Can the Global Supply Chain Continue Depending on Harvesting Raw Materials for Manufacturing Everyday Commodities?

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Practically all the material items we purchase were derived from raw materials. Raw materials come from the forest (wood) and the earth (crude oil, coal, and natural gas). For example, since the commencement of the Industrial Revolution, the automobile structure was composed of metals (stainless steel, carbon steel, and aluminum, etc.) derived from the earth. Hence, another significant class of raw materials (coke, iron ore, limestone, and sinter) were mined for its usability on consumer products. Sadly, humans have an unsatisfied desire for convenience (transportation/shelter/ technology) and luxury. Thus, their unquenchable cravings created a demand which outweighs the supply chains' abilities to deliver products fast enough**.**

Presently, the raw materials shortage paradigm shows signs of rapid depletion; for example, paints and epoxy resins are becoming a scarce and expensive product because of the scarcity of their raw materials. Note: epoxy and paints are made from epoxy pre-cursors such as aliphatic glycols, phenol, o-cresol novolacs, and zinc. To reiterate, zinc is manufactured from raw materials and minerals found in the earth. Those minerals can be a combination of sphalerite, smithsonite, hemimorphite, and wurtzite.

Over the years the coatings (paints/epoxy resins) industry has seen the massive demand from China, put unsustainable pressure on the supply of raw materials (zinc, etc.) … This, together with other factors (instability of supply), has created world shortages that are affecting all (British Coatings Federation, 2019).

The aforementioned materials along with other raw materials (iron ore) are becoming scarce, the reasons for the scarcity of those raw materials are due in part to high demands of merchandises by consumers, "this includes cellphones, coffee makers, washing machines, headphones, lamps, wearable devices, and almost anything else you can think of…" (Jacob, 2014).

Other reasons for the depletion of raw materials are the increased population (birth rate) and longer life expectancy (catalyzed by modern medicine) of humans over the years, this was explained by the Malthus' perspective. Mr. Thomas Robert Malthus theory presented the argument that an increasing population + limited resources = catastrophe. More so, Malthus believed the better we get at making things, the cheaper it is to consume and the faster we reproduce and use up the planet's resources (Marsillac, 2019).

With the acknowledgment of what causes (high demand for goods/growing population) scarcity of raw materials, this research acknowledged that modern-day technology has provided kinetic information systems which are used as the primary tools by customers to create demands, the high demand (pull) by consumers leads to a discussion about demand capabilities: in the spring of 2019 at ODU, course number IT 660 (Information Technology) brought to light, the ability of the Internet of Things (IoT), this new-age technology (connects everything) can be synonymously associated with the industrial revolution, because it has the same effect on modern-day society just as the industrial revolution had on the society of yesteryear. Customers can energize (pull) the supply chain system with just the click of a mouse. What IT 660 lingo meant by the click of a mouse as was the IoT, gone are the days of the industrial revolution, the Gilboy thesis referred to the industrial revolution in terms of supply vs demand, in fact, Gilboy described demand as an equal partner in bringing about the most profound economic change in human history (Mokyr, 1977).

Raw material depletion was not a supply chain constraint in early 19th century, because the supply model was based on a linear 19th and 20th Century model conceived for a significant smaller world population and implicitly ignoring the limits of earth resources and the impact of resource consumption on our climate Hoffman, et al. (2018). Raw materials come from different countries across the globe; this research took a close look at the top three countries that are well known for being mega suppliers of raw materials. Starting with China, this country supplies about 80 percent of the rare-earth elements imported by the United States, which are used in oil refining, batteries, consumer electronics, defense, and more (Johnson, et al., 2019).

With current trade wars between the United States and China, it is obvious to the economist that China will use its dominant position in rare earth's (precious metals, etc.) as geopolitical leverage when dealing with such matters as international trade. Other dominant countries that provide precious metals are Mexico and South Africa, their statistics are as follows: Mexico produced 21% of the world's silver and South Africa turned out a massive 71% of all the world's platinum (Mining, 2016).

When it comes to crude oil, natural gas, coal, cement, iron, timber, and sugar the three countries leading those commodities are the U.S., Russia, and China (See Figure 2). Brazil, on the other hand, is leading the global competition regarding the supply of coffee beans. How much longer can the global supply chain depend on harvesting virgin raw materials for manufacturing everyday commodities? The aforementioned inquiry is the keynote questionof this research; that said, there is endless information leading up to the propensity of raw material famine; for example,

two things make it difficult to supply… raw materials and they (metals, etc.) are limited on earth… extraction is with great effort and environmental pollution, both have concerned mankind for centuries… even a renewable resource (wood)… used for fires of melting furnaces (Schmidt, 2018) can become a problem if mankind continues to aggressively mine minerals and materials.

Figure 1. Infographic of the raw materials we all rely on.

There are significant signs of raw material depletion: in 1963, a large systematic empirical study by Barnett and Morse, of historic trends for various natural resources between 1870 and 1958 eventually supported the hypothesis of a decreasing (rather than an increasing) scarcity (Schmidt, 2018). Some economic signs of raw material shortage include the tariffs on raw material imports and the quest to harness renewable fuels in storage containers made from raw materials (pig iron, etc.).

One such use of iron as storage for renewable energy is the use of metal hydrides, this particular metal, bonds to hydrogen to form a new compound, the hydrogen/metal bonds are usually covalent (molecular or chemical); that said, the metal hydrides can be adapted to other technologies and thus contribute to design a general model illustrating the influence of raw material prices on the development of energy technologies (Sick, et al. 2019). Considering the methodologies of logistics, an exponential amount of transportation (truck/ship/rail/airplane) is necessary, fuel will be one of the main factors for international and intermodal transportation; given those circumstances, fossil fuel will eventually (connotate) run out, therefore, the need for renewable fuels is presently a focal point for researchers.

Iron ore has become one of the highly sort out raw material for introducing renewable fuels, as a result, research in this field concentrates on the reaction of hydrogen with othermaterials (metal hydrides) as one of the most promising… Although metal hydrides are still subject to research, they offer some characteristics which are essential for mobile applications, particularly in conjunction with fuel cells (Sick, et al. 2019).

Considering the rate at which humans consume (per demand) products and the time (centuries) since we have been doing so, the hypothesis regarding the existence of raw material in the next 30 years propose that renewable energy and closing-the-loop (a cure to the Malthus perspective) on cradle to grave products will positively impact sustainment of raw and renewable materials. Closing-the-loop on previously harvested materials will reduce the intensity of mining, harvesting, and mitigate the destruction of biodiversity. Another factor which will enable

sustainment of virgin materials is legislation and law of the land. For example, the continent of Antarctica contains large mineral and metal deposits, but as of the Antarctic Treaty signed in 1998, no commercial mining is allowed there (Industrial Metal Supply Company, 2019). For too long the practice of cradle to grave (C2G) have been diminishing (no recovery) the earth's natural resources. That said, ODU course PORT 616 (reverse logistics and sustainable operations) introduced students to a sustainable concept, a concept that is backed by legislation in most countries around the globe, some legislation goals "champion" the reduction of the environmental impact by suitable recycling methods, and the discarding of electrical-waste, whereas, abating the socio-economic impact on day to day living.

Homogeneous recovery is the best approach for countering consumers' C2G behaviors if the nine (9) planetary boundaries are to be sustained. It is time to holistically invoke a cradle to cradle (C2C) lifestyle. That said, an attractive repurposed raw material produced in a recycling plant should be relatively homogenous and not too complex in nature. The elemental content of the "material should be well-specified, and the supply of the material should be in suitable quantities and associated with functioning logistic systems" (European Commission, 2019).

The prescriptive analysis in figure 3., suggest a solution to the problem of raw materials depletion, figure 3., presents an illustration of a sustainment-cycle process that is feasible for closing-the-loop on materials, in this illustration, steel is the renewable product, but this concept is applicable to almost all raw materials used by humans for sustainment of life.

Cradle to Cradle Closed-Loop Process Cycle

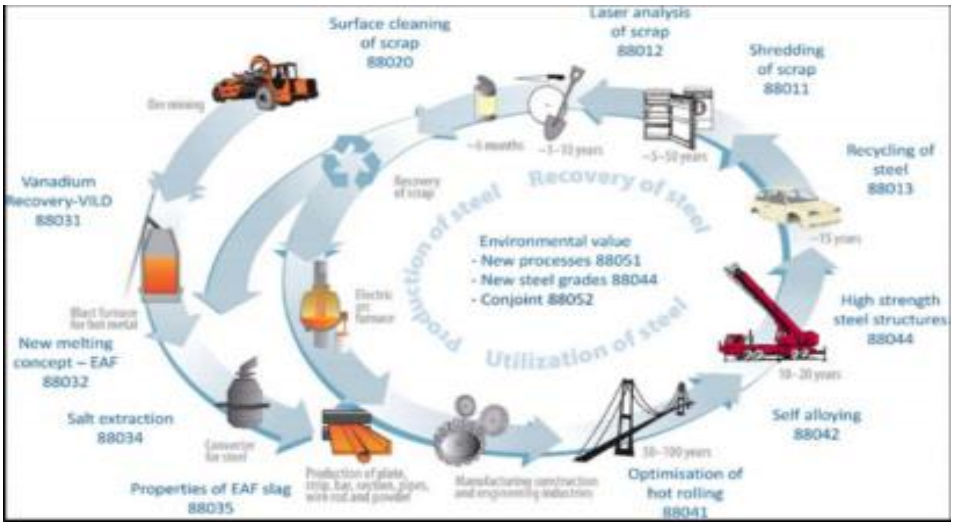

Figure 2. The steel eco-cycle concept – a schematic illustration.

Centralized return centers allow aggregate material to be properly sorted, accounted for, processed, and shipped with little to no constrictions. The greatest challenge with centralized locations is getting society to accept the process as the standard for disposal or preservation of etc., as opposed to flooding landfills with materials that are readily renewable.

When standardization is established, the procurement, distribution, and the shipping of renewable-raw-materials for manufacturing becomes easy in the supply chain network. Characteristics of the centralize return centers include large volume, higher potential revenues/profits, specialized expertise (labor savings), machinery, centralized, consistent decision making and disposition decisions, better organization/management, improved space utilization, customer service, and aggregate data (quality) (Marsillac, 2019).

Maritime transportation (ships) is ideal for transporting C2C materials around the globe. In order to have an idea of the number of raw materials that traverse the continent annually, this report looked closely at how much steel is imported and exported to and from several countries around the globe. Statistics regarding the payload capabilities and type of cargo cape size carriers handle include the following: "According to estimates, 93% cargo of Capesize bulkers comprises of iron ore and coal. While a standard Capesize vessel is around 175,000 DWT, bulkers are up to 400,000 DWT or even more (Maritime Connector, 2019)."

Conclusively, it is impossible to network the supply chain without raw materials (catalyst) for manufacturing. Raw materials produce cars, phones, bridges, food products (flour/cranberry sauce), and many other things consumers need and enjoy. For the sake of fostering a healthy planet and human existence, the rate at which raw materials are extracted must be reduced to levels that have little to no impact on the planetary boundaries. Reducing mining initiatives, while providing products to consumers is not possible without the C2C process, that means renewing raw materials or non-replenishable minerals from the earth by reprocessing/repurposing. The problem with our past and even current practices are our flagrant abuse of the natural resources: mining (any type) obscures the nature of things, it destroys natural habitats for animals, and removes necessary forest/foliage that otherwise increases the soil's fertility.

The entire world is taking a hard look at the preservation of the environment, as opposed to the outlook mining companies have on their financial quarterly reports (although the latter is preferred by venture capitalists), there is a lot of work to be done: getting the layperson to comply with a C2C way of life can prove to be the toughest challenge. Some reasons why mining should cease includes data analysis from the past few decades; for example, more than 2,000 miles of streams… that provide drinking water for millions of Americans… permanently buried and destroyed by mountaintop removal mining. Hundreds of mountains… blown up for the coal beneath. An area the size of Delaware has been flattened (Earth Justice, 2019).

This research resulted in the hypothesis that the global supply chain can depend on harvesting virgin raw materials, for manufacturing everyday commodities (well beyond the next 30 years). However, this is possible when our manufacturing practices are standardized; more so, the longevity of virgin raw materials is highly possible as long as the global supply chains are standardized, thus operating on the principles of reverse logistics and the closed-loop philosophies. Sustainability was proven with the metal hydrides examples as explained in previous paragraphs of this report.

The bottom line is as follows: stop mass mining, adhere to mining regulations where they exist, sign agreements to establish mining regulations where they do not exist, be stewards of the planetary boundaries, practice the principles of lean-six-sigma, and the supply chain will become ecofriendly. The aforementioned should be considered holistically because the consumer levels of demand show no signs of decrease anytime soon. Repurpose all salvageable raw materials for manufacturing/ remanufacturing and save the planet.

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