Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Perspective

COVID-19: A pandemic with positive and negative outcomes on resource and waste flows and stocks

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As of May 15th, more than 4.5 million people worldwide has been infected and more than three hundred thousand died in the COVID-19 pandemic. To halt the epidemic, many countries have endorsed lockdown measures to ensure social distancing and reduce the pressure on medical institutions. Even after lockdowns, social distancing shall remain the norms for several months until herd immunity is built or/and the availability of COVID-19 specific anti-viral medicine and vaccination. The world gross domestic product (GDP) is expected to drop by 3.2 – 4.9% (UNDESA, 2020) demonstrating the serious effects of the pandemics on the world economy with the disruption of supply and production chains. The question of whether overall impacts on resource and waste management and the dynamics of material and energy flows will be positive remain uncertain. In this context, addressing the following points appear essential.

1. A pandemic that questions the viability of current supply chains

Criticality studies deal with the risk of supply disruption and the vulnerability of a system to this risk and usually concern rare geological resources (Graedel and Reck, 2015). The pandemics revealed the criticality of global supply chains could also concern usual commodities. Indeed, the first lockdown imposed in China in February revealed the dependency of the world economy to Chinese production as supply shortages related to metals, textiles, plastics, car parts, electronics, medicine and other goods for which China is the main world exporter occurred. After mid-March, many countries around the world imposed lockdown measures and production output went down in these countries reducing the demand on the parts produced in China. Health commodities experience an opposite trend with an increasing demand in all countries, especially Western countries where the absence of mask wearing habits and the lack of preparedness led to important mismatches between the supply and the demand for masks, medical gowns, disinfectant products, chemical products necessary for PCR tests and breathing apparatus. Critical studies are thus necessary to identify for all types of commodities the current vulnerabilities of supply chains, proposed more resilient ones and design more sustainable trade-off between local and global supply chains.

2. A pandemic with many potential effects to investigate

- **In industrial and service sectors**, currently work-in-progress stocks in industries or service sectors cannot reach the market increasing storage costs and the risk of physical loss and obsolescence inventories. This issue is particularly important for companies producing perishable products such as restaurants and companies not using just-on-time logistics organization.
- **In the agriculture sector**, the current system is strongly dependent on temporary workers for the harvest of crops. With lockdown measures, the impossibility for these workers to access agricultural fields can result in food losses whereas the disruption of global supply chain may lead to the starvation of the many developing countries dependent on imports for their food supply.
- **In the energy sector,** reduction of commuting and industrial activities endorsed by lockdown measures may reduce overall energy consumption. On the other hand, the increase in the time spent at

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home is associated with an increase in the demand of electricity, gas and heat of households for space cooling/heating and household appliances. Besides, with telework suddenly becoming the norm, the pressure on internet connections and data centers increased and so did the associated energy consumption. The carbon content of electricity mix for each country will be determinant to evaluate the effect associated with the increase of these indoor activities.

- **In the transportation sector**, passenger transportation almost stopped during the lockdown, but home delivery of goods and food products increased so that the overall effect on air pollution remain unclear. Besides, even after the end of lockdown measures, social distancing will remain the norm favoring personal cars over collective means of transportation.
- **In the waste management sector**, reduction in industrial activities may lead to a diminution of industrial wastes. However, household wastes may increase due to increased home cooking and an increased demand of home delivery. In addition to household behavioral changes, movements from main residence to secondary residences observed in countries such as France before the enforcement of lockdown measures by authorities may add pressure to rural waste management capacities. Finally, the disposable nature of masks and medical gowns raise the issue of hazardous waste management capacities. Developing countries are particularly at risk as the absence of proper waste management of these hazardous waste may further spread the virus.
- **Regarding material stocks**, it should be noted that contrary to earthquakes, floods, volcanoes eruption, and other natural disasters, the pandemic did not destroy any capital assets but only slowed down human flows and the processing of materials within the economy. In other words, capacity utilization of capital assets remains low as long as social distancing measures are in place but may come back to normal level at the end of the sanitary crisis. However, if the loss of income and consequent unemployment induced by the pandemics further contract the demand, the sanitary crisis may degenerate in an economic crisis leading to the obsolescence of capital assets and a degradation of the material stocks.
- **Regarding social innovation**, the disruption of global supply chain has put in the frontline Fab lab and 3D printing for the local fabrication of masks and other health commodities and the use of substitution materials: cloth face mask made from pillowcases or 100% cotton t-shirts, and snorkeling masks turned into ventilators for hospitals (CDC, 2020; Nicholson et al., 2020). The economic viability of these productions in normal economic conditions is nonetheless doubtful and require investigation. The same can be claimed for telework whose large deployment during the sanitary crisis is a unique social experience, especially in countries like Japan where the pre-crisis use of telework is inexistent. The pandemics is a unique opportunity to better capture the strengths and weaknesses of these new organizations to see how they could contribute to the sustainability of our societies in normal conditions.

In conclusion, many uncertainties remain on the positive and negative effects of the pandemic on the resources and waste flows and stocks as transfer of environmental impact between sectors and regions may be expected. The worldwide degradation of economies will also play an important role in shaping the after-crisis material world. The combination of analytical tools such as material flow analysis, life-cycle assessment, network analysis and input-output analysis appear necessary to fully comprehend the consequences of the COVID-19 epidemics. The development of such analyzes may however depend on our ability to collect unconventional data.

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