barney and Clark, 2007). Further, resources can be classified as tangible (such as plant and machinery) and intangible (such as processes and patents) that help firms establish knowledge and relational competitive capabilities. Knowledge capabilities help firms to dynamically learn from their natural environment and foster the creation of further intangible resources (Hart, 1995; Nandi et al., 2020a; Nandi et al., 2021b).

On the other hand, relational capabilities assist firms to capitalize on the resources of alliance partners such that they can create, extend, or modify those resource bases for mutual gains (Teece, 2000; Hefalt and Peteraf, 2003). Similar to the institutional theory, the resource-based view of the firm is critical to cater theoretical justification for creating capabilities that are needed to effectively manage sustainability and resiliency of CE-driven supply chains during and after COVID-19 and future pandemic occurrences (Ketchen et al., 2014; Ketchen and Craighead, 2020; Nandi et al., 2020b).

From a CE transition perspective, we stress upon the complementary role "*institutional forces*" and "*firm resources*" in identifying strings of unique organizational resources and capabilities and institutionalize those into circular production chains both internally and across their supply chains (Miles and Snow, 1978). For example, an efficient optimization technique or a robust sharing platform by one firm can curb the extraction of new mineral to some extent, but the institutionalization of those resources and capabilities as proven CE practices across other firms can exponentially spread the sustainability logic to their external environments (de Sousa Jabbour et al., 2019) and extremely disruptive environments (Loi et al., 2021).

In addition, an institutionally derived multi-stakeholder approach to possess and deploy emerging digital technologies as bundled resources can handle complex yet sustainable operations systems to achieve a competitive edge to the entire industry ecosystem. Such bundled resources include cyber-physical systems, smart sensors, machine-human interactions, big-data, blockchain-based data transparency systems, tracking and tracing systems, artificial intelligence, and robots, and alike during and after pandemic (Bag et al., 2020; Nandi, et al., 2020a).

2.2. The Circular Economy and the ReSOLVE Model

The circular economy (CE) concepts are well known and they aim to reduce waste and minimize the use of limited natural resources while improving the economic performance of regions and firms. According to the Ellen MacArthur Foundation, CE rests on three core ideas: (a) preserve and enhance natural capital, (b) optimize returns from resources that are currently in use, and (c) promote system effectiveness (i.e., minimize negative externalities) (EMF, 2015). CE can lead to sustainable supply and process management of stakeholders (Tseng et al., 2021) as well as to sustainable consumption and production leading to economic growth (Tseng et al., 2020; Jabbour et al., 2019). In our study context, CE is related to creating circular supply chains and can address resource needs during and after pandemics. However, reconfiguring traditional supply chains to meet circular economy goals and applying CE for supply chain resilience is still in early development (Ivanov and Dolgui, 2020; Sarkis et al., 2020). For additional information on CE benefits see, for example, Lüdeke-Freund et al., 2019, Nandi, et al., 2020b, Bocken et al., 2016, and Charter, 2016, Geissdoerfer et al., 2017, Geng et al., 2016; Nandi et al., 2021b, de Jesus and Mendonca, 2018 Genovese et al., 2017.

The ReSOLVE framework developed by the Ellen MacArthur Foundation captures the strategic significance of several of the proposed CE business models. The ReSOLVE[1] framework illustrates a set of six strategies that firms can implement and state institutions promote to commonly achieve CE transition. These strategies include: REgenerate, Share, Optimise, Loop, Virtualise, and Exchange.-In this study, we consider the ReSOLVE framework to elucidate the behavioral linkages between environmental goods and (their customers) decision-making processes of firms to establish a non-market-based valuation condition. The pandemic pressures that both firms and societies are currently facing sets the perfect example to assessing the performance of environmental goods utilization using the CE 'ReSOLVE' framework.

2.3. The Non-market-based Valuation Methods of Environmental Goods

Total economic value includes both "use value" and "non-use value." Use value includes "direct use" and "indirect use," and non-use value includes option values; bequest values; and existence values. Economic benefits accrue whenever economic goods are produced and

[1] For more details about the ReSOLVE framework, please refer: https://www.ellenmacarthurfoundation.org/publications/delivering-the-circular-economy-a-toolkit-for-policymakers).

consumed. An economic good contributes to one or more person's well-being. Use value is obtained when someone gets enjoyment from some form of direct interaction with the resource. This type of value may be obtained from scenic views or by benefiting from enhanced water purity. Use and non-use values that individuals place on environmental resources are measured through techniques that use either physical or behavioral linkages (Mitchell and Carson 1989; Mauro and Humberto, 2020).

There are two approaches to estimate the use and the non-use components of the total economic value of environmental resources: market-based and non-market-based valuation techniques. These two approaches can support and integrate intangible as well as tangible valuations for environmental benefits: (1) Market-based valuation techniques and (2) Non-market-based valuation techniques. Market valuation techniques include physical linkages whereas non-market-based valuation techniques tend to include behavioral linkages. Economists typically rely on direct observable market interactions to place monetary values on goods and services. In this study, we focus solely on non-market-based valuation approaches (NMVM).

The NMVM, or the *behavioral linkage method*, as its name implies, focuses on behavior and welfare changes. Behavioral changes may either be *revealed* or *stated*, and the changes may be directly or indirectly linked to the environmental resources being valued. The NMVM uses the behavioral linkage approach to measure environmental benefits, unlike the market valuation techniques are primarily viewed from the physical linkage approach (such as physical damage function, assign prices, and estimation of the economic value damage).

Revealed preference methods, an indirect estimation, include the hedonic price method (Kahn, 1998; Brown et al., 1984; Garrod and Willis, 1992; Merlo et al., 2015; Lee, 2020; Ndindeng, 2021); the travel cost method (Randall, 1994; Birol et al., 2006; Chae et al., 2012;

Schneider et al., 2021); the averting expenditure or preventive expenditure method (Courant and Porter 1981; Abdalla et al., 1992; Maciosek et al., 2015; Gavurova et al., 2021; Kim et al., 2021); and random utility models (Peterson et al., 1983; Bhat, 2008; Hensher et al., 2013; Kitamura et al., 2018, 2019).

Stated preference methods use hypothetical markets to extract valuations to measure benefits and include contingent valuation (Cummings et al., 1986; Kolstad and Guzman, 1999; Cerda and Garcia, 2021), contingent choice (Forster et al., 2011; Santos et al., 2021), discrete choice (Hanley et al., 1998; Haab and McConnell, 2002; Kemperman, 2021), referendums (Foster and Mourato, 2002; Hindsley et al., 2020), calibrated and conjoint analysis (Louviere, 1988; Cameron and Englin, 1997; Klein et al., 2020), and choice experiments (Meyerding and Merz, 2018; Brand et al., 2020). Stated preference (SP) methods are widely used in health economics, for example, to estimate the relative value of alternative service changes (De Bekker Grob et al., 2012; Quaife et al., 2018; Viney et al.,2002), and to elicit the willingness to pay for health gains. Table 1 provides a summary of NMVM for measuring the environmental benefits that we use in this study.

-----Insert Table 1 Approximately Here-----

The relevant non-market-based valuation methods can be applied to estimate a cost measure of the adverse impacts of crisis or disruption in the supply chain. Further, these estimates of costs provide the organization an estimate for the benefit of building a resilient supply chain. This study provided an alternative approach to measure organizational sustainability performance by integrating social sustainability indicators with the market-based approach of environmental goods valuation methods (Hervani et al., 2017; Sarkis et al., 2017). More effective and non-traditional performance measurement approaches for social sustainability in supply chain processes and resilience bring more complexity to be addressed (Huang et al. 2020; Negri et al., 2021).

2.4. The Multi-stakeholder Digital Ecosystem

During the pandemic, the need for digitalization of assets, operations, and supply chain networks has surfaced strongly. Firms and governments have realized that a multi-stakeholder digital ecosystem (MDE) approach might be a possible way to overcome unforeseeable supply chain disruptions, such as production uncertainties of essential supplies (Ivanov and Dolgui, 2020). Pairing CE with smart devices, blockchain, Internet of things, can drastically change the resource productivity of a particular product or service, its usage, and its associated environment (Askoxylakis, 2018). We noted that a hierarchical and heterogeneous platform-based architectural approach is commonly proposed to effectively interconnect these emerging digital technologies for the seamless and secure flow of physical and information data in a production system (Ben-Daya et al., 2019).

To achieve this sort of MDE, as shown in Table 2, we classified the overall digital platform into three layers–Integrators, Enablers, and Hardware and Data Sources. Blockchain and the Internet of things form the topmost layer (Integrator) of the MDE for a series of enabling technologies layer (Enablers), such as artificial intelligence, augmented and virtual reality, predictive analytics, robotics. Big data and cloud servers, drones and smart sensors, and 3D printers form the physical foundation layer (the Hardware and Data Sources). The MDE approach toward CE practices highlights how firms could treat MDE as a dynamically learning technological capability for applying NMVM approaches to CE performance measurement plays in supporting supply chain sustainability and resilience as a competitive advantage.

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3. Evolving a Neo-Institutional Thinking for CE Performance Measurement

The main argument of this study is to generate a revised sense of institutionalism for the prevailing and possible CE practices and their respective circularity performances in curbing depletion of resources and downgrading of the environment (Fischer and Pascucci, 2017). Despite the availability of several ‘sustainability’, ‘green’, and ‘circular economy’ performance indicators, such as product lifecycle stage approach, environmental performance indicators, material flow cost analysis, and alike (see Sassanelli et al., 2019), there is a lack of assessment model that can ‘transparently and autonomously’ measure the performance of a firm’s production system from CE perspective. Further, the application of environmental goods valuation methods to complex circularities within supply chains is important for meeting sustainability objectives (Hervani et al., 2017). Given the recent COVID-19 supply chain disruption, firms need to urgently consider how to effectively manage their external pressures and strategic goals with various internal resources and capabilities. The COVID-19 crisis provided numerous and variable external pressures where norms tended to shift. That is, when people speak of the new ‘normal’ post-COVID there is an expectation of new norms and rules that are likely to exist or will likely cause shifts in how organizations plan their actions (Oborn et al., 2021). These new norms and other types of pressures represent new institutional logics that will likely emerge.

In the logistics and supply chain field, the COVID-19 crisis has shifted an institutional logic and expectation to be more strongly associated with digitalization to address supply chain issues and resilience (Herold et al., 2021; Nandi, et al., 2021a,b). This shift in logic also supports new industrial norms and mimetic pressures to adopt digitalization for both large and small companies (e.g., Bai et al., 2021). Another shifting institutional logic–the one that integrates how government regulators and policymakers view opportunities for change–is that organizations need to further balance sustainability and environmental concerns in supplier and logistics relationships (Govindan et al., 2016). This shifting institutional logic result may be an offshoot of finding greater efficiencies due to learned experiences in supply chain management. For example, the dramatic fall in domestic and international travel due to the COVID-19 may set a new norm and practice in supplier visits for supplier auditing purposes. Organizations are now more willing to trust suppliers to provide accurate audit information virtually and in virtual meetings. The justification in this case example is not only cost efficiencies, but these new travel restrictions can help build carbon neutrality into supply chain operations (Obal and Gao, 2020; Sarkis, 2021).

These new sustainable supply chain norms may result from other COVID responses including work-from-home and fewer products that will be produced resulting in greater resource efficiency (Sarkis et al., 2020; Sarkis, 2021). These new institutional logics and pressures will require competitive organizations to build organizational capabilities and resources to address these concerns. To evaluate the managerial and business activities associated with investing in these new capabilities, the evaluation performance measures that are required may be limited. Performance measures are needed for organizations in the justification and management of these new resources and capabilities. For example, determining the value of sustainability efforts using traditional performance and appraisal approaches may not be effective and some projects and practices will fail to be justified or managed appropriately (Presley et al., 2007; Varsei et al., 2014).

As an example, the justification of carbon neutrality and less travel may not result in a financial windfall and may perhaps cost more financially. Using traditional financial and business measures to capture the full costs or benefits of environmentally sustainable logistics and supply chain practices, may provide inaccurate estimates. Thus, utilization of non-market-based valuation models may provide different and important perspectives for evaluating and managing these COVID-19 related organizational environmental sustainability practices. These techniques have been reviewed—their linkage to organizational strategy and institutional fields relate to justifying and introduce resources and capabilities into the organizations; especially those resources and capabilities that are difficult to quantify.

The institutional void can be dealt with more effectively when considering broader social and environmental sustainability performance and measures (Silvestre, 2015). In this study, we are specifically considering how intangible resources—specifically information-supported performance measures, methodologies, and techniques–provide new knowledge to justify practices that can help firms build a competitive advantage through greater legitimacy and meet the new institutional norms. These new performance measures can be more effective than prior performance appraisal tools, especially those based only on economic performance such as return on investment or payback. The environmental goods valuation tools are capabilities that can help support circular economy practices.

This is the theoretical reasoning of the proposed circular economy performance measurement model (CEPMM) framework and its evaluation steps in this paper. We have emergent institutional ideas and norms from COVID-19 that influence logistics and supply chain management. Finally, a resource- and capabilities-based approach toward digitalization scope needs to be considered to address these shifting institutional fields for operational and strategic-level competitive advantages for supply chains and partners (Treiblmaier, 2018; Nandi et al., 2020a). We provide examples of responses, new intangible performance measurement methods for evaluating these responses, and tools to help gather information—especially a multi-stakeholder resource-based approach to the emerging digital technologies, that ranges from blockchain and the internet of things as platforms to smart sensors and 3D printers—all that can be considered as sticky resources and capabilities capable of providing competitive advantages to the ecosystem of firms practicing CE strategies in supply chain settings.

4. Methodological Framework

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The CEPMM framework applies a five-stepped approach to assess the performance of CE transition practices. The first step is identifying an institutional disruption that was commonly observed during early and later COVID-19 spans. We identified seven common institutionally challenging COVID-19 disruptions. These institutional disruptions are the much-highlighted interruptions that have caused cause environmental and social imbalances. We have carefully scanned and qualified such events from the scholarly literature and/or reputed press releases. For example, travel restrictions, social distancing, and supply shortages of essential food items at local grocery stores are probably some of the most apparent occurrences from the COVID-19 crisis.

In the second step, keeping the 'ReSOLVE' CE framework in mind, the classified institutional disruptions are decomposed further per their impact on production and operational subjectivities to the environment and societies. Per decomposed scenario, we recommend real and/or hypothetical possibilities of implementing one or more CE transition strategies– REgenerate, Share, Optimise, Loop, Virtualise, and Exchange. For example, when COVID-19 forced consumers to seek online grocery and merchandise purchase behavior, manufacturers are forced to use more plastic for packaging that ends up as recyclable trash at customers' houses (Leal Filho et al., 2021). To counter its influence on the environment and societies, businesses can gradually shift to a reclaimable, returnable packaging-oriented logistical ecosystem that encourages consumers to return the used packaging boxes to the sellers (REgenerate), thus reducing the need for more plastic and other packaging material. Similarly, firms can collaboratively craft reward programs to educate customers for a multipurpose usage of such packaging material and boxes (Share). Likewise, electronics manufacturers, such as iPhone and Android phone devices, can introduce modularity to standardize their product designs to promote the reuse of older parts and use less core and associated input material (Optimize).

In the third step, we identify applicable non-market-based valuation methods based on revealed or state preferences of value estimates that firms imply for adopting the CE transition strategies stated in the earlier step. Accordingly, we identify one of the four revealed preference methods and/or one of the five stated preference methods are suggested as the environmental goods assessment tools for achieving and improving the environmental sustainability of the CE-based production and operations approaches. The four revealed preference-based non-market-based valuation methods include averting expenditure (NMVM-R1), hedonic pricing (NMVM-R2), random utility (NMVM-R3), and travel cost (NMVM-R4) methods. The five stated preference-based non-market-based valuation methods include contingent valuation (NMVM-S1), contingent choice (NMVM-S2), calibrated and conjoint (NMVM-S3), discrete choice (NMVM-S4), and referendums (NMVM-S5) methods. For example, waste generated due to excess packaging material use resulting from online purchase demand during COVID-19 (Leal Filho et al., 2021), the following four revealed preference-based non-market-based valuation methods can be applied: (a) averting expenditure - to engage in actions to reduce the call for more plastic materials, (b) hedonic pricing - to determine the cost of making better reusable boxes for products; and (d) contingent valuation method - to determine how firms could respond to customers' understanding and realization of the need to lessen plastic usage in packaging purposes and use more reusable and reclaimable packaging methods (Hervani et al., 2017).

In the fourth step, we seek to strengthen the need for information sharing and dependencies by integrating applicable multi-stakeholder digital technologies. Such technologies may include a range of emerging technologies such as blockchain, internet-of-things, artificial intelligence, remote sensing, and offline and online tracking technologies. For example, in vaccine production and distribution demand-supply mismatch cases (HHS, 2020; Research and Markets, 2020; Businesswire, 2020), a wide range of known and emerging technologies, such as BCT-based tracking, distributed cloud-based warehousing in production, IoT supported distribution, and RFID and remote sensing support disposal can improve the overall operational efficiencies of such calibrated and conjoint collaboration efforts (Ivanov and Dolgui, 2020). Lastly, the fifth step reflects achievement of sustainable and resilient supply chain as the ultimate CE performance outcome. In Table 3 we have coded a series of examples from seven commonly observed institutional COVID-19 disruption scenarios.

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5. Results and Discussion

As we have seen in the application of the CEPMM model, building resiliency and sustainability into supply chain and logistics can be completed through CE practices. These practices can be evaluated—likely more effectively and non-traditionally, through NMVM. To help encourage and develop these metrics we propose the use of multi-stakeholder digital technologies since many of the NMVM require inputs from stakeholders outside the scope of a single organization.

The feasibility of these approaches was evaluated through various exemplary outcomes and recommendations to help solve specific COVID-19 based scenarios, and further, these scenarios provide insights into the supply chain and logistics fragility. The responses and recommendations help build resilience with sustainability explicitly considered. The solutions presented in this paper are only exemplary, but many are feasible.

Some general observations can be made on the examples provided. First, the disruption scenarios that arose during the COVID crisis were critical for the environment and societies. Each one had direct implications and issues related to supply chain and logistics issues. These scenarios were not difficult to identify and have appeared in the popular press and academic literature since the beginning of the COVID crisis (e.g., Chowdhury et al., 2021; Singh et al., 2021; Sarkis, 2021). Another general observation is that these scenarios occurred at various stages of the COVID crisis. For example, shortages in some materials and oversupply in other materials occurred immediately after shutdowns occurred, vaccine production and distribution occurred towards the latter portions of the crisis. Thus, even within a larger crisis, the supply chain and logistics implications of resilience, risk, and sustainability will tend to shift. This shifting of the situation means that responses, measures, and solutions will also shift.

The next general observation concerns how multiple CE dimensions using the ReSOLVE framework can be used to help address recovery and build future resilience from these situations. The comprehensive solution sets show that sustainability through CE can and does address supply chain fragility concerns effectively (Ivanov, 2020; Kumar et al., 2021; Linkov et al., 2021). Many more tools may exist, but the ReSOLVE practices are valuable for building resilience and sustainability to manage supply chain disruptions.

The environmental goods-NMVM are each represented. The variety of valuation approaches can be due to the characteristics of the scenario and ReSOLVE dimension (REgenerate, Share, Optimise, Loop, Virtualise, and Exchange). For example, some deal more directly with individual consumers where individual evaluations can be completed and aggregated. Recycling and reuse activities and products have been effectively evaluated using experiments and hedonic pricing (e.g., Li et al., 2018). In many cases, multiple approaches can be used to evaluate the effectiveness or utility of some of the recommended ReSOLVE solutions to the COVID supply chain risk or disruption. An implication of these multiple approaches that might be available is that managers can have a choice based on ease of use and accuracy of information gathered.

The achieved CEPMM model applies an ecosystem of multi-stakeholder digital technologies to help manage the valuation methods and responses. In this case, the baseline platform we have utilized is BCT and where appropriate, complements the transparency and automation aspects of the CEPMM. Overall, there is some flexibility in the capabilities these technologies offer including incentivization, information sharing, visibility, transparency, data acquisition, and virtualization, depending on the potential solution provided. Many examples already exist as BCT and the complementary technologies have been used for various CE practices include ReSOLVE practices (Kouhizadeh, et al., 2020). Unlike these previous solutions, digital solutions are provided here for aiding the implementation of NMVM. These technologies, overall, have significant flexibility to support a broad variety of NMVM. The distributed and multi-stakeholder nature of these tools is likely to make the use of NMVM more feasible; yet not all organizations are familiar with these technologies and are only beginning to seriously consider the ways that BCT and its complements can provide true competitive advantages to these firms (Kouhizadeh, et al., 2021).

5.1. Research Implications

The research implications of this study are multi-faceted because of the many relationships identified between the COVID supply chain and logistics disruption scenarios, CE responses, valuing these responses to help make choices, and the multi-stakeholder technologies to support the valuation approaches and the practices.

A broad-based theoretical perspective is whether the resources and capabilities provided here will be adopted by organizations. Theoretically, the adoption is likely to occur when organizations see a competitive advantage from investing in the resources (the technologies) and building the capabilities (CE responses and NMVM approaches) to the various external forces (the COVID-19 crisis) that may disrupt institutional norms associated with supply chain practices and to build broader resilience. In this case, the shifting institution norm supports a stronger sustainability outcome when applying solutions. These outcomes can be more guaranteed with CE responses. A particularly important and interesting research question in this context is whether the overall performance and competitiveness of organizations improve when multi-stakeholder digitization is utilized. One of the difficulties with this study is that traditional organizational performance—especially economic returns and market share—are measured using financial and market-based measures. This latter issue brings about another research question on whether the NMVMs are consistent with the more traditional measures of organizational performance. The focus of this research question is on the strategic level of analysis.

Operational and tactical research questions relate to how effectively the CEPMM can be integrated into organizations. Research on adoption strategies and implications of the various elements need to be considered. What has been presented are relatively conceptual relationships and responses. The literature on the use of BCT for some NMVM approaches is in its infancy (e.g., Shew et al., 2021). How it may be used for broader and evolving performance measures for supply chain resilience and sustainability (such as in the NMVM approaches) still needs empirical validation.

Benchmarking and performance measurement for joint supply chain resilience and sustainability are in their early research stages (see Negri et al., 2021 for a thorough review on this topic). CE as a vehicle for addressing supply chain resilience is also becoming established although still early in the scholarly investigation (e.g., Bag et al., 2018; Fiksel et al., 2021; Nandi et al., 2021a, b). There is substantial potential to integrate, compare, and contrast the application of NMVM and traditional business, environmental, and social performance measures. Designing these systems is critical. Design research (Ishfaq, 2012; Melnyk et al., 2014) can be applied in this context especially when considering the development of operations and CE processes. Design research is also important for information and communication technology and human-computer interaction and is valuable for building theory for emergent topics (Junge, 2021). Design research can provide a way to help build theory given the multi-stakeholder technology plays an important role in CEPMM. Transition design is an emergent design research field that proposes design-led transition toward a more sustainable future (Ceschin and Gaziulusoy, 2016), and in our case a more resilient future.

We have considered that there might be variations in outcomes between traditional and NMVM approaches and performance; an important consideration is whether there are differences in the results of the NMVM approaches. A comparative analysis with the various tools can be evaluated to determine the relative consistency of the measures. If differences occur, the relationship to specific resiliency and sustainability measures needs to be carefully evaluated. Tools for evaluating the reliability, validity, and accuracy of information are necessary.

Not only are the tools and application important from a practical perspective, but whether the performance measures and tools used can be valuable for empirical research, that is dependent on the data, may be needed. The techniques presented here are methodologies, the outcomes of these methodologies may provide scales for testing various theoretical and empirical questions. For example, the hygiene of supply chain stakeholders in healthcare (Tseng et al., 2021) can be captured using calibrated and conjoint analysis. Worker hygiene could be considered a scale measure for supply chain resilience as well as sustainability used to investigate theoretical relationships. Table 3 provides a significant foundation for scale measures for initial research in specific resilience and sustainability research for supply chains. Researchers may be able to take advantage of these measures if visibility and transparency of results can be accessed by the public, including researchers.

We also note a limitation of the framework, and an area for further research, is to link the steps of the framework more closely to COVID-19 pandemic disruptions and other supply chain disruptions to further distinguish the framework from scenarios common to all supply chain disruptions and link them more to disruptions from outlier events like the recent COVID disruptions around the globe in 2020-2021.

5.2. Practical and Managerial Implications

Organizations and policymakers were made quite aware of the fragility of supply chains during the COVID crisis. These events, although devastating, provide learning opportunities. The CEPMM, even conceptually, provides significant examples for policy makers and practitioners to implement or consider implementing.

They can learn from these examples, and the structure with various definitions can help them propose their solutions and use the referred ReSOLVE practices, measurement methodologies, and technologies jointly. The results and examples are general enough to apply to many settings, whether it is country, industry, or even product family settings.

One real practical concern is the feasibility of these solutions to be implemented. A question that will arise from managers is whether there is a payoff and benefit from utilizing such a—currently—complex system and series of relationships. The practical value is more accuracy and justification of intangible considerations of resilience and sustainability, but change is expensive and difficult. The benefits of such an approach need to be realized. If the ultimate goal is resilience and sustainability, then these tools can help justify approaches based on multi-stakeholder input. This justification can be more plausible for what is recommended here, but the value of this input needs to be weighed against the costs of implementation.

Policy makers may be less hesitant to adopt these practices since many of them can be used to capture resilience and sustainability of broader systems and infrastructure that support supply chain and logistics resilience. Transportation networks and infrastructure is an example;

a particular area of concern is whether the infrastructure is in place to make the technology work to capture the necessary information and data. Policymakers can justify greater investment in multi-stakeholder technologies to build knowledge and experience to determine whether these major CE projects are worth investment.

6. Conclusion

We have utilized the resourced-based and neo-institutional theories in this research. Implications are from a multi-governance perspective, but we have implications for the build-back better. While the research is concentrated on a small sample of COVID-19 examples, the conceptual ideas are extremely important but whether these are acceptable to a particular industry must be carefully evaluated.

We have identified a number of practical and research implications. Many of these implications include particular unanswered research questions.

- *Will the resources and capabilities discussed be adopted by organizations?*
- *How will the overall competitiveness of organizations improve when multi-stakeholder digitization is utilized?, and finally,*
- *How will NMVMs be consistent with the more traditional measures of organizational performance?*

Future research should extend these findings and include a larger sample of cases, include additional performance data for quantitative analysis, and carefully elaborate on the blockchain and IoT examples for replication and adoption. Similarly, cases for supply chain textbooks and college classes should be developed from the COVID-19 pandemic examples to train and alert future generations of business students of the value and importance of NMVM and the CEPMM model.

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Figures

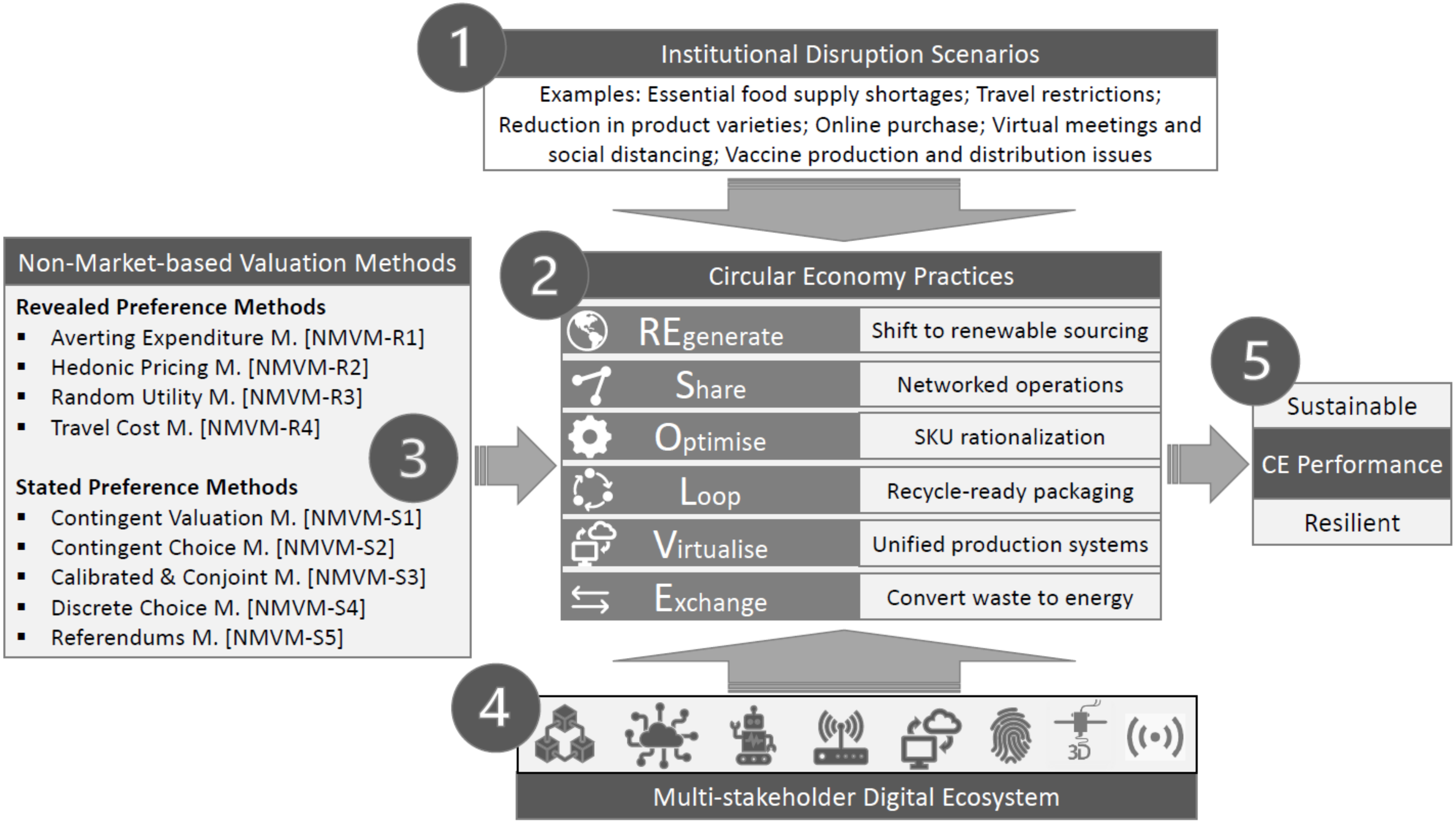

Figure 1. The Circular Economy Performance Measurement Model (CEPMM) Framework

Tables

Table 1. Non-market-based Valuation Methods (Behavioral linkage) from Environmental Goods Valuation Literature

Non-market-based valuation Methods	**Definition**	**Supporting References**
Revealed Preference Methods	*An approach that is used to identify the underlying preferences, and thus demands of individuals, based upon the choices each reveals in their consumption.*	
Averting Expenditures [NMV-R1]	To measure actions and expenditures incurred to reduce risks. In some cases, it is possible to engage in actions that reduce risks (e.g., staying indoors on days with high air pollution) but it is not easy to place a monetary value on these actions.	Jarl et al., 2010; Ommen et al., 2013; Dickie, 2017; Buonocore et al., 2021
Hedonic pricing [NMV-R2]	To assess the value of an environmental feature (clean air, clean water, serenity, view) by examining actual markets where the feature contributes to the price of a marketed good.	Yang et al., 2020; Zhang, 2020; Hu et al., 2020; Czembrowski, et al., 2019; Hung et al., 2020; Levantesi et al., 2020; Kisiała et al., 2021; Nakamura et al., 2021
Random Utility Model [NMV-R3]	To assess consumer choices in which the consumer is assumed to have perfect discrimination capability between goods or activities to maximize their 'utility' (relative attractiveness of competing alternatives).	Wang et al., 2019b; Cheng et al., 2019; Kitamura and Stoye, 2018; Hagenauer and Helbich, 2017; Kitamura et al., 2018, 2019
Travel cost [NMV-R4]	To estimate economic values associated with ecosystems or sites that are used for recreation. It assumes that the value of a site can be deduced from how much people are willing to pay to travel to visit the site.	Daisy et al., 2018; Hadiuzzaman et al., 2019; Daisy et al., 2020; Joonghyun et al., 2021; Ma et al. (2020); Wan et al., 2019.
Stated Preference Methods	*Utilized when the researcher does not have actual data on behavior with regards to a certain environmental good or service. The individuals are provided with hypothetical scenarios, based on plausible outcomes and options, and their choices are used to determine the value of the environmental good or service.*	
Contingent Valuation [NMV-S1]	To elicit values for environmental goods and services based upon hypothetical situations, using a survey questionnaire format.	Wong et al., 2020; García and Cerda, 2020; Harapan et al., 2020; Sarasty et al., 2020
Contingent Choice Method [NMV-S2]	To state a preference (by asking questions to respondents) between one group of environmental services or characteristics, at a given price or cost to the individual, and another group of environmental characteristics at a different price or cost.	Allo, 2020; Kang, 2019; Santos et al., 2021; Hinnen et al., 2017; Janßen and Langen, 2017; Jaller and Pahwa, 2020
Calibrated and Conjoint Analysis [NMV-S3]	To statistically determine how people value different features that make up an individual good or service; it is used to determine the values to be attributed to different environmental resources.	Agarwal, 2015; Meyerding and Merz, 2018; Benedikt and Rausch, 2020; Klein et al., 2020
Discrete Choice [NMV-S4]	To assess consumer choices in which the good or alternative chosen by the consumer is available only in discrete (integer) units.	Randle et al., 2019; Viglia and Dolnicar, 2020; Van Dongen and Timmermans, 2019; Hergesell et al., 2019; Olmsted et al., 2020; Tussyadiah, 2020
Referendum Method [NMV-S5]	To assess a hypothetical tradeoff between some amount of environmental good or service and something else of value (typically money) by asking respondents to answer in 'yes' or 'no'.	Ku and Wu, 2018; Regier et al., 2019; Bobinac, 2019; Kunwar et al., 2020; Haghani, 2020

Table 2. The Multi-stakeholder Digital Ecosystem

Architectural Role	Emerging Technologies
Integrators	Blockchain
	Internet of things
Enablers	Artificial intelligence
	Augmented reality
	Robotics
	Virtual reality
	Predictive analytics
Hardware and Data Sources	Big data and Cloud
	3D printing
	Drones, tracers, biometrics, sensors, flash media

Table 3: Coding of COVID-19 Disruption Use-cases using the CE 'ReSOLVE' Framework, NMVM of Environmental Goods, and Multi-stakeholder Digital Ecosystem

COVID-19 Use-case	CE 'ReSOLVE'	NMVM of Environmental Goods	Multi-stakeholder Digital Ecosystem (MDE)
Essential food supply shortages at local grocery stores. Source: Guan et al. (2020); OCED (2020)	Online grocery shopping and delivery. (***Virtualize***) Take industrial-sized foods and repackage for consumer use at grocery stores. (***Share***) Consumers can adopt food substitution options. (***Loop***)	**Travel Cost Method (NMVM-R4) –** How much a consumer would pay to travel to another community to find groceries. **Random Utility Model (NMVM-R3) -** To substitute foods in recipes/meals (i.e., beef for chicken)	IoT and BCT in information sharing to review purchase behavior and substitutions to online grocery pick-up orders. Companies can use the information to help sell their excess food supplies. Consumers are incentivized to provide their information (affinity cards). Can be validated by trucking firms and delivery agents and warehouse facilities to build a consensus.
Travel restrictions and disruptions. Source: Moyer and Ruane (2020); Guan et al. (2020)	Build Online and virtual capability for essential business meetings. (***Virtualize***) Locate and identify sources of delivery for essential items such as food and medical supplies. (***Regenerate***) Develop a network of cooperation with the primary and intermediary materials suppliers to avoid production disruption. (***Share***)	**Averting Expenditure (NMVM-R1) -** To measure expenditures incurred to reduce risks (enhanced network capability). **Contingent Valuation (NMVM-S1) -** To elicits values that consumers place on having the ability and option to obtain the essential items. **Discrete Choice Method (NMVM-S4) -** Derives an estimate of the organization's willingness to pay to maintain the current production levels and this measure is inferred from tradeoffs that include the cost of building resilient.	BCT information sharing can enable Firms to compare the cost difference of conducting remotely supported localized support to the travel-dependent on-site support and decide on the needed resilience. BCT-based source identification system can enhance *information sharing and source identification*. The use of BCT and IoT platforms would improve *information sharing* and create an *incentivization* and *negotiation* system for smart contracting.
Shifting of supply chains (toilet paper) from industrial to consumer sizes.	Share including reuse of materials used for one supply chain across to another supply chain. Materials that are used for industrial can be shifted to retail. (***Share***)	**Discrete Choice (NMVM-S4) -** Valuation can be completed to determine the value associated with second-hand materials that were originally used for industrial purposes?	BCT can provide some time of exchange negotiation to determine whether some products or choices are more effective in terms of actual practice. Can

Source: Human Behavior (2020)	Big data usage can identify what type of materials are available to help in optimizing. The concerns are some areas had great waste while others did not. (***Optimize***) The exchange may be appropriate in highly populated regions where extensive supplies and resources are available can be exchanged to those areas that need it. For example, the food systems can be shifted to feed. Applying new technologies appears with our BCT example. (***Exchange***)	For example, is packaging difference an issue? **Averting Expenditures (NMVM-R1)** - Can be integrated into optimization models for usage. For example, some materials have significant waste, but if alternative uses and costs incurred with these alternative uses are evaluated, could this be offset by averting expenditures of loss? The **referendum method (NMVM-S5)** - Maybe appropriate when trying to value shifting of use of material. For example, what is the value assigned to wastes from one area that can be used for another area? Some may view waste as not having value but having multiple stakeholders can give a better perspective of value.	smart contracts be executed in the discrete choice mechanism? BCT data on the number of wastes and potential alternatives that are available can be monitored. The tokenization of these potential wastes can provide opportunities to be delivered and used in areas where they may provide value and avert expenditures. BCT can offer consensus mechanisms that can help determine a referendum value and execute and give value depending on a referendum approach.
Consumer goods companies strategically decreased the scope and variety of product availability (SKU rationalization and optimization) due to sourcing issues. Source: Garbato (2021)	Food manufacturing firms stayed profitable by strategically reducing their net product SKU counts to further reduce production costs and inventory and logistical complexities resulting from input supplies and labor shortages during pandemics (Cosgrove, 2020; Hamstra, 2021). (***Optimize)***	**Hedonic pricing (NMVM-R2)** - Firms can reveal to customers the estimated losses in material and productivity wastages that occur, and thereby, they will incur the added costs per product category–as the logic of SKU rationalization during the pandemic period.	Firms can leverage BCT and automation on supply-side systems and big data and artificial intelligence on customer-side systems to improvise SKU optimization efforts (Jabbour et al, 2019).
Online purchasing of merchandise led to increasing waste generation streams. Source: Leal Filho et al. (2021)	Food and goods vendors have shifted to recyclable and renewable materials. (***Regenerate***) Programs are in place to re-use and/or packaging materials and boxes. (***Share***) Removing or reducing packaging wastes initiatives are in place. (***Optimize***) Recycle-ready materials. (***Loop***)	**Averting expenditure (NMVM-R1) -** Engaging in actions that reduce waste including more recyclable materials. **Hedonic Pricing (NMVM-R2)** - Reusable items make the purchase more valuable to consumers. **Contingent Valuation (NMVM-S1)** - Value consumers place on reducing packaging wastes. **Calibrated and conjoint analysis (NMVM-S3)** - Features including	IoT and BCT in information sharing to review recyclability of packaging. Consumers are incentivized to re-use packaging materials. Can help consumers locate easy drop-off locations for delivery agents. RFID can locate excess materials for transfer to other locations where they are needed and can be used and re-used.

		recycle-ready materials are more valued by consumers.	
Use of virtual meetings and distance communication from social distancing. Source: Woolston (2020)	Use virtual meetings to discuss supply gluts such as waste streams, water maintenance, and distribution disruptions. (***Loop***) Develop remote communication capabilities to conduct virtual distance meetings, discuss planning for products, and capacity amongst, adding to sustainability planning across the supply chain. (***Share***) Use the virtual meeting option to enhance organizational ability to perform production, inventory auditing, and capacity adjustments virtually through video setups. (***Virtualize***)	**Stated Preference Methods (NMVM-S1) -** To identify an alternate supplier versus maintaining the current supplier based on the involved risks to the firm. The value of this risk is dependent on how well their virtual sessions provide information. **Averting Expenditures (NMVM-R1) -** Measures the expenditures incurred to reduce risks of disruptions by building supply chain resilience. **Random Utility Model (NMVM-R3) -** Consumer is assumed to have perfect discrimination capability between goods or activities to maximize their 'utility' (relative attractiveness of competing alternatives).	BCT -based supply chain: One of the difficulties with virtual meetings in this context is how much you can trust the data and results. Auditing through distributed channels using blockchain information, e.g., employees of the firm giving input and verified by other employees can be used to inform the virtual meeting data. BCT-based supply chains enable organizations to practice transparency, virtualization, and sharing of data.
COVID-19 Vaccine Production and Distribution. Source: HHS (2020)	The demand for vaccines and their related-medical supplies that are typically disposable and not recyclable (e.g., syringe, gloves, bandages, masks, etc.) has increased globally since the Covid-19 outbreak, thus putting pressure on hygiene-related single-use plastic product industry (Research and Markets, 2020; Businesswire, 2020). Firms can collaborate for efficient production, logistical and disposal systems along and across value chains to reduce transaction costs. (***Share***) Governments can provide business, technological, and financial support systems to such collaborating partners (***Virtualize***)	**Calibrated & Conjoint Analysis Method (NMVM-S3) -** Firms can justify collaboration benefits for making single-use plastic products by stating the importance of hygiene to stakeholders that can be determined by capturing how individuals perceived hygiene factors during vaccination drives that comprise not only the vaccine but its associated services too.	A wide range of known and emerging technologies, such as BCT-based tracking, distributed cloud-based warehousing in production, IoT supported distribution, and RFID and remote sensing support disposal can improve the overall operational efficiencies of such calibrated and conjoint collaboration efforts.