The impact of COVID-19 on Europeans' economies: first and second-order supply and demand shocks

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Extended Abstract

1. Introduction

In this paper we examine the economic and welfare effects of the COVID-19 pandemic for a set of European countries, based on a (frontier) production model with upstream-downstream sectoral linkages. Our empirical model is developed using the theoretical framework introduced by Caliendo et al (2017) to study the impact of intersectoral and interregional trade linkages in propagating disaggregated productivity changes to the rest of the economy. This framework allows us to both control for sectoral heterogeneity productivity and for the effects caused by the competition for intermediate inputs in a globalized world. Our econometric specification also accounts for technological spillovers through the linkage of industries in the same fashion as Liu and Cheng (2021). This study uses a non-frontier Cobb–Douglas production function with spatial externalities to simulate the economic effects of the COVID-19 pandemic outbreak for a set of Asian-Pacific countries. The frontier specification of our production model permits simulating the underutilization of capacity directly attributable to the COVID-19 outbreak as well as larger misallocations of resources within the industries.

The paper's main contribution is to provide an analytical framework that can simulate a large variety of cascading effects caused by the public health measures implemented in each country and the changes in preferences aiming to avoid infection. Deriving overall impact estimates involves modelling immediate (first-order) supply and demand-side shocks, as well as second-order effects, such as the decline in aggregate consumption as workers experience a reduction in income, and the additional output reduction due to shortages of materials or components due to the disruption of the production of intermediate inputs in the upstream countries, the blockage of technology diffusion caused by the trade and travel restriction measures, the deterioration in capacity utilization due to factory closures, and the output (productivity) reductions associated to a deterioration of sectors' comparative advantage in international trade.

To perform the analysis and calibrate the model for the 28 European countries considered, we use data from two different sources: EU KLEMS (van Ark and Jäger, 2017; Stehrer, 2021) and World Input-Output Database (Timmer et al., 2015). Using the information available in EU KLEMS for the period 1995-2017 we obtain data for the values of the main variables: capital service and capital compensation; labour service and labour compensation; and intermediate inputs; as well as gross output and value-added. Making use of the information on intercountry trade flows from WIOD, we can compute some of the parameters needed such as the bilateral trade shares and the regional trade surpluses. Additionally, also from WIOD, we obtain the shares of value-added in gross output and final consumption shares by sector and country.

2. Theoretical framework

Our empirical model is inspired in the static two factor model with N regions and J sectors developed by Caliendo et al (2017) to study the impact of intersectoral and interregional trade linkages in propagating productivity changes to the rest of the economy. In our empirical application the regions are the European countries. They assumed an economy with two factors, labor and a composite factor comprising land and structures that we associate to capital. Sectoral final goods are used for consumption and as material inputs into the production of intermediate goods in all industries. In each sector, final goods are produced using a continuum of varieties of intermediate goods in that sector. A given sector may be either tradable, in which case goods from that sector may be traded at a cost across regions, or non-tradable.[1] While final goods in their model are non-tradable, the intermediate goods in tradable sectors are costly to trade.

We denote a particular country by $n = 1, \ldots, N$ and a particular industry by $j = 1, \ldots, J$. Following Eaton and Kortum's (2002) probabilistic representation of technologies allowing productivities to differ by country and also by sectors, Caliendo et al (2017) assumed that the firms located in region n and operating in sector j produce a continuum of varieties of intermediate goods. Each firm has its own idiosyncratic productivity level. The dispersion of productivities is modelled using the inverse of an industry-specific parameter, θ^j, that can be interpreted as a trade elasticity that determines how trade flows react to changes in trade costs. Intuitively, the relationship between productivity volatility and trade elasticity works as follows. In the context of this model, a smaller value of θ^j implies a higher dispersion of productivity across goods, a notion of comparative advantage. If productivity is less dispersed, as indicated by a larger value of θ^j, then a change in trade costs will not change the share of traded goods in a substantial way because those goods are less substitutable, and producers are less likely to change their suppliers.

Assuming a global competitive market for intermediate goods, and having solved for the distribution of prices, we can measure sectoral total factor productivity in region n and sector j as

$$lnA_n^j = lnY_n^j - (1 - \beta_n^j)\gamma_n^j lnL_n^j - \beta_n^j \gamma_n^j lnK_n^j - \sum_{k=1}^{J} \gamma_n^{jk} lnM_n^{jk} \qquad (1)$$

where Y_n^j is a measure of real gross production in region-sector pair (n, j); K_n^j and L_n^j denote the demand for capital and labor respectively; M_n^{jk} is the demand for material inputs by firms in sector j from sector k; $\gamma_n^{jk} \geq 0$ is the share of sector j goods spent on materials from sector k; and $\gamma_n^j > 0$ is the share of value added in gross output.

Manipulating equation (1) we get the following production function:

$$Y_n^j = A_n^j \left[(K_n^j)^{\beta_n^j} (L_n^j)^{1-\beta_n^j} \right]^{\gamma_n^j} \prod_{k=1}^{J} (M_n^{jk})^{\gamma_n^{jk}} \qquad (2)$$

where the term in brackets can be interpreted as a value-added production function. Notice that both value-added shares and intermediate goods shares in gross output (i.e. γ_n^j and γ_n^{jk}) and labor and capital shares in value added (i.e. β_n^j and $1 - \beta_n^j$) vary across regions and industries. As pointed out by Liu and Sickles (2021), this parameter heterogeneity should be considered in productivity growth analyses using industry-level data, as such heterogeneity is intrinsic due

[1] Caliendo et al (2017) abstracted from international trade because they focused their analysis on the US economy.

to techno-economical features of each distinct sector. These share parameters can be computed, by sector and country, using the information on inter-country trade flows from the World Input–Output Database (WIOD). This is an appealing feature of our approach because it allows for heterogeneous parameters when modeling the technology of each industry.

The way of propagating the effects from one region to another (or one country to another in our case) enters in how TFP is defined:

$$lnA_n^j = \gamma_n^j lnT_n^j - \frac{1}{\theta^j} ln\pi_n^j \tag{3}$$

The first term in (3) depends on what Caliendo et al (2017) labelled as 'fundamental' productivity, T_n^j, a new concept of productivity that refers to how much value added can be produced in the absence of intermediate inputs. This industry-specific productivity indicator is common to all firms located in region n and operating in sector j, and it might increase over time for several reasons, e.g., technological progress, larger utilizations of capacity, better allocations of inputs within the industry, or the existence of knowledge spillovers. The second term depends on region's share of its own intermediate goods (π_n^j). With no trade, $\pi_n^j = 1$. Therefore, this equation indicates that, with no trade, a region and sector specific productivity change has no effect on the measured productivity of any other region or sector. In contrast, with trade, productivity changes are propagated across sectors and regions. A major contribution of Caliendo et al (2017) is to prove that the competition for intermediate inputs in a globalized world propagates productivity changes across sectors and regions. They show that this effect of trade on measured productivity arises by way of a 'selection' effect, which is entirely captured in equation (3) by the region's share of its own intermediate goods, π_n^j.

With this framework, we are able to show the contagion effects of impacts occurring in one country over the other ones by industrial sector, and also in terms of total output, GDP change and welfare.

3. Combining immediate supply and demand shocks

So far, most of the articles have examined the immediate (first-order) supply shocks attributed to the COVID-19 pandemic through reduced working hours or the deterioration in capacity utilization due to factory closures. However, del Rio-Chanona et al (2020) point out that deriving overall impact estimates attributed to the COVID-19 pandemic involves modelling both supply and demand-side shocks. Although aggregate effects are generally dominated by supply shocks, they find that sectors such as Transport, Entertainment, Restaurants, and Hotels are likely to experience immediate demand-side reductions that are larger than their corresponding supply-side shocks. General and systemic impact estimates attributed to the COVID-19 pandemic should not only involve modelling first-order (immediate) shocks, but also second-order (cascading) effects. In this paper, we outline a couple of second-order supply-side effects that keep production partially halted due to shortages of materials or components, the deterioration of sectors' comparative advantage in international trade, as well as the blockage of technology diffusion caused by the trade and travel restriction measures.

Keywords: Spatial stochastic frontier models, upstream-downstream sectoral linkages, COVID-19 pandemic, EU countries.