

Flattering curves: Leveraging the shapes of a pandemicⁱ

‘Flattening the curve’ has become the theme song of 2020 and it looks like we shall be dancing to it for some time. While awaiting a vaccine or cure to Covid-19, widespread testing remains of utmost importance. This is not a note everyone can sing. Policy-makers’ decisions are driven by wanting to see sufficiency, often resulting in outright abundance.ⁱⁱ However, testing-kits being a scarce and finite resource, abundance in one country contributes to shortages in another. *Can countries effectively help one another other by reallocating surplus inventories across borders?* Supported by supply chain management theory, we posit they can.

The curve and its two phases

To better understand the need for testing and the potential of international collaboration, let’s take a closer look at the shape of the epidemic curve. Figure 1 displays the typical course of an epidemic, starting off slowly with a few cases, followed by a fast and furious increase to a peak, where after the number of infectious people starts to slowly decrease. The first phase is a so-called reinforcing feedback loop where each infected person contaminates more than one other person. Because the novel coronavirus is highly contagious, but symptoms may not quickly manifest themselves, infected people may quickly spread the disease without even being aware. This causes the exponential growth and overburdened hospitals. Early extensive testing, in the first phase of the epidemic, allows for quick confinement of the sick and swifter flattening of the curve.

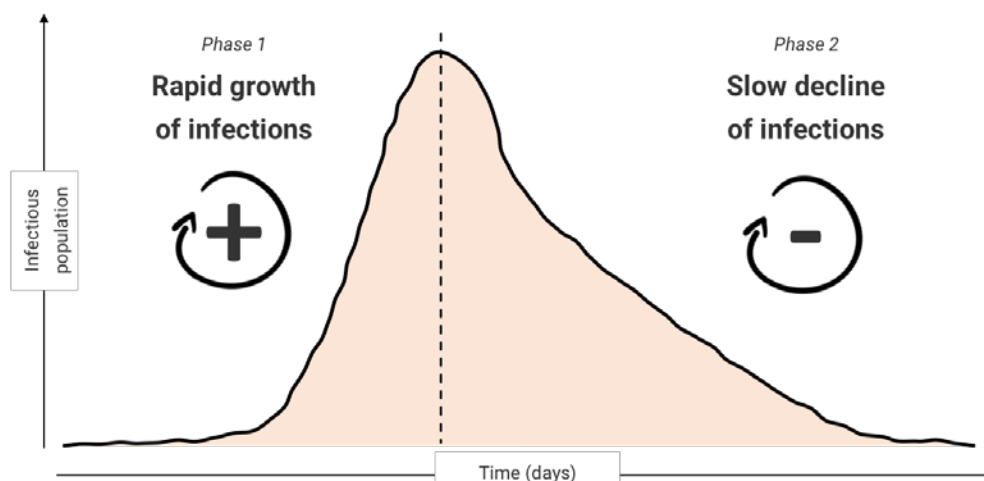


FIGURE 1 - THE TWO PHASES OF AN EPIDEMIC

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ⁱⁱ Kavanagh, Matthew M et al. (2020) Access to lifesaving medical resources for African countries: Covid-19 testing and response, ethics, and politics. The Lancet, Volume 395, Issue 10238, 1735 - 1738

The contagion phase is followed by a recovery phase, during which the number of newly infected people slowly declines. This is known as a balancing feedback loop, a self-stabilizing cycle in which each infected person infects less than one other. Eventually, the disease dies out, and the system is back in equilibrium. This behavior is generic, it will happen everywhere. Even when countries manage to “flatten the curve”, there will still be these two phases of rapid growth and subsequent slow decline.

Phases of growth and decline in Supply Chain Management (SCM)

Phases of growth and decline are well-known territory to supply chain managers. For instance, when introducing new products to the market, it may be difficult to keep pace with increasing demand. Figure 2 shows how this leads to shortages and missed sales. By the time the deliveries are up to speed, demand is declining again, leaving one with obsolete inventory.

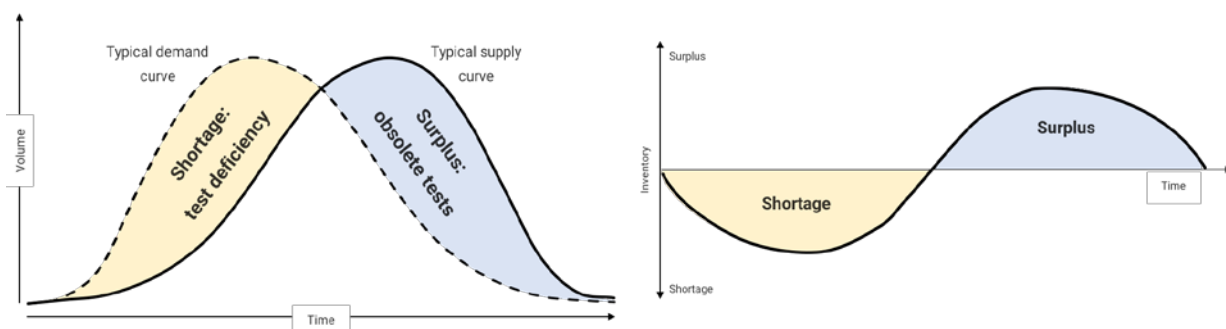


FIGURE 2 – PHASE LAG BETWEEN DEMAND AND SUPPLY OF TESTING KITS

As Figure 2 shows, this can easily be applied to testing kits. Countries in the first phase of the pandemic struggle to get sufficient tests. Reasons for this are plenty: delays in forecasting, decision making, production, shipping, and distribution, or scarcity of raw materials required for tests. Real or perceived shortages lead to amplification of orders, a bullwhip effect further hampering accessibility, creating additional anxiety and irrational behavior.ⁱⁱⁱ

With the onset of the recovery phase, the need for testing declines. Tests are only needed to monitor potential new pockets of contagion so they can be promptly contained. Fewer kits are needed, yet because of hoarding behavior and time lags in supply chains, earlier orders keep rolling in and a surplus starts to build up. While surplus often means obsolescence in business, and shortage of supplies means lost sales, they affect human lives here. Global supply of testing kits is finite and scarce. Hence, obsolete stock in one country affects availability of testing-kits in another:

ⁱⁱⁱ Lee, HL, Padmanabhan, V, Whang, SJ (1997). Information distortion in a supply chain: The bullwhip effect. *Management Science*, 43(4): 546-558

“Health officials report procurements have been unsuccessful because supplies have already been purchased for use in North America and Europe. [...] No single community, country, or continent should bear the full brunt of global shortages. Although difficult decisions in resource allocation are inevitable, it is unethical for African countries to have considerably less access and harder choices than others.”^{iv}

The waltz of the pandemic

A pandemic waltzes rather unpredictably around the globe, hitting countries at different times. Take South Korea, Norway and Colombia, for instance (Figure 3). The phases of contagion and recovery of these countries hardly overlap, with peaks clearly separated. When Norway entered the reinforcing contagion phase early March, South Korea was already in the balancing recovery phase, and when the contagion really started in Colombia early April, the situation in Norway had stabilized.

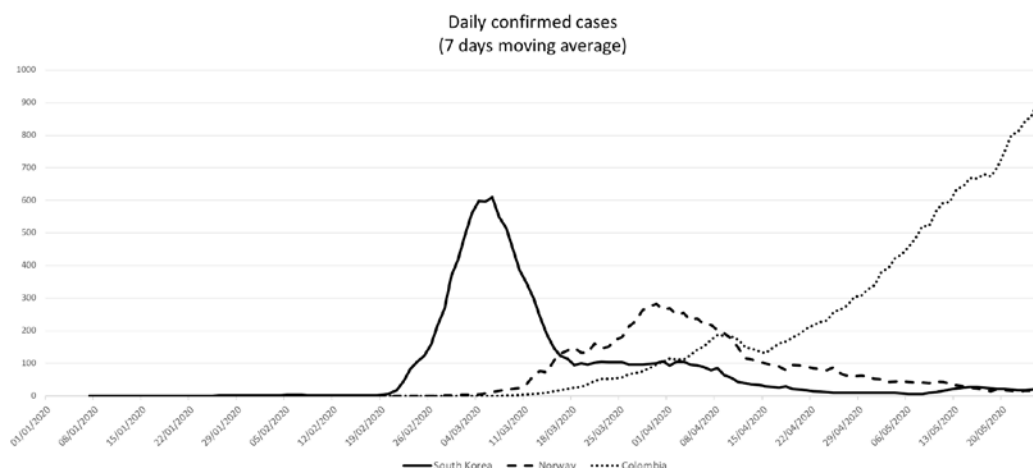


FIGURE 3 - EXAMPLE OF PHASE LAGS IN THE PANDEMIC

Putting A and B together, we note that: 1) some test kits will arrive when they are no longer needed, creating a surplus. 2) some countries will have a surplus when others still struggle with a shortage. This answers our question whether countries can help one another other by reallocating excess inventories across borders.

The idea of collaborating across borders is nothing new. To avoid expensive stockpiling, the SCM literature suggests collaboration across the supply chain to reduce missed sales in the growth phase and obsolete stock in the decline phase. Collaboration is also crucial to improve responsiveness and mitigate effects of a disruption. It requires transparency, i.e. sharing who has what in stock, and coordination, i.e. alignment of objectives and actions. To test whether this ancient wisdom of SCM holds the fort amidst a pandemic, we simulated the idea.

^{iv} Kavanagh, Matthew M et al. (2020) Access to lifesaving medical resources for African countries: Covid-19 testing and response, ethics, and politics. The Lancet, Volume 395, Issue 10238, 1735 - 1738

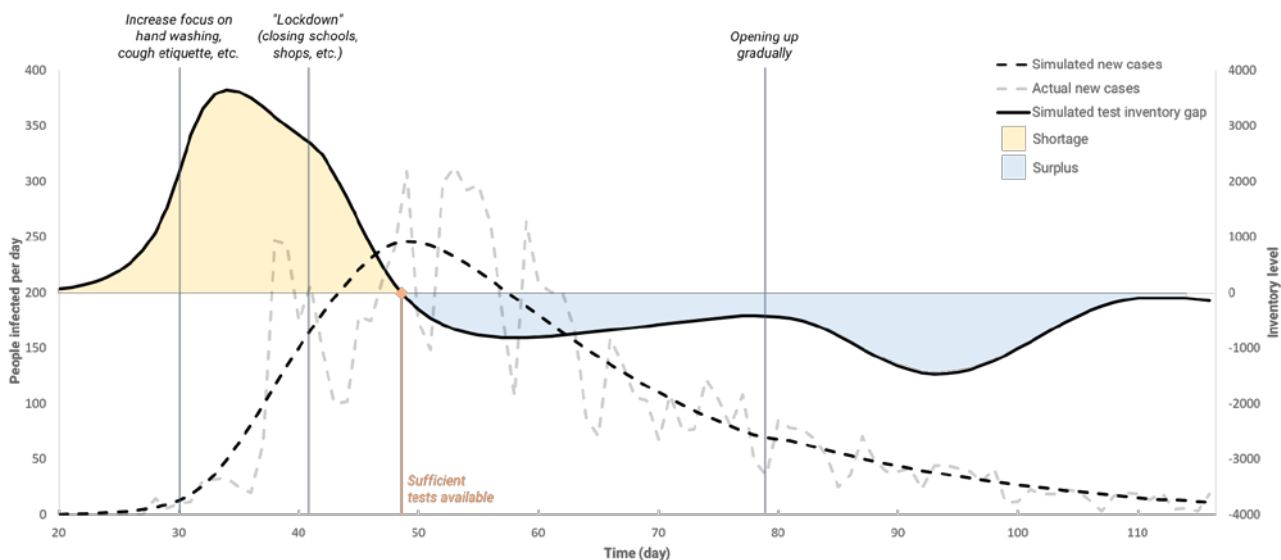


FIGURE 4 - SIMULATED AND ACTUAL NEW CASES OF COVID-19 IN NORWAY

Our model assesses the case of Norway and evaluates the impact of collaboration. Figure 4 displays the actual number of infections and some interventions targeted at “flattening the curve”, e.g. hand washing campaigns. More interestingly, it shows our simulated number of cases and the estimated shortage/surplus of test kits.

Clearly, there was an inventory surplus in the recovery phase. To assess the potential of collaboration (Figure 5), we simulated two scenarios: (1) Norway’s test deficiency was partially (50%) resolved by a second source during the first phase of the outbreak, (2) Norway gave away its surplus of tests when it entered the recovery phase.

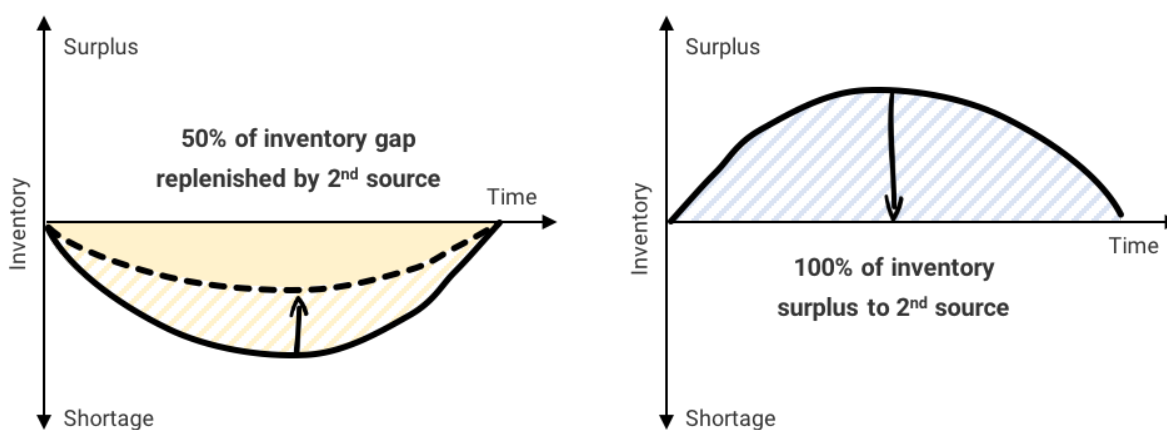


FIGURE 5 – TESTED SCENARIOS

One cannot be too careful in the early days

The first scenario considers the contagion phase. The simulation shows that Norway’s curve would have been completely different had it received half its shortage from another country

(Figure 6): (1) the curve is flatter and (2) the curve starts earlier. By increasing the number of tests, the monitoring of cases improves, resulting in fewer hospitalizations and reduced uncertainty. Furthermore, Norway passes its peak earlier and the stabilized recovery phase sets in sooner. From our simulation it shows that Norway would have been substantially better off with the extra testing capabilities sent by other countries.

Yet, one can be too careful in the later days

The second scenario considers the recovery phase. Norway has a surplus of tests to which it can hold on to - just in case - or it can decide to help others by giving away all of its surplus, keeping just enough for its own basic testing. Although the latter is not without consequences, Figure 5 shows these are quite minor: recovery slows down slightly and hospitalizations continue for a longer period of time.

Giving away tests seems like a huge and risky event when you barely passed the Covid-peak yourself and not many decision makers will dare do so. However, the system is already in self-stabilizing mode and this act of kindness hardly has any consequences for the giver but can save precious lives and flatten the curve for the receiver. Selfishness by being too careful won't help you while you could have helped others.

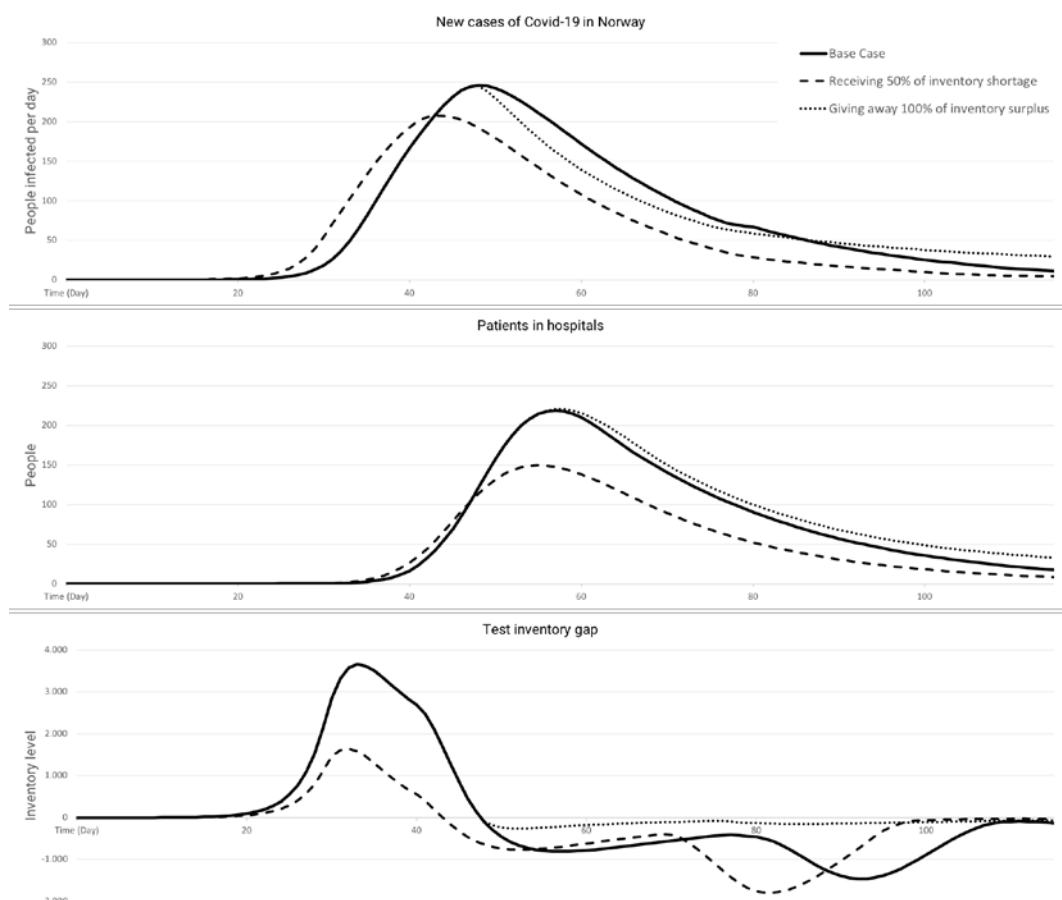


FIGURE 6 - THE EFFECTS OF HAVING MORE INVENTORY IN CONTAGION PHASE AND LESS IN THE RECOVERY PHASE

We are more flattering together

Although the call for collaboration feels rather intuitive, it might still be a blind spot for decision makers. Our model shows we can use the characteristics of pandemics to our advantage. Acknowledging the two phases of the curve, we can exploit the time delays of the pandemic's waltz around the world. Governments have the obligation to protect their citizens. To this end, one cannot be too careful in the contagion phase. However, when the peak has passed this argument no longer holds since the system is already in a self-stabilizing mode. An act of kindness at this stage hardly has any consequences for the giver except that it is indeed flattering to help save lives by flattening the curve for the receiver.

This is not only an ethical imperative but also a shared interest. Covid-19 has taught us the hard way that unaddressed outbreaks in one spot can put the entire world at risk. Although it may be too late to share tests, we might get a second chance when limited supplies of Covid-19 vaccines will need to be allocated. Will those reveling in abundance hold on selfishly to their safety blanket, or generously share their surplus stock to help save their unfortunate neighbor? Paraphrasing the UN Sustainable Development Goals: will we ensure that 'no one is left behind'?