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Can disruptive events trigger transitions towards sustainable consumption?

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ABSTRACT

Disruptive events have historically been shown to upset business as usual practices that can leave temporary or lasting changes. The emergence of a pandemic in 2020 triggered a rapid digital transformation. Electronic platforms are able to support essential socio-economic activities through virtual transactions and interactions yet products remain a physical output of raw material consumption. Furthermore, the digital world has also easily provided consumers access to more products than they normally need, allowing for rebound effect through "retail therapy" and "revenge procurement". As widespread digital consumption becomes the "new normal", this paper cautions against unsustainable consumption practices in the digital world, cites affluence data, and proposes a systemic design-based poka-yoke strategy as a feasible pathway to sustainable consumption: (i) a resource-based sustainability transition that accounts for the consumption of both intermediate (producer) and end- (finished product) consumers, (ii) a design philosophy in developing products and services that embeds sustainability attributes, and (iii) limiting consumer choices to sustainability-proofed products and systems that can guide and lock-in sustainable consumption.

1. Scenario of new normal consumption pattern

Historically, disruptive events have proven to be important factors in upsetting entrenched unsustainable business-as-usual (BAU) practices. Past disruptions have been either man-made or natural in nature. For example, the oil crises of the 1970s gave impetus to industry efforts to increase energy efficiency, which also led to reductions in greenhouse gas (GHG) emissions even before climate change was a major public issue. In the 1990s, the advent of the Internet paved the way to increased firm performance through intelligent use of information technology; this transition continues to this day via the so-called Industry 4.0 revolution, which promises to enable further gains in the responsiveness of firms to their respective markets through tools such as the Internet of Things, Big Data and artificial intelligence. More recently, the COVID-19 pandemic and the ensuing lockdowns put in place to control its spread have also upset the economic BAU, with mixed results. Dependence on work-from-home arrangements worldwide and the slowing down of economic activities have led to a dramatic drop in GHG emissions and other air pollutants (Gillingham et al., 2020). On the other hand, there has also been a surge in various types of plastic waste from the consumption and use of personal protective equipment, packaging materials and disposable medical supplies (Klemeš et al., 2020). It is too early to ascertain whether these changes, whether beneficial or disadvantageous, are transient or will persist in the future "new normal" world. Such manifestations of a disruptive event offer a valuable opportunity to assess the resulting sharp increase in digital technology consumption, and guide the world economy towards a more sustainable trajectory that falls within planetary boundaries (Rockström et al., 2009). In this note, we discuss the outlook for such a persistent, long term transition towards the sustainability of consumption. The analysis of complex interactions of value-chain players as consumers of intermediate and finished products (i.e., firms and consumers) is presented. Finally, we suggest systemic design-based poka-yoke or "foolproof designing" (Kiran, 2020) sustainable consumption options to reach several priority sustainable targets (e.g., low carbon and circularity).

2. Digital world consumption impact

The creation of digital markets has changed the production and consumption patterns of economies as technology provides consumers with convenient access to the global market. With it came the complexity and risks of dealing with international trade (Meral, 2019), failure of

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technology (Pal et al., 2020) and information security (Popova et al., 2019), which may have slowed down the pace towards its complete adoption. However, the emergence of a pandemic early in the year 2020 has disrupted the normal and prevailing BAU, and fast-tracked the digital transformation. Such disruptive black swan event (Nicola et al., 2020) and consequent mobility restrictions reduced the inertia towards digital transformation, triggering the widespread offerings of e-products and the migration to e-platforms to remotely accomplish essential activities (e.g., working from home, conducting online classes, carrying out telemedicine, and ordering food and groceries). McKinsey & Company reported that the rate of digital adoption by consumers and businesses in a five-year period was achieved in only about two months (Baig et al., 2020). Digital technology presented as a convenient alternative for consumers to continue on with some form of economic and social activities while following social distancing, allowing for its rapid diffusion (Zeng et al., 2020). This rapid digital transformation brought in a virtual experience for producer-consumer interaction, and made more products available to the consumers at the convenience of a few clicks. It is noteworthy that while the process of procurement may be digital, the finished goods are still physical and bears environmental impacts.

The shift in consumption activities from conventional physical transaction to digital platforms has been happening since early 2010 evolving from e-commerce to widespread mobile digital access. Accelerated digital consumption in the Asia Pacific has become a dominant feature of the increasing affluence in the region. The United Nations International Resource Panel (UN IRP) showed that in less than two decades, affluence has significantly driven material footprint in Asia Pacific from 24% of 46% net change in Domestic Material Consumption (DMC) during the period 1990 to 2000 (Fig. 1) to 18% of 18% net change in DMC during 2010–2015 (Fig. 2). Even prior to the recent surge in digital consumption, the ease of access to a broad range of products in e-platforms afforded digital consumers with more options, and may have resulted in unintended consequences such as rebound purchase due to convenience, increase in use of logistics services (home delivery) and more packaging waste. At a time when digital transformation has suddenly become mainstream, the digital market has expanded, and digital platforms have become accessible and acceptable as well. Businesses previously resistant to the shift to e-commerce now have online presence, and consumers previously hesitant in making online purchases and payments have begun using e-wallets. It is too early to conclude if this "new normal" phenomenon of accelerated digital transformation can be worse than "normal" for sustainable consumption (SC). We should be wary of a rebound effect in the form of "online retail therapy" and "revenge consumption" behavior once the world begins to normalize after the pandemic. Considering that the affluence is the strongest qualifier to resource use impact, a sustainability transition that deals with the physical production system and product as a limiting factor would be a feasible and effective path. As affluence is the most influential qualifier to resource consumption, choice editing by design limiting the embedded product and system impact is more deterministically manageable. Human behavior change towards sustainable consumption patterns can be the next strategy and be a longer term target. In the next section, we present consumption as emanating from intermediate consumers (producers as natural resource consumers) and as a behavior of end consumers (end consumers as finished-product consumers).

3. Consumers re-identified systemically

Consumption is often defined as finished product and service consumption; hence, end consumers became the target of research studies. This narrow definition of consumption corresponding to the economic concept of final demand cannot properly account for raw material use in upstream production processes, which correspond to the economic concept of intermediate demand. We should also highlight the producer as raw material/natural resources consumer using simple Pareto analysis. In resource management, macro- and meso-level studies examine the big picture or the system as a whole using tools such as Material Flow Accounting and Extended Environmental Input-Output Analysis. At micro-level studies, cleaner production principles provide the guiding framework with a particular objective of reducing resource demand and emissions generation vis-à-vis BAU (Huang et al., 2019; Chiu et al., 2017). The scope of sustainable consumption must, therefore, cover the consumption of both intermediate and final products and services.

Most of the recent works on sustainable consumption study the behavior of individual consumers or collective clusters. In an increasingly global and virtual market, producers respond to changing consumer preference and recognize purchasing habits of consumers. For instance, consumer preference for convenience products push manufacturers to create products that cater to this lifestyle. Single-use items, instant products and fast fashion comprise some of the products that fuel a throwaway society, and negatively impact resource use and waste generation. In addition, the value attached to materials such as a status symbol leads to materialism, which puts the market in an overdrive for products that will satiate consumer lust for new and better things (Lindblom et al., 2018). These consumer preferences and materialistic tendencies shorten the product utilization and life cycle, and illustrate the disregard for reduce-reuse-recycle principle in this consumption culture-catalyzed linear economy (Ghisellini et al., 2016). Understanding SC in the context of sustainable consumption and production is still an ongoing and pressing issue despite the advances and empirical evidences collected in recent years (Fischer et al., 2017).

Many studies also look into drivers and motivators of individual and collective cluster's consumption behavior. Internal factors, pertaining to demographic (i.e., age, gender, marital status and financial capacity) and psychological variables (e.g., attitudes, beliefs and subjective norms), as well as external factors (e.g., social norms, convenience, community

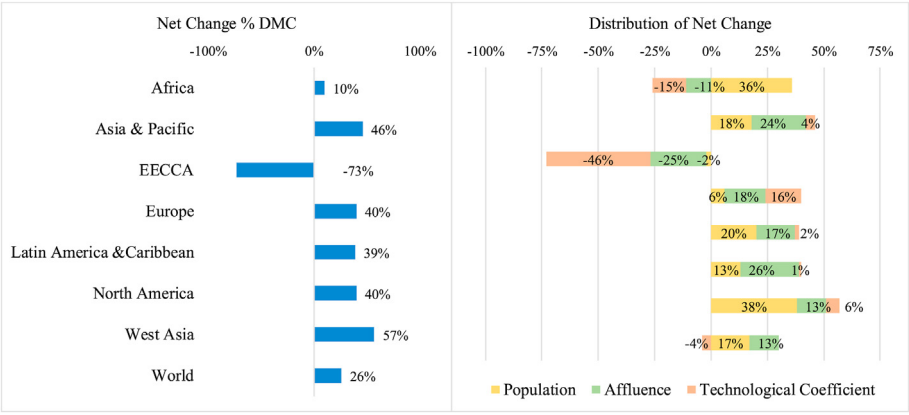

Fig. 1. Drivers of material footprint, 1990–2000 (percentages) (adapted from IRP, 2017).

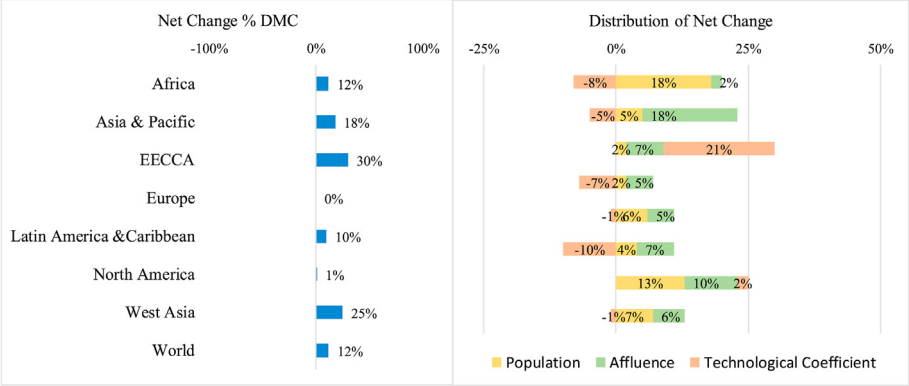

Fig. 2. Drivers of material footprint, 2010–2015 (percentages) (adapted from IRP, 2017).

facilities and innovation), influence decision to engage in a sustainable lifestyle (Li et al., 2019). However, researchers also acknowledge the presence of attitude-behavior gap – consumers may have the knowledge and the consciousness for environmental concern, but they do not necessarily act on it, so it does not always translate to sustainable behavior (Jaeger-Erben et al., 2015). Everyday habits are usually rarely reflected upon and will need intervention (e.g., regulatory or economic measures) in order to induce a shift to a more sustainable lifestyle. Shifting from old, entrenched bad habits to sustainable practices may take a long time to develop, and a single event or change (e.g., sudden unavailability of a sustainable product or peer influence) may easily break such new sustainable consumption effort overnight (Walker et al., 2014; Carden and Wood, 2018). With the COVID-19 pandemic, efforts in reducing the use of plastic has taken a back seat, and "revenge tourism" has gained traction where mobility restrictions have been lifted. For example, there are reported cases where travelers massively flocked to Penghu Island in Taiwan, that exceeded the destination's ecological carrying capacity (Liu, 2020). Also in Asia, many special airline travel arrangements were made to cater to demand for air travel – by taking them on a short-haul flight of circling the skies before returning to the same airport where they took off (Wong, 2020). In Europe, England initially allowed international travel for tourists to selected "safe" destinations that will not require 14-day isolation when they return (Gallardo, 2020). However, when COVID-19 cases increased anew in France, British holiday-makers rushed back home to beat the 48-hour deadline; if they arrive beyond this date, they are required to self-isolate for 14 days (Sullivan, 2020). The phenomenon of reverting back to old bad habits brought in much more research studies on retaining a successful sustainable consumption transformation.

Collaborative consumption has been linked to sustainable consumption in primarily encouraging resource efficiency and surplus utilization (Toni, Renzi and Mattia, 2018) to close resource loop into circularity. Since the 1990s, collaborative consumption of resources has been studied as industrial symbiosis (Chiu and Geng, 2004). This emerging consumption-side phenomenon is often used in conjunction with sharing economy and product-service system (PSS), changing the way we consume things from an ownership-based economy to one where we are provided access to the utility function and share in the use of other people's resources (Fraanje and Spaargaren, 2019). It may involve sharing of product use (asynchronous bicycle share) or service use (synchronous ride share). This arrangement promotes the use of underutilized goods and services such as in the case of Uber, Airbnb and other similar services. It also encompasses peer-to-peer (P2P) barter exchange or selling of second-hand goods in digital platforms, such as eBay (Parguel et al., 2017). However, a disruptive event such as a health crisis may restrict use and affect interest to use these services. Lodging services in collaborative consumption may be impacted more than transportation services. Big hotel chains may be deemed as more capable and in control of maintaining specific standards (e.g. disinfection and sanitation) than individual-owned houses or rooms for short-term rentals (Pires, 2020). While transportation services are affected due to movement restrictions of people, diversifying and strengthening other services such as food and grocery deliveries have softened the impact. Collaborative consumption still remains as a promising field for sustainable consumption; however, individual behaviors and differences still result in indulgent consumption – those who believe they are supporting zero-waste tend to purchase items they do not actually need (Parguel et al., 2017), which is still deemed unsustainable. Such behavior leads to the rebound effect. This, together with sufficiency, de-growth and minimalism (e.g. Danshari) still boils down to the complexity of influencing individual consumption behavior.

Understanding collective consumption, particularly in household context, may shed light into how available and purchased resources are utilized and optimized (Bruce et al., 2019). As households employ collective decisions toward consuming goods and services, the many layers of collective dynamics within the family are present (e.g., how they prioritize things and how they negotiate with each other), which eventually lead to purchase decisions (Thomas et al., 2020). This interaction within the collective journeys of households may contribute to value creation of sustainable businesses through interactions with other customers and with the firm providing the resources (Bruce et al., 2019). This type of interaction between household members and among customers, and with the firm may open opportunities for influencing each party to embrace sustainable consumption as end consumers and intermediate consumers, respectively. Increasing the responsiveness of this consumer-firm interaction can be a valuable bottom up strategy, while top down system design could close the gap for sustainable consumption to occur.

4. Systems and design thinking

Systems thinking, design and optimization are recognized approaches that provide resource-based strategic solutions to both intermediate and end consumers. These concepts can be implemented at different levels and in the different components which make up the economic system. Systemic design, for example, can be utilized using "positive" lock-in effect which could transition into sustainable consumption patterns. Product design (including LCA) and system design have developed poka-yoke lock-in feature to consumption. Developed in 1961 by Dr. Shigco Shingo, poka-yoke involves the use of devices or design, that is, auto-nomation to eliminate mistakes and defects by incorporating "foolproof" steps in the process (Tsou and Chen, 2005; Yui, 1997). One advantage of poka-yoke is that it does not require additional process steps (e.g. quality control), but rather the design is incorporated in the process (Pötters et al., 2018). Such an industrial system engineering concept may be combined with the lock-in concept, and extended to encompass choice editing and PSS. This perspective assumes that the producer and consumer have a leader-follower relationship, as in a classic Stackelberg

game. The producer can anticipate consumer reactions and thus design products and services to edit the consumer choices; the latter merely reacts to available choices from the producer and its competitors. This outlook places greater responsibility on firms to design greener products for the market. By comparison, previous work has assumed that producer and consumer engage in a Nash game between equals (Grimes-Casey et al., 2007). This strategy is also related to choice architecture concepts in behavioral economics. In particular, Nudge Theory can have a powerful influence in determining effective, unobtrusive, and low-cost techniques to influence consumer behavior towards more sustainable trajectories (Thaler, 2020). Such strategies can be used by both firms and governments.

On the meso-level, production system boundary analysis since 1990s has shown great success in implementing circular economic eco-industrial development (EID) concepts in dealing with production clusters; most popular among these EID options are industrial symbiosis and eco-industrial park (EIP) transformation (Chiu and Geng, 2004; Park et al., 2008; Geng et al., 2019). Government can also influence interactions among economic agents through various policies and economic instruments. In the same way, the Stackelberg game framework has also been applied to model how government can implement incentives to induce green behavior by firms (Aviso et al., 2010).

Taking cities as another meso-level economic system, one may find that the per capita domestic material consumption of cities generally does not reflect its level of development. For example, Lisbon's annual consumption of materials per capita is nearly 20.8 tons, London's is under four tons per capita, and Cape Town at 3.3 tons during the mid-2000s. Energy requirements for mobility has been significantly less where there is a correlation between high population densities and efficient public transport system that makes private car use a disincentive. Those living in urban areas require less energy in general compared to those in the rural areas; however, the use of urban materials and energy will fluctuate with context, urban form, economic activity, scale effects (UNEP, 2013; IRP, 2019; Kennedy et al., 2015) and the sustainable development policies that are put in place.

Hence, the form and design of the supporting structures where economic and social activities take place need to be considered in the sustainable consumption discourse. Lock-in unsustainable consumption pattern was once treated as a dilemma on excessive resource demand. For example, an infrastructure's high energy consumption from ventilation and lighting requirements is locked-in for decades due to weak building design. A reduction of as much as factors of 5 and 10 in operational energy consumption can be achieved by changing the way urban systems are designed, and radically reorienting to a hybrid strategy on renewables, energy efficiency and demand-supply management (UNEP, 2013; IRP, 2018). This turn-around "poka-yoke foolproof" strategy reverses "unsustainable lock-in" design into a "sustainable lock-in" design. *System-based and resource-based infrastructure as limiting factor (poka-yoke) can be further explored for positive effect.*

At the product level, poka-yoke has long been utilized in industrial tool design; a shift to integrate with product sustainability design thinking is a good approach that can alter consumption behavior and still cater to certain human tendencies or preferences. Design for Sustainable Behavior (DfSB) specifically focuses on influencing consumption behavior of consumers towards sustainable habits. Particular attention is given to the use phase in product design because ultimately, consumption of products is what produces environmental impacts on the consumer side. This eco-design approach involves consumer interaction with the product as a consideration in the design phase, and develops products that reduce resource use in production as well. The approach centers its principles on encouraging sustainable behavior and discouraging the performance of unsustainable actions (Gutierrez et al., 2020; Ceschin and Gaziulusoy, 2016). For example, as consumers are after convenience, installing the wall electricity outlet at the floor level and behind the table may invite additional task steps, i.e. bend, reach out; for the users to unplug computer and other electrical appliances – while it is a task that may not involve much struggle, it can be uneasy to do habitually. Installing the outlet on a level that is comfortable for the user to utilize, like somewhere above the table, may easily change the users' behavior of unplugging electrical devices. This habit of regular unplugging will accumulate to significant energy savings over time. DfSB offers a potential solution that can influence behavior on a bigger scale if executed properly and effectively. It can also address customer convenience – a key element in the current unsustainable behavior – so that a sustainable behavior will no longer be perceived as an inconvenience, but rather a norm in everyday choices.

5. Conclusion

Disruptive events alter the status quo. These changes may be temporary or permanent. On the surface, the accelerated digital transformation caused by mobility restrictions has brought about an increased need for online content and infrastructure to support remote implementation of socioeconomic activities like e-commerce, teleconferencing and telemedicine. While we are far from exacting the impacts and extent of this shift, which may or may not be lasting, the immediate consequences illustrate fundamental vulnerabilities in the present way of life in the face of a disruption. The digital world enables societies to accomplish transactions in isolation, yet products, services and infrastructure remain tangible creations. Designing sustainable products and services addresses sustainability aspects in production, but this may not easily elicit sustainable choices among consumers. Herein lies an opportunity for sustainable transitions.

Transitioning to a system that promotes sustainability is central to the Sustainable Development Goals (SDG). Sustainable consumption can delink resource demand and environmental degradation from economic growth using the following approaches:

1. Role of systemic analysis and thinking. A resource-based approach is needed in sustainable consumption, involving both the producer as intermediate resource consumer and the end-consumer as finished product consumer. As the extent and form of the accelerated digital transformation taking shape is still unknown, macro-, meso-, and micro-level measures (e.g., regulatory, strategic business decision and consumer preference) need to favor embedding sustainable consumption in this digital future.
2. Poka-yoke system design to nudge consumption pattern. Being stuck with a wrong design will prove costly for the strides being made towards sustainable consumption especially with the added threat of rebound effect. In the leapfrogging of digital ubiquity, the producer will need to be responsive in providing "lock-in sustainable" enabling condition and limiting available choices to sustainable ones to guide consumer behavior. For example, a building that does not have windows will consume more energy resources because of the demand for ventilation and air conditioning; this represents lock-in unsustainable consumption during the use stage. On the contrary, a building designed to integrate natural lighting and good ventilation; and is equipped with other technological/landscape architectural solutions, represents a poka-yoke lock-in sustainable consumption product system.
3. Poka-yoke product and service design to nudge consumption pattern. As essential socio-economic activities are increasingly done on digital platforms, new products and service markets are likely to emerge to cater to perceived consumer needs. In this changing landscape of digital transformation, the increasing access to digital platforms means that more consumers from across demographic and socioeconomic segments and producers of varying size and capability (for sustainable consumption and production) are able to participate in e-commerce. Sustainability-proofing of product and service design, e.g. DfSB, as well as consumer education on sustainable consumption, will become more important.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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