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Domestic Vaccine Manufacturing Capabilities and Pandemic Preparedness

Methodology Note

Supply chain analysis

We use data from the ONS supply and use tables to map out supply chain spending in the pharmaceutical sector from other sectors. We exclude spending within-product purchases as well as spending on retail and wholesale trade services. For the top 10 sectors the pharmaceutical sector relies on, we calculate dependence on imports and how the domestic share of production has changed in recent years, expressed in percentage growth.

For the sectors with the highest import dependence (agricultural and animal products, petrochemicals, and machinery and equipment), we use data on distance from the Atlas of Economic Complexity.[1] Distance is a measure of a country's ability to make a product, measured by how closely related that product is to its current exports. A high distance score represents little similarity to existing capabilities. Distance scores for UK products lie between 0.62 and 0.83. Consequently, we normalise the scores using min-max normalisation to better compare different values.

We map products in the Atlas dataset onto ONS SIC codes using a HS-SIC crosswalk. For the three aforementioned sectors, we shortlist products based on their relevance to pharmaceutical production, and particularly their use in vaccines. We also extend this analysis to components specific to mRNA production, such as enzymes like T7 RNA polymerase.

For agricultural and animal products, we shortlist products like plants and plant parts used in pharmacy, soya beans (used to produce soy lecithin which acts as an adjuvant), as well as oil seeds (used to produce squalene).[2] We exclude birds eggs despite their use in influenza vaccine development because the trade data category does not differentiate between birds eggs for food markets and those for pharmaceutical uses.

For machinery and equipment, our shortlist of products include:

- Air or vacuum pumps (used for filtration, contamination prevention),
- Air conditioning machines,
- refrigerating and freezing equipment (for temperature control),
- Machinery for food and drink manufacturing (such as blenders and mixers),[3]
- And dishwashing machines, including those used to clean and fill bottles and capsules.

Key petrochemical products include:

- Ethyl alcohol (used as a solvent and for sterilisation)

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[1] The Atlas of Economic Complexity
[2] From Sharks to Yeasts: Squalene in the Development of Vaccine Adjuvants - PMC
[3] 8 Types of Mixers Used for Pharmaceuticals

- Cellulose and its derivatives (used as a stabiliser, thickening agent, and to make drug tablets)[4]
- Natural polymers (used for drug delivery and as adjuvants)[5]
- Ion-exchangers (used for virus purification)[6]
- Polymers of ethylene (used in packaging, e.g. High-density polyethylene (HDPE))
- Polyacetals (used in packaging)[7]

We further explore the dependence on imports for each product using 2023 trade value data from the Observatory of Economic Complexity (OEC).[8] This data tells us who the largest importers are, their market shares, and allows us to calculate the Herfindahl-Hirschman index (HHI), a measure of the import concentration. A high HHI score implies that the UK relies on very few countries for a particular product, and is consequently more vulnerable to supply chain disruptions, whereas a low HHI score implies that the UK has a diversified range of partners from which it imports. We also calculate the HHI treating EU countries as a single bloc to capture the UK's reliance on the EU across different products.

Labour market analysis

We use Labour Force Survey (LFS) data to set out quantitatively the labour market structure of the UK's pharmaceutical industry. We construct an occupation-industry cross-walk to calculate the share of each occupation within each sector. For the pharmaceutical supply chain, we weight these shares by the respective sector's share of supply chain spend. We then aggregate these results to calculate the top occupations in the pharmaceutical sector and in the wider supply chain.

For each occupation, we calculate the share of UK workers and share of migrant workers. We also look at the share of the total workforce with a tenure under 5 years to determine where a tighter migration regime would most impact the supply chain. These results are derived by combining 2023-2024 waves of the LFS, using population weights to accurately reflect the actual composition of the workforce.

We also use data from the Employer Skills Survey to map out skills shortages. In particular, we focus on which occupations have high proportions of job vacancies that are difficult to fill due to a lack of skills, qualifications or experience among applicants.

Economic and social impact of vaccination delays

Using UKHSA data for the COVID-19 pandemic on cumulative vaccinations, cases, hospitalisations, and deaths by day and by local authority district, we build Fixed Effects OLS models to quantify the relationship between changes in vaccination and changes in health outcomes at the local authority level.

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[4] Microcrystalline cellulose, a direct compression binder in a quality by design environment—A review - ScienceDirect
[5] Polymeric Nanoparticle-Based Vaccine Adjuvants and Delivery Vehicles - PMC; Use of Biopolymers in Mucosally-Administered Vaccinations for Respiratory Disease - PMC
[6] Single-Step Influenza Virus Purification | Bioradiations
[7] Plastic pharmaceutical packaging: types and requirements | Bormioli Pharma
[8] The Observatory of Economic Complexity

We adjust for national time-variant and time-invariant covariates, such as demography, population density, and national caseload. We also cluster standard errors by local authority and time to soak up regional trends, such as the impact of tiered lockdowns.

We apply our estimates for the impact of vaccination on various health outcomes to a range of scenarios to quantify how changes in vaccine procurement and domestic production capabilities impact on numbers of cases, hospitalisations, and deaths. Using data from the academic literature, NHS reference costs collection, and HM Treasury's Green Book, we then cost these changes in health outcomes in terms of additional demands on the NHS and lost economic output. NHS costs arise from the costs of oxygen therapies, hospital bed occupations, and the primary care costs of long COVID. Economic costs arise from the output loss from deaths, sick days, and GVA losses across sectors of the economy from lockdown.

We model the costs of lockdown by simulating the impact of different lockdown lengths on sectoral GVA and, in turn, on overall GDP and public sector net borrowing (PSNB). Using baseline GVA by sector, we calculate the proportion of output lost in each sector adjusting for exposure to restrictions during the COVID-19 experience. We aggregate these sectoral shocks to derive the total GDP loss associated with a given lockdown length.

Fiscal impact of vaccination delays

Leaning on our lockdown model, we also isolate the fiscal impact of changes in vaccine procurement and domestic production capabilities. We do this by applying fiscal elasticities to translate changes in GDP into estimated effects on tax revenues, public spending, and consequently, PSNB. This approach allows for consistent estimation of the macroeconomic and fiscal costs of lockdowns under different duration and severity scenarios.

ROI on vaccine manufacturing capabilities

We sum the fiscal and economic costs associated with each of our scenarios. To avoid double counting, we consider NHS costs to be subsumed within changes to public sector net borrowing and do not add them into our calculations of total pandemic costs separately. Similarly, we also use HM Treasury's estimate of the tax share of GVA to remove the portion of our economic costs that shows up in our fiscal costs model.

We then calculate the return on investment from changes to government spending on the vaccination programme. We do this by summing the difference between total costs in each of our scenarios and our baseline COVID-19 scenario. We then subtract the change in government spending from this figure, before dividing the result by the change in government spending. The resulting figure gives us the marginal return on changes in government spending in a future pandemic relative to the COVID-19 baseline.

Influenza pandemic modelling

We replicate the modelling above for the event of an influenza pandemic. First, we derive clinical attack rates, case-hospitalisation ratios, and case-fatality ratios from the academic literature on the four influenza pandemics since 1900. We apply these rates to the UK population and adjust for the ratios of observed to logged cases during the last pandemic to realise baseline estimates for total cases, hospitalisations, and deaths for an influenza pandemic which are comparable to our COVID-19 modelling. We then use Borse et al. (2013) analysis on swine flu in the US to identify the impact of vaccination on cases, hospitalisations, and deaths.[9] We use this to model how changes to vaccine availability and domestic production capabilities under a variety of scenarios impacts on key health outcomes.

As above, we monetise these changes to the health burden using NHS reference cost data, HM Treasury's Green Book, QALY valuations from the literature. NHS costs include the costs of oxygen therapies in hospitals. Economic costs arise from the output loss from deaths, sick days, and GVA losses from disease mitigation and sector-specific effects.

To estimate the scale of the economic consequences from disease mitigation and sector-specific effects, we lean on Smith et al. (2011) analysis, which builds a computable general equilibrium (CGE) model of the UK economy during a swine flu–type event.[10] We then estimate the fiscal impact of an influenza-type pandemic.

We then quantify the fiscal costs of an influenza pandemic by summing NHS costs and the tax share of lost GVA from economic costs. We choose to lean on the literature and other costs to derive fiscal impact in the case of a swine flu–type event to ensure that our estimate is not impacted by noise in PSNB data from the severe impact of the 2008 financial crash during this period.

Finally, we calculate the return on investment across a variety of vaccine procurement strategies by summing the above costs, subtracting changes in initial outlay on vaccine procurement, and dividing the result by changes in this initial outlay. As above, this gives us the marginal return on changes in government spending in a future influenza pandemic relative to previous baselines.

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[9] Borse RH, Shrestha SS, Fiore AE, Atkins CY, Singleton JA, Furlow C, et al. Effects of Vaccine Program against Pandemic Influenza A(H1N1) Virus, United States, 2009–2010. Emerg Infect Dis. 2013;19(3):439-448. https://doi.org/10.3201/eid1903.120394

[10] Smith, RD, Keogh-Brown MR, and Barnett, T. Estimating the economic impact of pandemic influenza: An application of the computable general equilibrium model to the UK. Social Science & Medicine 2011;72(2):235-244. https://www.sciencedirect.com/science/article/pii/S0277953611003029