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In and out lockdowns: Identifying the centrality of economic activities

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The effects of the Covid lockdown have been very severe in Italy, with a reduction in the value of potential output produced peaking at 69% for the construction and real estate and 63% for Mechanics. As a result, GDP is expected to drop by around 10% in 2020, according to most forecasts. Most activities were reopened on May 4th, although within strict social distancing and health safety guidelines. In this paper we argue that a targeted exit from the lockdown could have been implemented instead. Priority could have been given to those activities with the greatest impact on the national economy. This targeted strategy, combined with an assessment of the inherent health risks of each activity, would have reduced the risks of a second wave of contagion, still reactivating gross output and jobs to a similar extent of the general reopening actually implemented. In this study we propose a methodology to identify production activities for which total or partial closures or reopening would have the greatest impact on the country's GDP, output and employment, using input output tables and network centrality measures in production chains. The administrative lockdown implemented up to May 4th, if kept for one year, would wipe out 52% of GDP. The targeted reopening proposed

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here would reduce this negative impact by 70%. Our methodology could be applied also in the in the unfortunate event of a new wave of contagion and a new targeted lockdown.

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1. INTRODUCTION

The projections of the International Monetary Fund and of the main research institutes foresee a substantial reduction in world GDP in 2020 of more than 3%, driven by two main factors. On one hand, a supply shock due to the containment policies imposed by governments or by the self-restraint measures adopted by many firms. On the other hand, a demand shock triggered by uncertainty about the future and a decline in incomes and revenues hampering both consumption and investment.

The effects of the containment policies have been especially severe in Italy, with an overall reduction of 44% in the value of potential output produced, peaking at 69% for the construction and real estate and 63% for Mechanics. As a result, GDP in expected to drop close to 10% in 2020.

Closing economic activities, and reopening them when viable, requires a careful and measured action, aimed at minimizing health risks for those returning to work and for the country at large. Yet, at the same time, priority should be given to those activities with the greatest impact on the national economy. How to identify such activities? A similar question would emerge in case a country needs to control the risk of diffusion and thus has to introduce restriction on activities.

In this study, we propose a methodology to identify production activities for which total or partial closures have the greatest negative impact on the country's GDP, output and employment, and therefore have the greatest impact when reopened. Our approach aims at providing a tool for guiding the discussion on how to find a balance between operating safely and allowing the economy work as much as possible.

Understanding how to minimize the impact of the lockdown on the economy is of course important to design the re-opening strategy, but it is even more crucial to be ready to face a possible resurgence of the Covid-19 pandemic in the coming months, or the spread of a new pandemic in the next years. While we all wish that these events will never happen, we cannot risk being again unprepared to face them.

Identifying core sectors of the economy is not easy, because dimension is not the only issue. Given the tangled nature of value-chains, there are activities that weigh little from a quantitative point of view, but are fundamental links in several production chains, and therefore have a significant indirect impact on the production capacity of the country. Unfolding the impact of the interconnections among different sectors of activity has a long tradition in the economic literature, starting at least from the seminal contribution of Vassily Leontief (1936) on Input-Output (IO) relations. A parallel strand of analysis, closer to the business and management literature, has developed from the concept of value chain, building on the seminal contribution of Porter (1985). We merge these two strands of literature, integrating information from the IO matrices of the Italian economy (produced by Istat), with those from the structure of the value chains of the Italian economy, built by Prometeia.[1] To this purpose, we exploit and combine two sets of analytical tools that have been developed in the recent years: the methodology to extract some economics sectors from IO matrices proposed by Dietzenbacher et al. (2013), and the techniques used by social network analysis to identify key players within a system (Jackson, 2008).

We apply our analysis to the case of Italy, where prior to May 4th, 2020 only essential activities were exempted from the lockdown. Our results clearly show how a targeted action on a limited number of

[1] Value chains refers primarily to the value added in each step of production; since we are interested on the relevance of each step for the production and sale of the final goods, in the following we will interchangeably identify these networks as production chains.

industries, experiencing major lockdowns, can have a very significant impact on aggregate output. The activation of 20 central sectors in the national production system identified with this approach would have increased the value of production of Italian companies from 56% to 76% of the pre-Covid-19 national levels, with a particularly strong impact in some production chains. For instance, output of Mechanics would increase from 37% to 84% and of Constructions from 31% to 77% with respect to their pre-Covid-19 level. The prevailing level of lockdown, if kept for a year long, would have implied a drop in GDP of 52%. The reopening of the sectors identified above would have reduced this fall to 16%.

With our approach we identify three types of activities. First, we identify cross-cutting sectors, generally located upstream in the production processes. These are sizeable suppliers of many production chains at the same time, such as e.g. wholesale of industrial goods; machines for wrapping and packaging. Second, we identify activities with impact contained within a single production chain, but which are sizeable and central in some very large value chains like Automobile or Textile and Clothing. Finally, activities that are quantitatively less significant, but the activation of which is necessary for the functioning of an entire chain, for example chemistry for the Food industry.

This work faces some caveats.

First, we refrain from any epidemiological evaluation or the relative degree of safety of the various activities and how they can be reorganized to reduce the risk of contagion among workers. This is outside our areas of expertise. Yet, it is clear that security concerns are the key factor in the reopening decisions. However, operationally, such concerns will also have to be combined with an assessment of the economic impact of specific activities, as discussed in the present work. Many of the papers that have been written in these last months mainly focus on the epidemiology of the now famous SIR model and its variants, but they often treat the economy as a monolithic single sector. The present paper thus offers a complement to these works.

Second, the economic impact of industries also has a fundamental local dimension at a regional/provincial level in a country, given the heterogeneous spread of economic activities and, from the point of view of safety, the heterogeneous distribution of the outbreaks. It is our intention to extend this work later to include these considerations.

Finally, there is an international dimension to consider, given the global nature of the value chains. There is an issue of locked markets, both for the supply of components and semi-finished products and for the sale of exported products. And there is also an issue of strategic competition. In many cases, foreign competitors were open in certain countries but not in others. For instance, in France and Germany, most of the production activities were not affected by administrative. Seen from the perspective of an individual market, like Italy there is of course a risk of production chains relocating towards other competing countries. In this work, we will take stock of the international openness of industries, but we do not consider potential and actual constraints faced in international markets and we just focus on the national dimension of value chains.

The rest of the paper is organized as follows. Section 2 presents the data uses in the analysis. Section 3 describes the methodology and the intermediate results of each step of the analysis. Section 4 discusses the overall picture and proposes some possible extensions of the analysis.

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2. THE DATA: INPUT-OUTPUT TABLES AND PRODUICTION CHAINS

Ideally, to describe accurately the network of relationships among suppliers and users along a value chain we could use invoice data at the firm level, which are in principle available in some countries like Italy. To evaluate the total impact of the closure of one or more production activities, we would also need to assess the degree of substitutability between suppliers producing similar products, and between similar factors of production. Some suppliers can in fact be easily replaced, others less so. At the same time, some factors of production are essential, energy is a good example, while others may not be necessary for the continuation of production activities, especially if the shortage is limited to a tolerable period of time.

Unfortunately, this detailed information on the relationships between individual firms is rarely available for economic analysis. It is therefore necessary to make the best use of the information available, by integrating different sources, as we do in this paper. Our analysis is based on two main complementary sources: Istat's Input-Output (IO) tables and Prometeia's analysis of the structure of production chains.

Built following a standardized methodology (see, for example, Miller and Blait, 2009), Istat's IO tables report the value of intermediate flows of goods among the 63 sectors of the Italian economy, according to the classification of NACE revision 2 (the Statistical Classification of Economic Activities in the European Community).[2] For each sector, IO tables report along a column the value of the goods purchased from another sector, and value added (capital and labour). Symmetrically, along a row, they report the value of the goods sold to another sector or used to satisfy final demand. Total values are consistent with the aggregates of national accounts.

Both the direct contribution of individual industries to GDP and their ability to activate other branches can be measured by using IO matrices. As it is well known, if production in each sector can be described by fixed-coefficients, such as with a "Leontief technology", IO tables fully capture the upstream impact of changes in downstream sectors. A 10% increase in the final demand of goods produced by a given sector, for example, will cause a proportional increase in the usage of each factor necessary for the production of this good. In turn, this will cause a proportional increase in the usage of all factors necessary for the production of these inputs, and so on recursively according to the process at the basis of Leontief's intuition. While in the long-run a fixed-coefficient technology would be a strong assumption, it is acceptable to describe the short-term impact of an unexpected shock such that caused by the Covid-19 pandemic.

What IO tables are not good at capturing is the impact of changes in upstream sectors on the activities of downstream sectors. Even following the methodology first introduced by Ghosh (1958), when it comes to downstream relationships, the implicit assumption of IO tables is that a 10% contraction in the supply of a given input causes a proportional drop in the production in the downstream sectors, which is the same as assuming that the production technology is linear, implying an infinite elasticity of substitution among inputs. Indeed, this is a strong assumption, that would certainly lead to an underestimation of the impact of shocks in upstream sectors.

To partly overcome the limits of IO tables in studying the impact of shocks in upstream sectors, we have used the information collected by Prometeia on Italy's production chains. It is well known that the Italian economy is characterized by a large number of medium and small firms, intertwined in a web of usually

[2] ATECO, the classification commonly used in Italy, used the national version of NACE revision 2.

informal connections at the geographical level and at different phases of the production process (Camagni and Silone, 1993). Although a proper and unique definition of production chains is not available, production chains are in fact practical and effective tools of analysis that practitioners use in applied research.[3]

To account for the characteristics of this industrial structure, Prometeia has classified the entire Italian economy into 12 production chains ("filiere produttive"): Agrifood, Automotive, Home: furniture and design, Shipbuilding and aerospace, Construction and real estate, Energy and utility, Mechanics and Engineering, Fashion & beauty, Health, Media and TLC, Land transport and logistic, Tourism and travel. With respect to Italy's GDP, this mapping leaves aside only part of the activities provided by the public sector, such as defense and education. The objective of this classification is to describe "the full range of activities that firms and workers perform to bring a product from its conception to its end use and beyond" (Gereffi and Fernandez-Stark, 2011). Its rationale follows from the analysis of value chains in the business literature (Porter, 1985), and shares many points with the recent literature on global value chains, that are characterized by fragmentation of production processes, specialization in tasks and business functions rather than in the production of specific products.[4]

Within each production chain, identified by the main product or service sold in the final markets, Prometeia has identified all sectors producing goods and services used as inputs, including distribution and support services. The unit of this classification is at the level of 192 micro-sectors, obtained aggregating the Ateco (NACE revision e) classification at 5 digits into cluster of activities characterized by common inputs, working processes and final markets. Each chain is therefore fully characterized by the set of micro-sectors that contribute to the production of the a good or service. In addition, the production chain is split into four major sequential phases in the pace of production: sourcing and raw materials processing, intermediate output and part and component processing, final production of goods or services, distribution (wholesale and retail) and support services.

This provides a complete assessment of the links involved in production chains, including those crucial upstream services for the functioning of most production chains (design, marketing, logistics, etc.), the provision of capital goods for production (e.g., machines for the food industry in agri-food production chain) and the wholesale and retail distributive channels necessary for such products to reach their respective markets. Table 1 describes the agri-food production chain in detail, showing that: 1) agriculture and wholesalers of agricultural products belong to the first stage; 2) firms providing the transformation of agricultural products, producers of food packaging, food processing and manufacturers of packaging machines, producers of food and beverage additives belong to the second stage; 3) producers of final food products ready for consumption (e.g., beer, pasta, pet food) are in the third stage; and 4) distribution (wholesale and retail), logistics and transportation of food products and support to food businesses (certifications, marketing) belong to the fourth stage.

[3] For a discussion see Bidet-Mayer and Toubal (2013).

[4] Starting from the seminal contribution of Antras (2003), the literature on global value chains is burgeoning; for some recent developments, see Antras and Chor (2013), Alfaro et al. (2019), and Cipollina et al. (2020).

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Table 1 – The agri-food production chain

Sourcing and raw materials processing	Intermediate output and part and component processing	Final output products and/or services	Distribution and support services
Agriculture and Fishery Wholesale trade of agricultural products Chemicals products for agriculture	Butchery, meat and other animal products processing Milling industry Chemical products for food processing Food and beverage packaging materials Machinery for food processing and packaging	Processed food (pasta, bakery, frozen foods, cheese, ...) Non-alcoholic beverages Wine, beer and spirits Coffee and tea Confectionery and chocolate Pet food	Wholesale trade of food and beverages Retail trade of food and beverages Maketing, certification and other services for the food industry Cold chain and other food trasnsportation and logistic

3. EMPIRICAL METHODOLOGY AND INTEMEDIATE RESULTS

Our empirical strategy is based on threes steps. First, among all sectors present in the IO tables, we identify those sectors whose closure causes a larger drop of GDP. Second, we identify the production chains that characterize these sectors and use social network analysis to study the links among each micro-sector. In this way we can identify what are the most central micro-sectors within each production chain. Third, assuming that these micro-sectors contribute to the activity of the entire sector to which they belong in proportion to their output value, we use IO tables to estimate back the impact on GDP of their re-opening. In the following, we will describe each step in detail. The steps are assessed with specific reference to the Italian experience but the approach can be generalized to other countries.

3.1. Input-Output tables

To identify those sectors whose closure causes a larger drop of GDP, we use the methodology proposed by Dietzenbacher and Lahr (2013), simulating the effect of the total or partial lockdown of a sector. In practice, we single out each row of the table referring to one of the 63 sectors of the Italian IO tables and multiply its values (excluding those along the main diagonal, but including those of the final demand) by zero if the sector is fully closed and by its share of activity if only part of the sector is closed. To this purpose, we assume that only essential activities – that are defined by the two decrees promulgated by Italy's Prime Minister on March 22 and April 10, 2020 at a finer disaggregation level than the 63 sectors of the IO tables – are open, and that they contribute to the overall activity of each sector in proportion to their share in its total production.

Proceeding in turn for each sector (i.e., excluding interaction effects), we calculate the impact of a yearly lockdown on GDP. Table 2 below lists those sectors with an impact greater than 3% on GDP.

Table 2 – Impact of the lockdown on GDP

The table reports the estimates of the drop in GDP caused by the lockdown of a sector's economic activities, excluding essential activities as defined by the decrees promulgated by Italy's Prime Minister on March 22 and April 10, 2020. Only sectors with an estimated drop larger than 3% of GDP are listed.

NACE Code	Description	Impact on GDP (in %)
V28	Manufacture of machinery and equipment n.e.c..	-11,1
VF	Construction	-10,7
V46	Wholesale trade, except of motor vehicles and motorcycles	-9,2
VI	Accommodation and food service activities	-8,7
V29	Manufacture of motor vehicles, trailers and semi-trailers	-8,3
V13_15	Manufacture of textiles wearing apparel, leather and related products	-7,6
V25	Manufacture of fabricated metal products, except machinery and equipment	-7,5
V24	Manufacture of basic metals	-6,4
V31_32	Manufacture of furniture and other manufacturing	-3,4
V22	Manufacture of rubber and plastic products	-3,2
V27	Manufacture of electrical equipment	-3,2
V47	Retail trade, except of motor vehicles and motorcycles	-3,1

The size of the decline in GDP can be decomposed into three factors. First, the size of the sector; second, the degree of interconnection between the sector and others upstream and downstream; third, the degree of closure of the sector imposed by the Ministerial Decrees (i.e., the impact will be larger, the larger the extent of the lockdown).

The impact of the closure of production activities on GDP is consequently not uniform across industries. For example, the decline in GDP of over 10% related to the manufacture of machinery and equipment is because the industry is large, highly interconnected and 70% of its output is foregone because of the administrative restrictions. The lockdown of the construction industry, operating at 30%, is estimated to have a similar impact.

The sectors identified at NACE 2 digits are large and made of heterogeneous activities. At the same time, activities which are relatively small and have small weights in Input Output tables, may provide crucial inputs or crucial outlets to more than one production chain. Hence their closure may endanger a large share of national output anyway. This effect would not be detected by input-output table. For this reason, we must revert to finer industry statistics, and also to the analysis of specific production chains.

3.2. Production chains

In the analysis of the production chains, our unit of analysis is what we call "micro-sector", i.e. the smallest unit of observation available in the chains. Using the terminology of social network analysis, each production chain naturally maps into a weighted and possibly directional graph, in which the node is the micro-sector, the link corresponds to a business relationship, the orientation corresponds to the supplier-

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customer direction, and the weight can be measured by the relevance of the links, such as the value or the number of upstream and downstream connections.[5]

In our analysis, we posit the existence of a link between two micro-sectors if they belong to at least one common production chain. Moreover, we weight the link with the number of production chains that each couple of micro-sectors have in common. In practice, if micro-sector A belongs to production chains 1, 2, 3 and 4 and micro-sector B belongs to the production chains 2, 3, 4, 5, 6 and 7, A and B are linked with a weight of 3 (since they are linked in production chains 2, 3 and 4). Using this methodology, and assuming no directionality, we build a 192x192 symmetric adjacency matrix, in which each cell *i,j* represents the weight of the link between micro-sector *i* and micro-sector *j* (with a value of zero if there is no link).

In principles, we could have focused on all the links among the 192 micro-sectors uncovered by our 12 production chains. However, such a network would have been excessively dense and the results difficult to interpret. For this reason, we have focused only on the links among micro-sectors which belong to the 12 sectors listed in Table 2, those whose closure has a stronger negative impact on GDP. We therefore obtain an adjacency matrix with 12,838 potential links, 9,392 of which within a single production chain.[6] Figure 1 reports the degree distribution, depicting on the y-axis the number of micro-sectors that have the number of connections reported on the x-axis (excluding those unconnected).

Having characterized the network of productive relationships, the next step is to identify the most relevant nodes.

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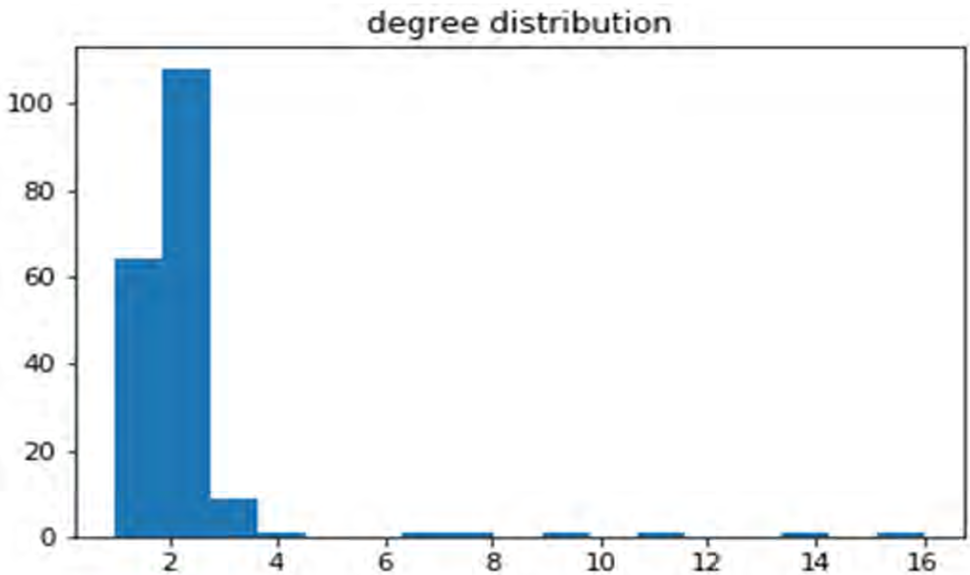
[5] See Jackson (2008) and Newman (2010) for a thorough introduction to social network analysis and the methodologies used in this paper.
[6] Restricting to this smaller adjacency matrix is also consistent with the subsequent identification of the most central micro-sector of the basis of the ranking based on eigen values, which is specific to the network considered.

Figure 1 – Network degree distribution

The y-axis reports the number of micro-sectors that have the number of links reported on the x-axis (unconnected micro-sectors are excluded)



Clearly, the micro-sector with 15 links is more likely to have a prominent role in production than those with just one link. The literature on social networks has proposed several measures to characterize the relevance of each unit (or node) in addition to the number of connections. We choose the eigenvector centrality, that is a measure frequently used to estimate the relative relevance of a node within a network which increases with the number of connections (production chain links) and with the centrality of the nodes with which each node is connected to. Micro-sectors with a higher eigenvector centrality, therefore, are more relevant within each production chain and across a larger number of production chains.

Figure 2 provides a representation of our network, obtained with the Python library *igraph* using the Kamada-Kawai display algorithm. To allow a neater presentation, the graph is first reduced through a maximum spanning tree algorithm (which retains only the strongest links between micro-sectors) and then plotted according to a force directed layout (to spread the sectors dependently on their proximity). Each dot represents a micro-sector, with a size proportional to its eigenvector centrality. The 'tails' in the picture represent production chains and their dots correspond to micro-sectors which only belong to a single production chain, therefore having lower centrality values. Dots in the center represent micro-sectors with higher centrality values, because they interact with a larger number of micro-sectors across different production chains (e.g., wholesalers of intermediate industrial goods).

Figure 2 – Micro-sector's network

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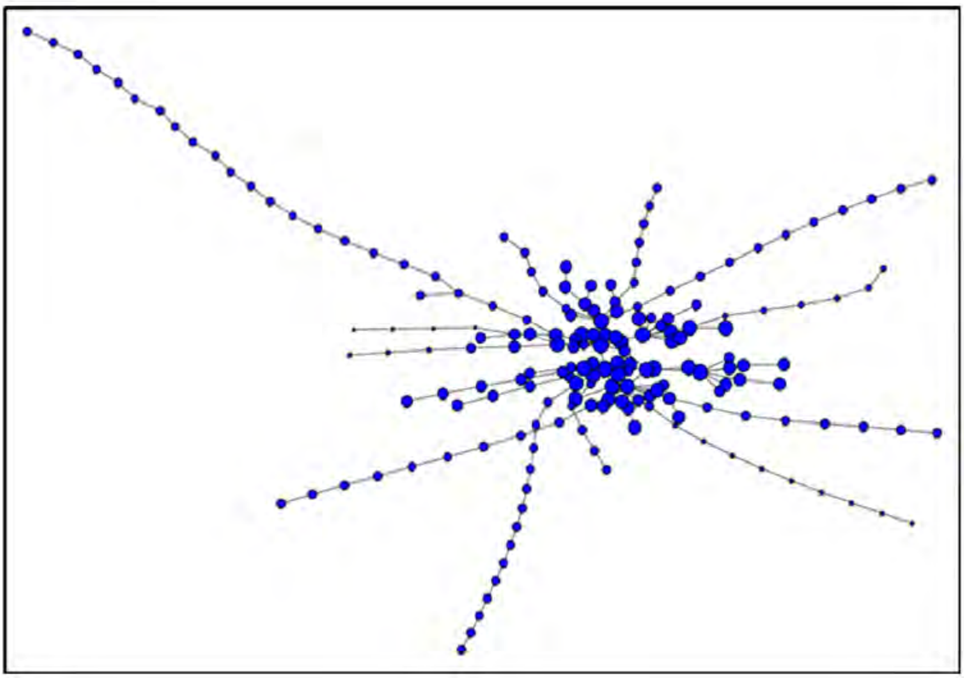
Representation of the relationships among micro-sectors within the network of the 12 production chains; each node represents a micro-sectors, with size proportional to its eigenvector centrality.



Having represented the web of production relationships as a network, we have then ranked the micro-sectors according to their eigenvector centrality. In this way we have identified a first group of 20 micro-sectors with a total value of production when fully open of over 820 billion (23% of the total production of the Italian economy). Allowing only for essential activities, as included in the list defined by the two decrees promulgated by Italy's Prime Minister on March 22 and April 10, 2020, these micro-sectors operate at 13% of their potential output (Table 2). Similar figures are reported for employment: of the approximately 4 million people employed before the crisis (22% of the entire economy), just over half a million are at work. When, in addition to those deemed essential, these additional 20 micro-sectors are allowed to produce, the total value of output to rise from 56% of its potential to 76% (similar values also for the number of employees).

Table 3 – impact of lockdown in central micro-sectors

	% share on Total Economy		Lockdown, in %	
	Value of output	Employees	Value of output	Employees
20 most central	22.8	21.5	86.9	86.1
additional 20	9.4	8.5	91.8	87.3
additional 10	3.9	2.2	74.4	78.2

Nonetheless, in some production chains (e.g., fashion) many core activities, such as clothing and footwear, would still remain closed, making the opening up of the identified micro-sectors within the production chain ineffective. We have therefore considered a second set of 20 additional micro-sectors, which are less central than the initial 20, but still relevant to ensure that the output capacity of some production chains reaches sizeable levels. The total value of output of these additional 20 micro-sectors is 304 billion euros, accounting for 9% of the entire economy. Allowing only essential activities, in lockdown they operate at 8% of their potential output. If, in addition to those deemed essential and the first 20 micro-sectors considered above, also these addition 20 micro-sectors were open, the value of production would rise to 84% of the potential output, with all the chains, with the exception of Construction and Real Estate and Tourism, operating at more than 90% of potential.[7]

Finally, by combining information on the centrality of the network with qualitative assessments regarding the articulation of the individual production chains, one can identify 10 additional micro-sectors. Since they are fairly small, accounting for only 3.9% of total production, they are not identified using our procedure, despite the fact that they are crucial to enable the activity of entire production chains. A prototype example is packaging paper for the food industry or textile finishing in fashion.

Tables 4 and 5 report the values total production and employment in each production chain under the hypotheses that: only essential activities are allowed as contemplated in lockdown (panel 1); the first 20 micro-sectors identified using our procedure are allowed to operate at full capacity (panel 2); the additional 20 micro-sectors are also allowed (panel 3); the additional 10 micro-sectors are also allowed (panel 4).

With just 50 micro-sectors operating at full capacity in addition to those deemed essential, out of a total number of 192, production chains such as Agrifood, Media and TLC, Transport and logistics, Energy and utilities, Health and Mechanics would be almost entirely active (reaching a capacity between 93% and 100%). Furthermore, some important industrial stages would be completely reactivated for the Home and Fashion production chains, such as furniture, home textiles and clothing.

[7] We have considered the centrality of micro-sectors of the original network, unaffected by lockdown. We have also checked ex-post that the central micro-sectors that we identify are also very central in the network that would emerge if they were reactivated. An alternative, and more comprehensive approach that we haven't explored yet (for its computational complexity) is that of identifying the combination of the top 20 micro-sectors by the increase in centrality they bring to the respective network (i.e. the network that would emerge adding these sectors to the economy in lockdown), among all possible combinations of 20 micro-sectors.

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Table 5 – central micro-sectors and total production

The table reports the percentage of total output activated in four different scenarios: Lockdown (Italy), activation of the 20, 40 and 50 most central micro-sectors.

	Lockdown: essential activities Panel 1	Including 20 micro-sectors Panel 2	Including 40 micro-sectors Panel 3	Including 50 micro-sectors Panel 4
Agrifood	81.4	94.2	94.2	95.8
Automotive	46.2	82.3	91.0	91.9
Home: furniture and design	45.3	86.1	90.3	91.7
Shipbuilding and aerospace	40.6	86.9	92.7	93.9
Construction and real estate	31.0	76.8	80.5	81.6
Energy and utility	85.5	94.1	97.8	99.2
Mechanics and Engineering	36.8	83.9	90.4	92.2
Fashion & beauty	48.5	75.2	88.9	90.8
Health	56.9	87.0	89.8	91.6
Media and TLC	96.6	96.6	96.6	100.0
Land transport and logistic	100.0	100.0	100.0	100.0
Tourism and travel	53.4	79.9	81.8	81.8

Table 6 – central micro-sectors and total employment

The table reports the percentage of total employment represented by the 20, 40 and 50 most central micro-sectors.

	Essential activities Panel 1	Including 20 micro-sectors Panel 2	Including 40 micro-sectors Panel 3	Including 50 micro-sectors Panel 4
Automotive	58.9	88.4	93.6	94.4
Home: furniture and design	55.1	85.5	89.5	90.6
Shipbuilding and aerospace	56.9	89.9	94.8	95.7
Construction and real estate	42.3	69.5	72.8	73.4
Energy and utility	86.2	94.5	97.3	98.7
Mechanics and Engineering	58.5	86.3	92.0	93.7
Fashion & beauty	59.6	73.4	87.7	89.5
Health	54.9	80.4	82.5	83.4
Media and TLC	97.4	97.4	97.4	100.0
Land transport and logistic	100.0	100.0	100.0	100.0
Tourism and travel	47.8	73.6	75.8	75.8

To verify the robustness of our results, we have performed two additional checks. First, we have verified that the 40 micro-sectors that we have identified as central would not be operating at a level of production above 75% of full capacity if only the activities defined as essential according to the Ministerial decree were allowed. This confirms that we are identifying micro-sectors whose operations are significantly hindered by the lockdown. Second, we have verified that if we add the 20+20+10 micro-sectors which we have identified as central to a network built considering only those micro-sectors which have more than

75% of their activities defined as essential by the Ministerial decree, all these newly added micro-sectors enter the network with higher levels of centrality than those defined as essential. This confirms that we are identifying micro-sectors whose operations are more central than those defined as essential.

3.3. Impact on GDP

The final step of our methodology is to estimate the impact on GDP of the core micro-sectors identified above. To this aim, we carry out an exercise similar to the one performed to identify the sectors whose closure has a stronger impact on GDP, listed in Table 2. The difference is that now we only focus on the impact of the micro-sectors identified by their centrality in the production network, which represent a subset of all micro-sectors included in each one of the sectors defined according to NACE revision 2 of the IO tables. In practice, we have singled out each row of the table referring to one of the 63 sectors of the Italian IO tables and multiplied its values (excluding those along the main diagonal, but including those of the final demand) by one minus the share of total production represented by essential activities and those of the micro-sectors identified above, therefore assuming that all other micro-sectors included in the given sector are inactive.

Table 7 reports the loss in GDP due to the closure of all but essential activities as in the Italian lockdown, and the losses that would occur under two scenarios: if the first 20 micro-sectors identified by our analysis were opened and then if also the subsequent 20 were reopened. Remarkably, allowing production in the first 20 micro-sectors identified above would reduce the negative impact on GDP of a lockdown of the construction industry by more than 10%. Equally sizeable would be the impact on wholesale trade, excluding that of cars and motorcycles (from 9.2% to 1.7%) and accommodation and restaurant services (from 8.7% to 1.4%). Opening of the second group of 20 micro-sectors would in turn have a sizeable impact for the manufacture of vehicles, trailers and semi-trailers, narrowing the reduction in GDP from 8.3% to 1.4% and also for the manufacture of metal products and textiles.

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Table 7 – Central micro-sectors and GDP

The table reports the estimates of the drop in GDP caused by the lockdown of a sector's economic activities, excluding essential activities as defined by the decrees promulgated by Italy's Prime Minister on March 22 and April 10, 2020 and the 20 or 40 most central micro-sectors.

NACE Code	Description	impact on GDP		
		Essential activities	+20 micro-sectors	+ 40 micro-sectors
V28	Manufacture of machinery and equipment n.e.c..	-11,1	-5,7	-4,4
VF	Construction	-10,7	-0,0	-0,0
V46	Wholesale trade, except of motor vehicles and motorcycles	-9,2	-1,7	-0,3
VI	Accommodation and food service activities	-8,7	-1,4	-0,0
V29	Manufacture of motor vehicles, trailers and semi-trailers	-8,3	-8,3	-1,4
V13_15	Manufacture of textiles wearing apparel, leather and related products	-7,6	-7,2	-5,2
V25	Manufacture of fabricated metal products, except machinery and equipment	-7,5	-2,7	-0,4
V24	Manufacture of basic metals	-6,4	-2,4	-0,0
V31_32	Manufacture of furniture and other manufacturing	-3,4	-3,4	-2,3
V22	Manufacture of rubber and plastic products	-3,2	-1,1	-0,6
V27	Manufacture of electrical equipment	-3,2	-2,2	-1,1
V47	Retail trade, except of motor vehicles and motorcycles	-3,1	-2,6	-1,6

CONCLUSIONS

The Covid-19 pandemic has forced lockdowns in several countries worldwide. Governments were then urged to plan re-openings of economic activities, according to both health and economic criteria. In our view, in defining the trade-off between the reactivation of the activities subject to the lockdown and the health risks that this poses, the economic impact of specific activities should be carefully taken into account, so as to maximize the impact on GDP, minimizing the risk of new epidemic outbreaks.

The methodology described in this paper allows to identify priority activities and sectors by combining information from IO tables with those on the structure of production chains. This approach has the advantage of combining information on the economic relevance of sectors, with a more granular information on the interconnections between the various production stages typical in value chains.

While our exercise is preliminary, the methodology can be widened to consider a number of additional factors, from the geographical dimension of the links in production using regional IO tables, to the international dimension of global production chains. This analytical framework can also be extended to consider the impact of the different probabilities of contagion of each production process.

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