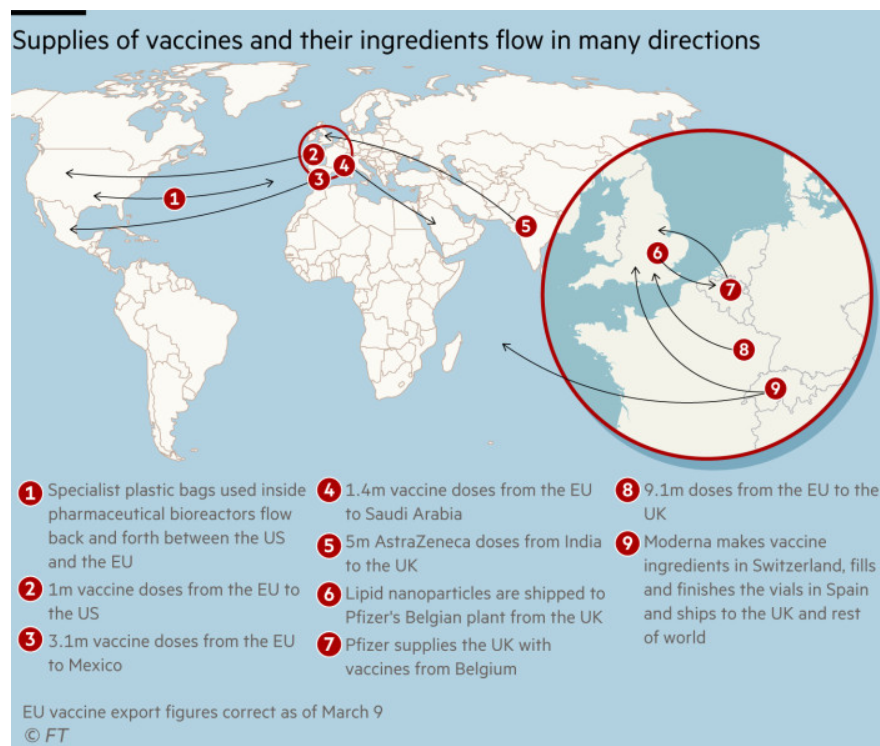


# Resilience of Trans-National Vaccine Supply Networks

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Problem description for ESGI 165 University of Durham

## We've all seen the news headlines



## The question

1. What are the mathematical principles that underlie the equitable resilient supply of COVID vaccines to the UK and to other nations?
2. What are the structural and the dynamical characteristics of the trans-national vaccine supply network and how does it affect its resilience?
3. What is the best strategy to ensure that all nations become COVID safe?

## Academic background

Contemporary organisations rely on international deep and wide supply networks for the procurement of most services, materials, parts, and systems. Although extensive outsourcing generally drives costs down, enables firms to focus on their core competencies, improves flexibility, and promotes innovation (Maskell et al., 2007; Kroes and Ghosh, 2010), it renders them susceptible to disruptions in their supply networks, which might originate deep in the network at a tier where they have very limited visibility (Sodhi et al., 2012; Bode and Wagner, 2015; Snyder et al., 2016). Various high-profile localised incidents, such as a fire at a supplier factory (Chopra and Sodhi, 2004) or continued supplier quality and product development problems (Tang et al., 2009), as well as catastrophic events, such as port strikes (Chopra and Sodhi, 2004) and earthquakes (Park et al., 2013), have disrupted international supply networks in the past decades. Therefore, the initial reaction of the supply chain scholars to the Covid-19 pandemic was to focus on the disruptions to global supply (Haren and Simchi-Levi, 2020; Linton and Vakil, 2020), for instance due to shortages in labour (Nagurney, 2021), temporary shutdown of factories (Haren and Simchi-Levi, 2020; Linton and Vakil, 2020), delays in logistics and protectionist policies of nation states (Xu et al., 2020; Handfield et al., 2020). However, supply networks have been stretched not only by the supply disruptions during the pandemic, but also by the unanticipated dynamics of demand, resulting from changing consumption patterns and behaviours, such as panic buying, product substitution, shifting from commercial to domestic consumption, and the decreased mobility of people (Paul and Chowdhury, 2020; Sheffi, 2020; Xu et al., 2020). Therefore, it is crucial for supply networks to be resilient to shocks from both the demand and the supply sides, so that they are least affected immediately and return to a desirable state in the shortest time possible (Linton and Vakil, 2020; Remko, 2020; Xu et al., 2020; Belhadi et al., 2021; Singh et al., 2021). It has been even argued that supply network viability / survivability, i.e. the ability of networks of individual supply chains to continue functioning in the face of severe shocks, has become a concern amidst the pandemic and the global recession (Ivanov and Dolgui, 2020; Sodhi and Tang, 2021).

The healthy operation of Covid-19 vaccine supply networks is crucial for global economic recovery as well as public health. However, the management of vaccine supply chains is compelling since they are characterised by highly uncertain supply and demand as well as the involvement of multiple stakeholders such as public health authorities and central governments (Duijzer et al., 2018). While different countries prioritise their own nations in the vaccination race, they might still

rely on the vaccines developed and produced in other countries or raw materials procured internationally (Golan et al., 2020), which has for instance created tensions between the EU and the UK (Wikipedia contributors, 2021). Moreover, the decisions and the attitudes of political actors as well as health authorities affect the behaviour of individuals, changing the adoption rate of the vaccine as well as the spreading rate of the disease (Haug et al., 2020; Bavel et al., 2020). Although there is a growing interest in the study of vaccine supply networks, for instance in the optimal design and the re-design of supply networks in developing countries (Lemmens et al., 2016; Lim et al., 2019; Yang et al., 2021), there is limited research on the resilience of global vaccine supply networks (Golan et al., 2020). In this data study group problem, we would like to model and investigate the resilience of Covid-19 vaccine supply networks in a way that would embed them within the broader social, economic, and logistic networks, as outlined above.

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This problem description is based on the outcome of discussions with a range of industry and government bodies in a previous problem-framing “data study group”.