Sectoral effects of social distancing

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Work in progress

The health crisis caused by the outbreak of the Covid-19 virus leads many countries to implement drastic measures of social distancing. By reducing the quantity of labor, social distancing in turn leads to a drop in output which is difficult to quantify without taking into account relationships between sectors. Starting from a standard model of production networks, we analyze the sectoral effects of the shock in the case of France. We estimate that six weeks of social distancing brings GDP down by 5.6%. Apart from sectors directly concerned by social distancing measures, those whose value added decreases the most are upstream sectors, i.e. sectors most distant from final demand. The same exercise is carried out for other European countries, taking into account national differences in sectoral composition and propensity to telework. Finally, we analyze the economic impact of phasing out social distancing by sector, region or age group.

Modern economies are characterized by the many interdependencies formed by companies in their production processes. These interdependencies are well identified in the literature as facilitating the propagation of non-systemic shocks (Barrot and Sauvagnat, 2016) and their aggregation (Acemoglu et al., 2012; Baqaee and Farhi, 2019), with applications for public policies (Grassi and Sauvagnat, 2019). For a recent review, see Carvalho and Tahbaz-Salehi (2018). Analyzing the effect of the social distancing rules implemented to curb the spread of the Covid-19 virus requires to estimate its effects on the active workforce, and to measure its impact across the production network [2].

Effect of social distancing on the workforce

Administrative closings The decree of March 14, 2020 prohibits certain categories of establishments from opening to the public [3]. Exceptions are granted by the decree of March 15, 2020, and relate in particular to the food and basic necessities trade. To estimate the reduction in active workforce due to administrative closings in each sector, we proceed as follows. Starting from the finest sector classification, the NAF rev. 2 in 732 sector classification, we identify the sectors corresponding to the decree of March 14, 2020, for which

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2. In what follows, we abstract from economic policy initiatives implemented in response to the crisis.

3. Hearing rooms, conferences, meetings, shows or for multiple use ; Sales stores and Shopping centers, except for their delivery and order picking activities ; Restaurants and drinking places, except for their takeaway delivery and sales activities, room service in hotel restaurants and bars and contract catering ; Dance halls and play rooms ; Libraries, documentation centers ; Exhibition halls ; Covered sports establishments ; Museums ; Marquees, tents and structures ; Outdoor establishments ; Educational, educational, training establishments, holiday centers, leisure centers without accommodation.

we consider that the active workforce is zero. By aggregation, using the number of workers by sector in the 2016 census data available on the INSEE website, we obtain the share of the inactive workforce for each of the 38 sectors of the aggregated NAF rev. 2 classification. The share of the total workforce affected by administrative closings stands at 10.9% and is concentrated in directly affected sectors : hotel and restaurants, arts and leisure, wholesale and retail, social work.

Closures of nurseries, schools, secondary schools and high schools In addition, all nurseries, schools, colleges and high schools were closed from March 16, 2020, in accordance with the decree of March 14, 2020. To estimate the effects on the workforce in each sector, we use data from the census to identify, in each of the 38 sectors of NAF rev. 2, the share of working people with dependent children under 16 and therefore forced into inactivity [4]. The share of the total workforce affected by childcare caused by the closings of nurseries, secondary schools and high schools stands at 13.2% [5], and varies, if we leave aside the sectors concerned by administrative closings and the health sector, from 11.7% (Agriculture) to 19.4% (Pharmaceuticals).

Confinement On the other hand, to prevent the spread of the Covid-19 virus, traffic restrictions are imposed, as well as the strict compliance with a safety distance of one meter between each individual. So that these rules do not lead to the shut down of business, the Minister of Labor asked firms to facilitate remote work as much as possible (telework), and urged companies to bring together their Social and Economic Committee (CSE) to adapt working conditions to health guidelines. In the absence of better data, the share of the active population in each sector likely to continue working at home is estimated using data from the European Community survey on the use of ICT and electronic commerce in businesses carried out by INSEE for Eurostat on a sample of 12,500 companies. This provides, for each sector, the share of employees of companies with more than 10 employees using a portable device provided by the company, connected to the Internet via the network of mobile phones (laptop, smartphone, tablet, etc.) in 2019. This stands at 32%, which is consistent with some recent telework surveys [6]. However, confinement should lead companies to increase their use of telework. The ICT survey also provides the share of employees of companies with more than 10 employees using a computer (including a portable device) with internet access for professional use (fixed or mobile connection), which averages 62%. We note that this indicator is significantly correlated (correlation = 0.5) with the share of employees in telework in 2017 estimated by DARES [7]. Some sectors being excluded from the survey (agriculture, financial services, public administration), the missing variable is imputed by applying the average ratio between the survey variable and the share of employees in telework estimated by DARES. In

4. More specifically, we consider that an active person has dependent children if there is not another inactive person in the household, who could take care of them. If there are several active adults in the household, we consider the drop in activity to be evenly distributed among these adults. We exclude from this calculation those who are forced to inactivity because of administrative closings, and health workers whose children are taken care of in the school system.

5. Sadique et al (2008) obtain a similar proportion based on English data.

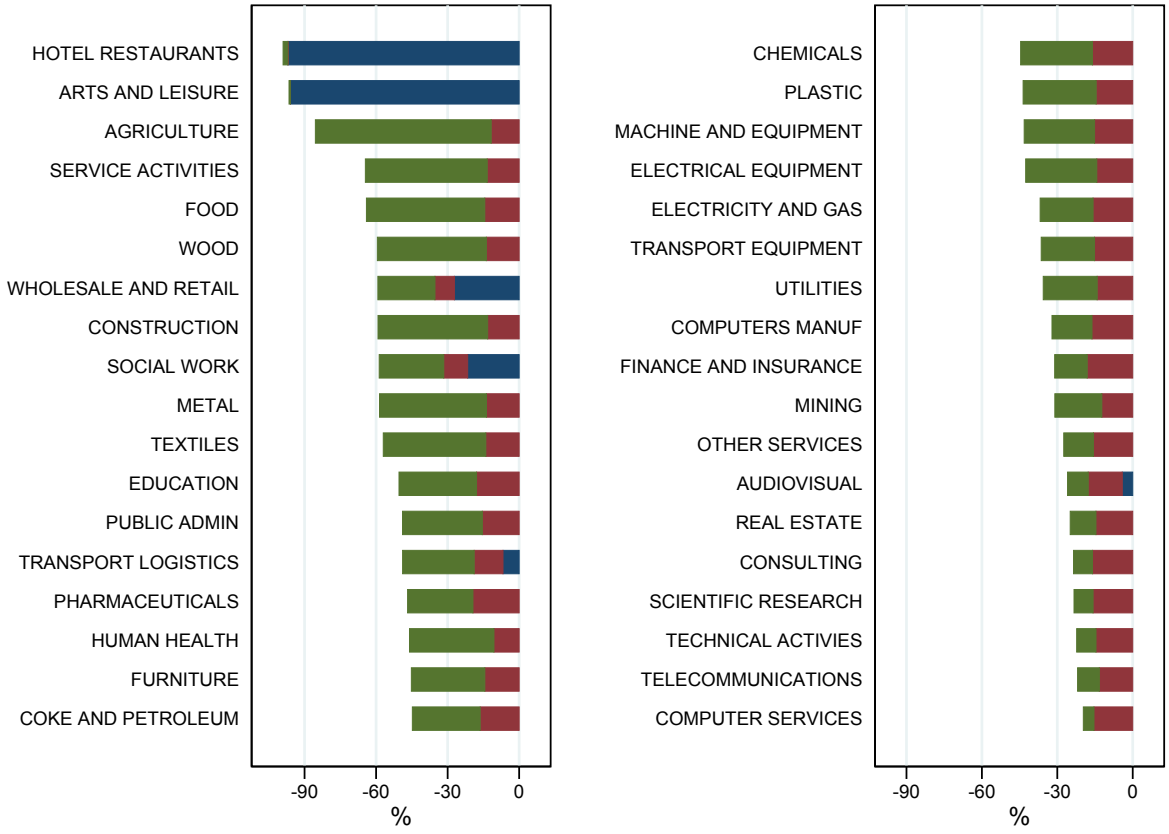
6. See for example the 2020 Telework study by Malakoff Humanis, March 2020

7. DARES Analyses, November 2019, Number 051

the limit case of absolute confinement, only these employees could continue to work, either because they can work at home, or because it is probably easier to reorganize their work environment in accordance with social distancing rules.

Figure 1
Decrease in active workforce caused by social distancing measures

This figure shows the effects of social distancing measures on the workforce by sector (in %). Blue bars represent the decline in the active workforce due to administrative closings. Red bars, the additional effect linked to school closings. Green bars, the residual effect related to confinement.



Cumulative effect By combining the effect of administrative closings, that of childcare imposed by the closings of nurseries, schools, colleges and high schools, and that of strict confinement allowing only people usually working with a computer to continue to do so, we obtain an overall drop in the active workforce of 52% [8]. The detail by sector is presented in Figure 1. The effect is broken down according to the origin of the shock. In blue, the effect of administrative closings ; in red, the additional effect of school closings ; and in green, the residual effect of confinement. Unsurprisingly, "arts and leisure" and "hotel restaurants" are

8. This number is remarkably close to estimates by Google of the drop in workplace mobility, -56% relative to baseline in France, see COVID-19 Community Mobility Report as of March 29, 2020

the hardest hit, due to administrative closings. Next comes "agriculture" or "business services", where the share of the workforce who does not work on a computer is high. Conversely, "technical activities ", "telecommunications " or "computer services " are relatively spared.

Description of the production network

Companies, and consequently the sectors of the French economy, are linked to each other through the network of customer-supplier relationships. There is no data to trace these business-to-business relationships. We therefore rely on the input-output table produced by INSEE, which describes and synthesizes transactions in goods and services in product and branch of activity. Figure 2 shows the structure of the French production network according to the 38 branches of activity of the NAF rev. 2 for 2015. [9]

In the first panel, each column represents the production of a sector. Each line represents the intermediate consumption of a sector, i.e. the inputs of its production process. In short, the column sectors are the suppliers, the row sectors are the customers. Each box in the table gives the intensity of use by a sector (on the column) of the input (on the row) in its production process. The darker the blue, the more quantitatively important the input. We thus verify that for the row (client sector) "hotel restaurants", the column (supplier sector) "food" is quantitatively important. We note that certain supplier sectors, in columns, contribute significant inputs from a large number of sectors. These are "business services", " consulting", and " wholesale and retail " activities.

In the second panel of Figure 2 are represented the links between sectors. Each point represents a sector, and its size is proportional to the total volume of its inputs. Each line represents a relation between a supplier sector and a client sector, and its width is proportional to the share of the input in the total of the inputs of the client. This graph highlights the chains of links : thus, the "agriculture" sector is an important input of the "food" sector, itself an important input of the "hotel restaurants" sector.

Finally, we report in Table 3 two key network statistics, Bonacich-Katz centrality and upstreamness, for each sector of the economy. The centrality of a sector measures the importance as a supplier to the economy, whereas the upstreamness measures the number of nodes between a given sector and the final demand.

Description of the model

To analyze the effect of social distancing on GDP and on the value added of each sector, we construct a standard model of production networks. Each sector produces a good by using labor and intermediate consumption produced by the other sectors, and by choosing the quantities so as to maximize its profit. Households consume goods produced by each sector [10], and provide a fixed amount of labor to each sector so as to maximize their utility.

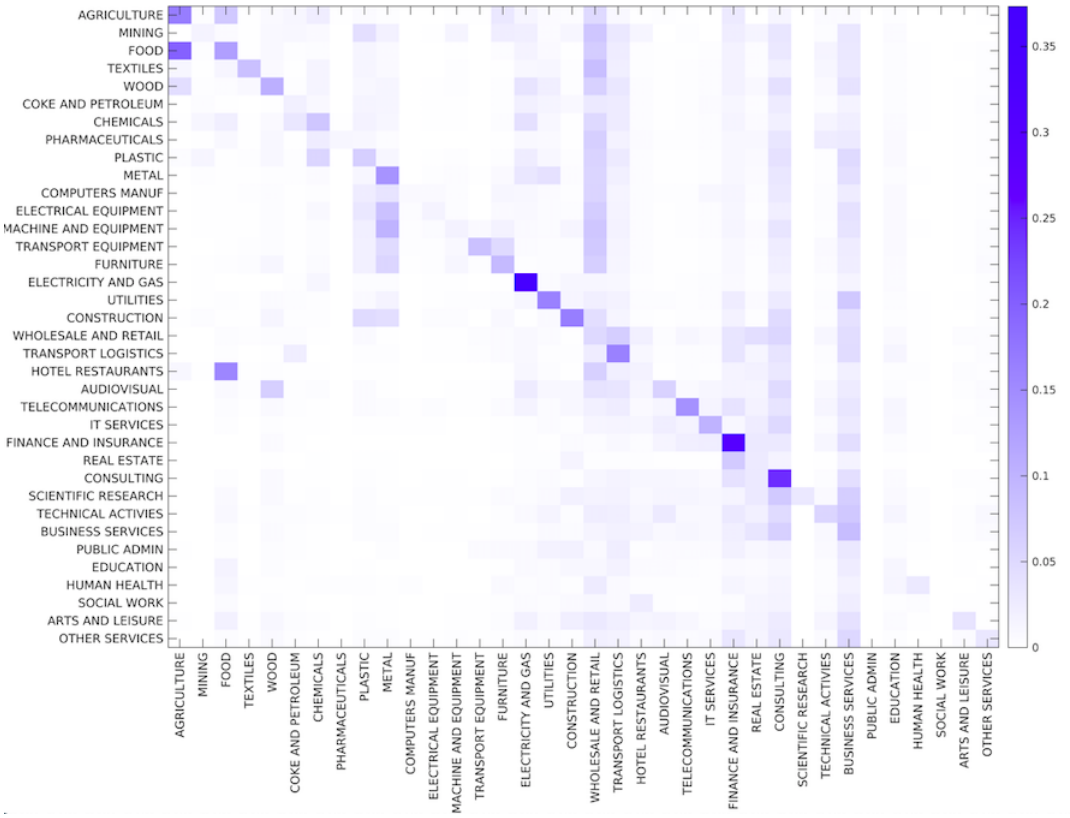
The economy's response to the shock depends on two parameters. The elasticity of substitution between goods drives the responses of household consumption to changes in relative prices. If the elasticity is greater than 1, an increase in the price of a given good leads to

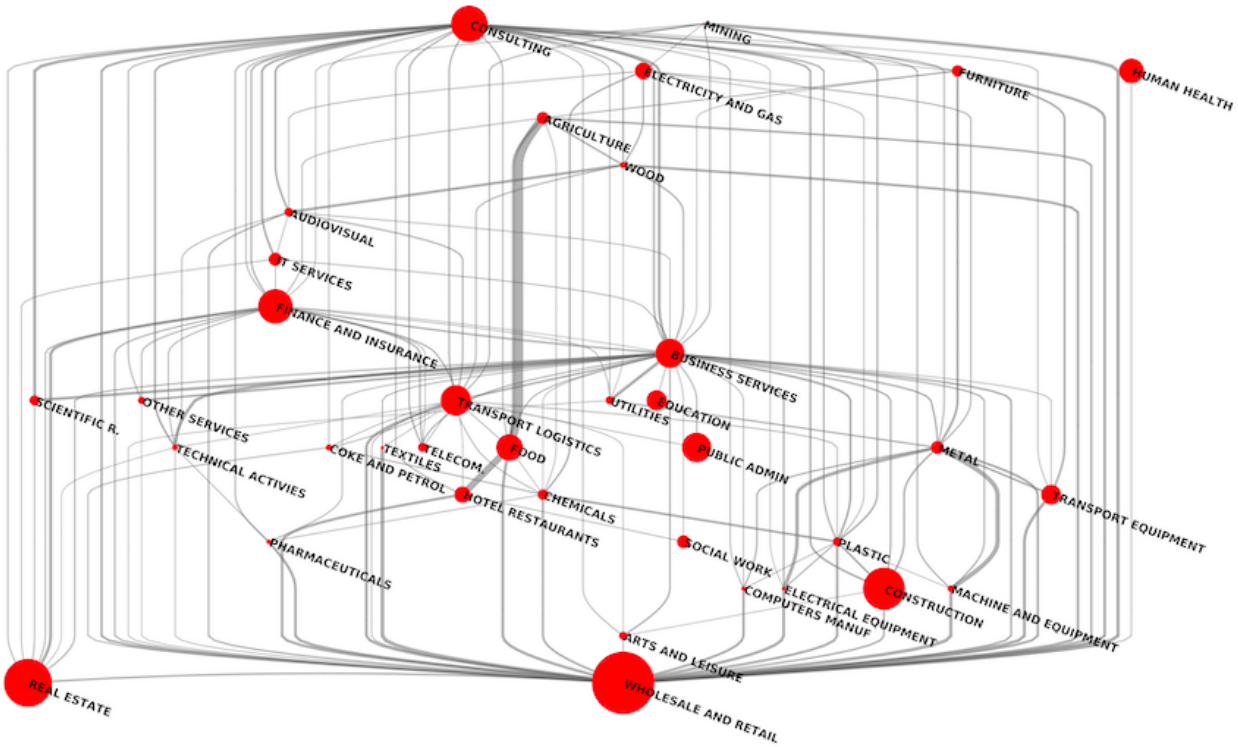
9. We report the full description of each branch in Table 2.

10. In such a closed economy model, household consumption includes public spending, investment and exports

Figure 2
The French production network

This figure shows the structure of the French production network according to the 38 branches of activity of the NAF rev. 2. In the first panel, each column represents the production of a sector. Each line represents the intermediate consumption of a sector. In the second panel, each point represents a sector, and its size is proportional to the total volume of its inputs. Each line represents a relation between a supplier sector and a client sector, and its width is proportional to the share of the input in the total of the inputs of the customer.





a decrease in its share in the household consumption basket, and vice versa. Similarly, the elasticity of substitution between intermediates describes the response of sectors to a change in the relative prices of the inputs they use. The higher it is, the more a sector can substitute inputs between them. This elasticity is lower when the horizon is short - it can be difficult to quickly substitute inputs between them -, and the level of aggregation is high - it is easier for a company to change supplier, than for a sector to do without an upstream sector. We rely on the literature to calibrate the elasticity of substitution between final goods at 3, and the elasticity of substitution between intermediate inputs at 0.5. We check that the results are robust to alternative values.

The model is useful for estimating the effect of the supply shock linked to social distancing, and its propagation throughout the production network. It does not take into account international trade [11]. Economic shocks affecting foreign countries with domestic repercussions are not quantified here. Furthermore, the model does not integrate the effect of automatic stabilizers and economic support policies announced in response to the crisis, such as the extension of partial unemployment, the suspension of contributions and tax charges, or the solidarity fund for the self-employed and very small businesses in France. The model also does not integrate the effects of possible demand shocks caused by the health crisis : increased demand for medical and surgical equipment, or the consumption of digital services. The model also ignores possible changes in the structure of consumption (or preference parameters in the utility function) of households linked to the consequences of the outbreak of the virus. Finally, it ignores the amplification effects linked to potential business bankruptcies, the destruction of customer-supplier relationships, and more generally the destruction of companies' relational or organizational capital.

Effect of social distancing on GDP

Table 1
Effect of 6 weeks of social distancing on GDP

	Administrative closings	Administrative closings + School closings	Administrative closings + School closings + Confinement
GDP growth	-0.9%	-2.5%	-5.6%

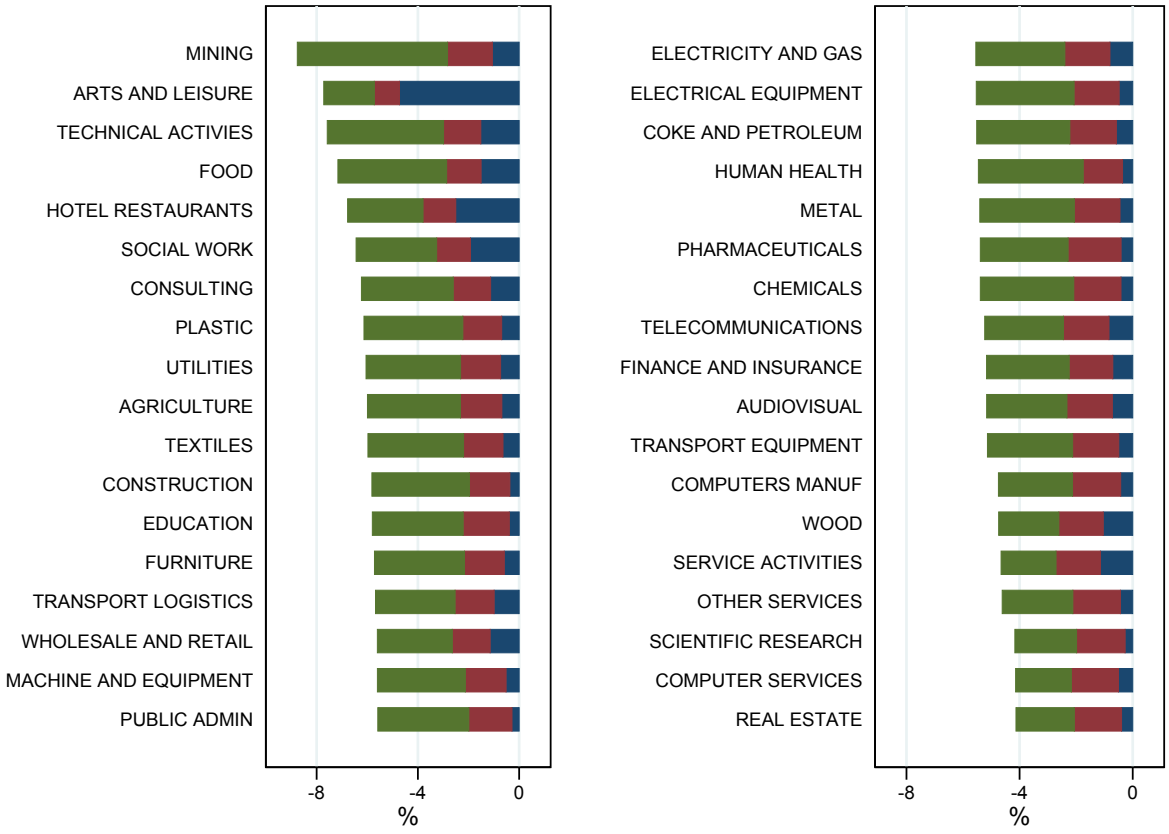
The model makes it possible to estimate the effect of social distancing on the value added

11. The effects of the shock in China on the French economy is studied, for example, by Gerschel et al. (2020).

of each sector, the weighted sum of which forms GDP. The results are presented for a period of 6 weeks. The fall in annual GDP is -5.6% [12] . We decompose this figure according to the origin of the shock, and present the result in Table 1. Administrative closings cause a decrease of 0.9%. When we add the closings of nurseries, colleges and high schools, the drop is 2.5%. The residual difference, ie 3.1 percentage points, is explained by confinement.

Figure 3
Value added growth for 6 weeks of social distancing (%)

This figure shows the effects of social distancing on value added growth for each sector (in %). Blue bars represent the decline in the active workforce due to administrative closings. Red bars, the additional effect linked to school closings. Green bars, the residual effect linked to confinement.



The model makes it possible to estimate the impact of the shock separately for each sector. Figure 3 shows the effect of six weeks of social distancing on annual value added growth in each sector. The effect is broken down according to the origin of the shock. In blue, the effect of administrative closings ; in red, the additional effect of school closings ; and in green, the residual effect of confinement. The drop varies from -8.8% to -4.1% depending on

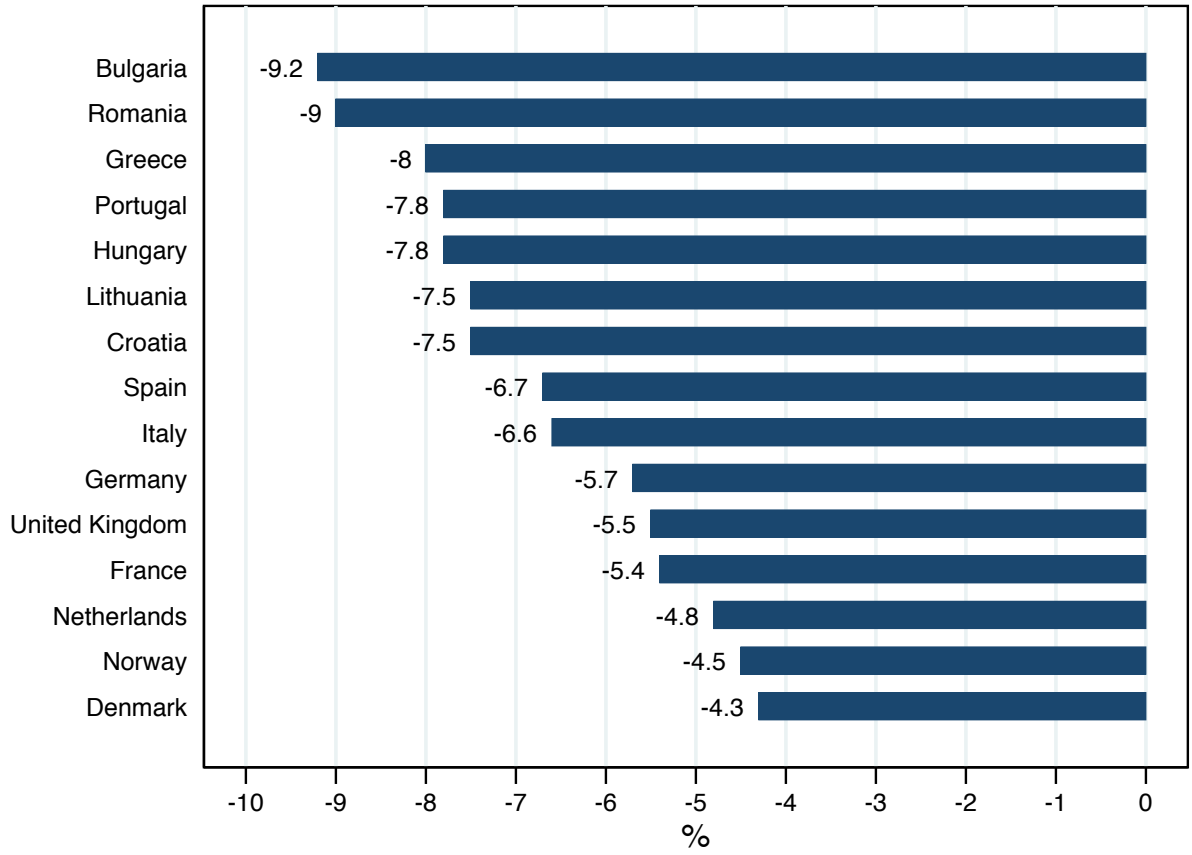
12. This estimate is higher than that presented by INSEE in its Conjoncture Point of March 26, 2020 from contemporary shock data, which finds 3% for a month of social distancing, and to that presented by the OFCE in its Policy Brief of March 30, 2020. This difference can be explained by the fact that the model does not take into account automatic stabilizers and support policies.

the sector. Among the sectors most affected, are some of those directly impacted by social distancing measures, such as "arts and leisure" (-7.7%) and "hotel restaurants" (-6.8%). However, among the most affected sectors are also upstream ones, i.e. those most distant from final demand, such as "mining" (-8.8%), and "technical activities" (-7.6%), "consulting" (-6.2%) or "utilities" (-6.0%). Thus, if the downstream sectors seem more directly disturbed by administrative closings in terms of active workforce, upstream sectors suffer most significantly in terms of value added.

Extension to other European countries

Figure 4
GDP drop by country for 6 weeks of social distancing

This figure shows the effects of social distancing on the GDP growth of European countries (in %). We assume that all countries apply the same restrictions, and that social distancing is in place for 6 weeks in each country. Only the sectoral composition and the propensity to telework vary.



We next analyze the effect that social distancing would have on other European countries, taking into account only national differences in sectoral composition, and in the telework propensity. It is therefore assumed that all countries take the same decisions on administrative

closings, closings of schools and confinement [13]. The structure of the production network in 54 branches is obtained from the "World Input-Output" database (WIOD, version 2016), which provides for each country the 2014 input-output table. The propensity of each sector in each country to telework comes from the community survey on the use of ICT and electronic commerce in businesses described above.

The results are presented in Figure 4. The GDP drops on average by 6.6% in the sample, for six weeks of social distancing [14]. The fall in GDP ranges from 4.3% (Denmark) to 9.2% (Bulgaria). These differences are partly explained by the sectoral composition, and partly by the propensity to telework, as shown in Figure 8 which shows the correlation [15] between propensity to telework and decline in GDP.

Progressive phasing out of social distancing

Phasing out of social distancing is anticipated to be implemented progressively. The model allows us to predict the marginal effect on GDP that phasing out would have on each sector, region or age group, taken in isolation. We consider each sector (or region, or age group) one after the other assuming that social distancing is lifted after 4 weeks instead of 6, and we measure the effect on marginal on GDP. We then normalize the implied GDP in euros by the number of released workers, which gives an approximation of the marginal benefit per worker of phasing out social distancing. The results are presented in Figure 5-7. The effect on GDP (Panel A) varies by a factor of 4 across sectors and across regions, but is relatively stable by age group. The marginal effect per worker (Panel B) is stable by region and age group, but varies very strongly by sector.

These results must be interpreted with caution, and within the limits of the model's assumptions. They correspond to the effect of the decline in the workforce linked to social distancing and do not take into account international trade or public policies undertaken to support the economy. They describe the supply side response at the sectoral level and make it possible to identify the most affected sectors. They do not in any way challenge the importance of social distancing, which is well identified by the medical literature as an effective means of slowing down the epidemic propagation, whose human, social and economic costs are considerable.

13. All countries in the sample closed their schools, but not all of them imposed administrative closings and confinement.

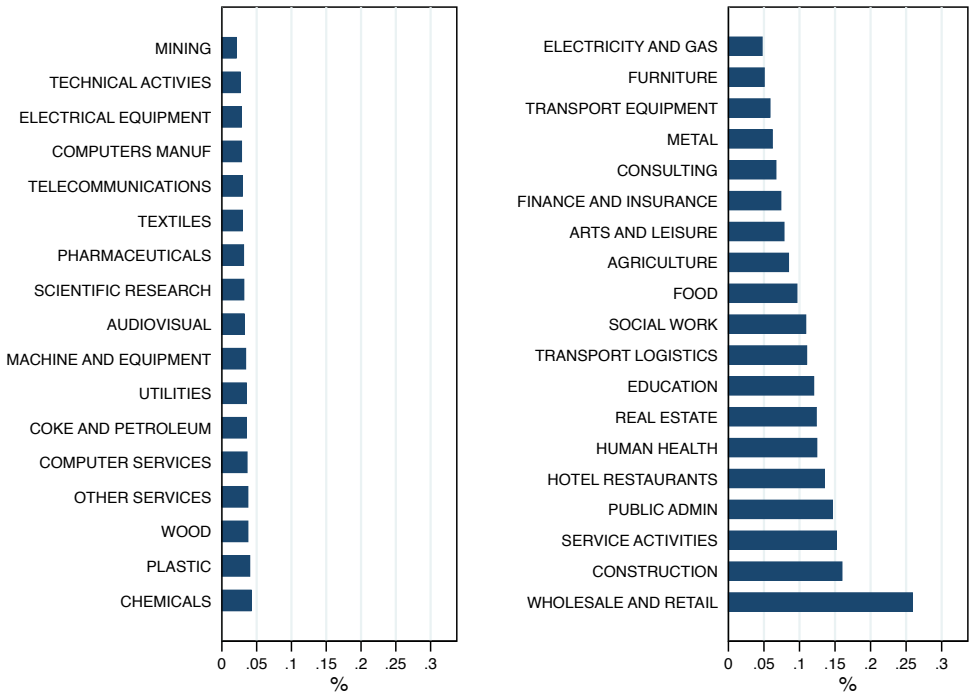
14. We note that France undergoes a drop in GDP of 5.4%, very close to the 5.6% estimated above from 38 sectors, instead of 54.

15. A 10 percentage points increase in telework propensity increases GDP by 1%.

Figure 5
Effect on GDP of differentiated phasing out by sector

This figure shows the effects on GDP of phasing out social distancing in each sector individually, after 4 weeks instead of 6.

Panel A : % of GDP



Panel B : euros per released worker

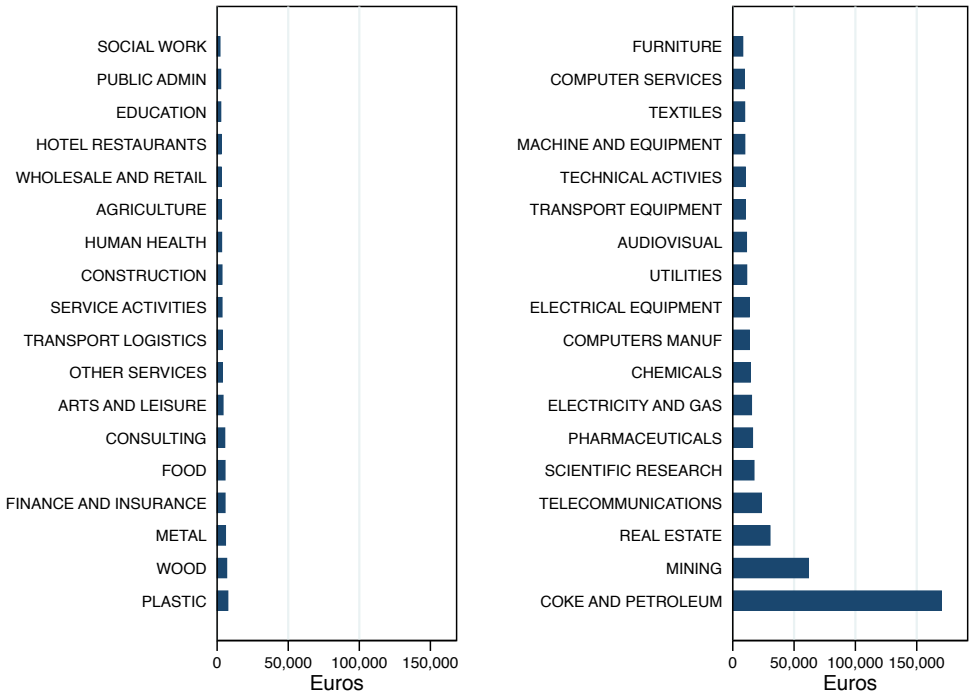
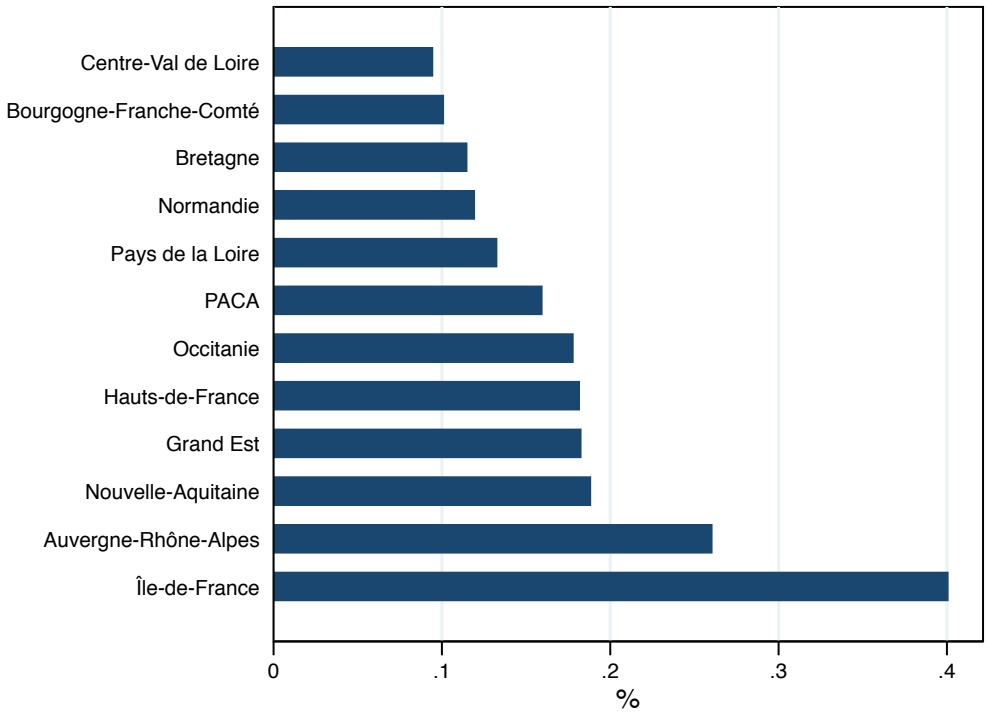


Figure 6
Effect on GDP of differentiated phasing out by region

This figure shows the effects on GDP of phasing out social distancing in each region individually, after 4 weeks instead of 6.

Panel A : % of GDP



Panel B : euros per released worker

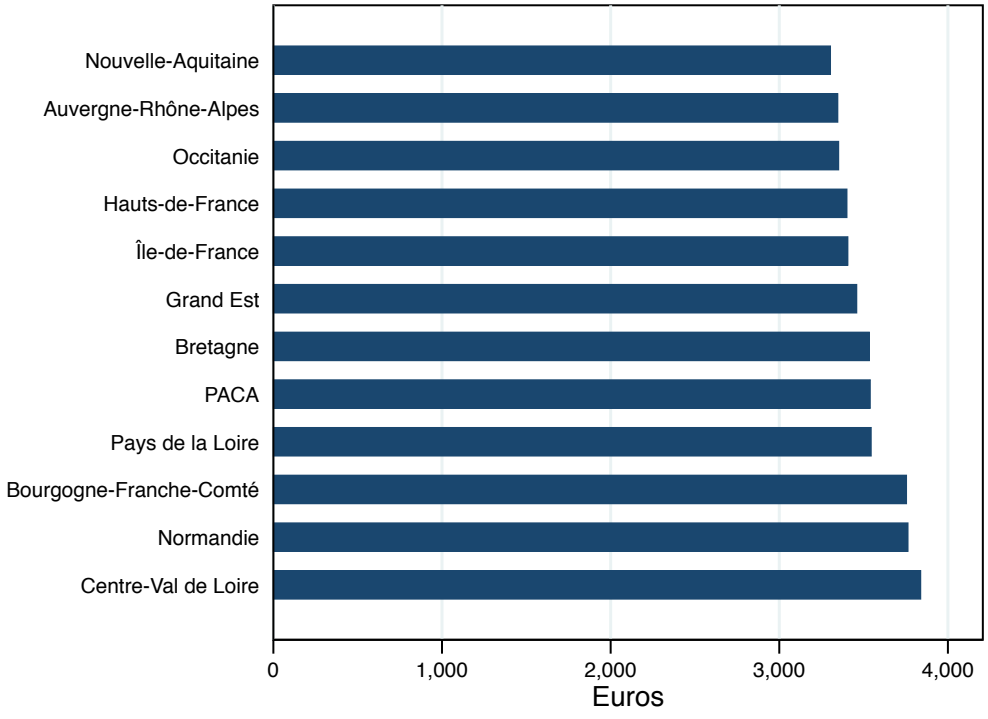
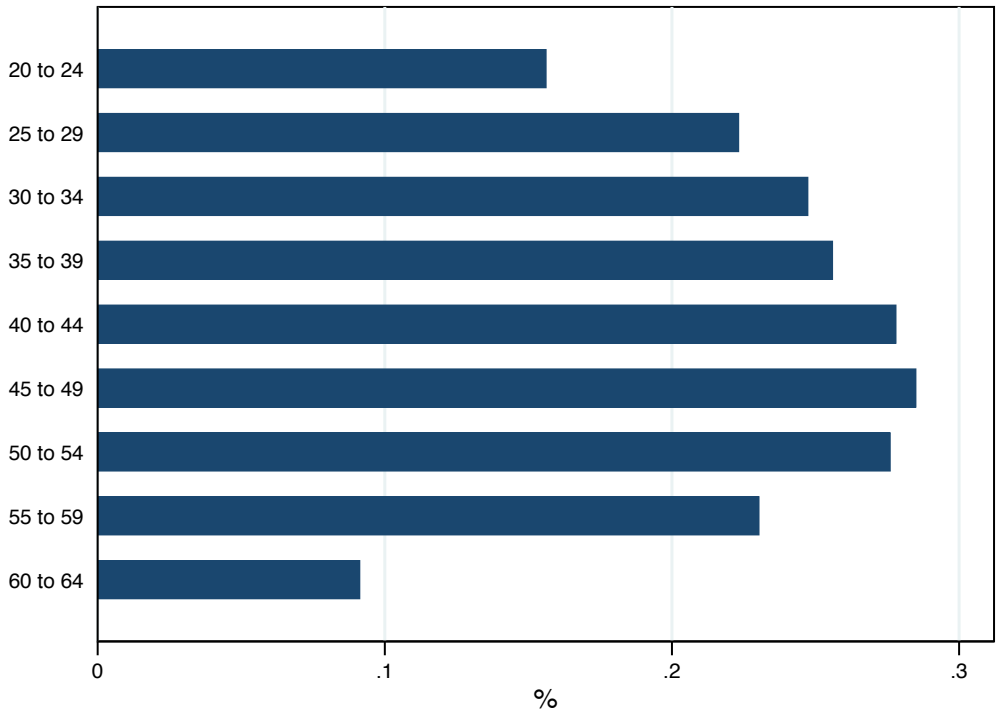


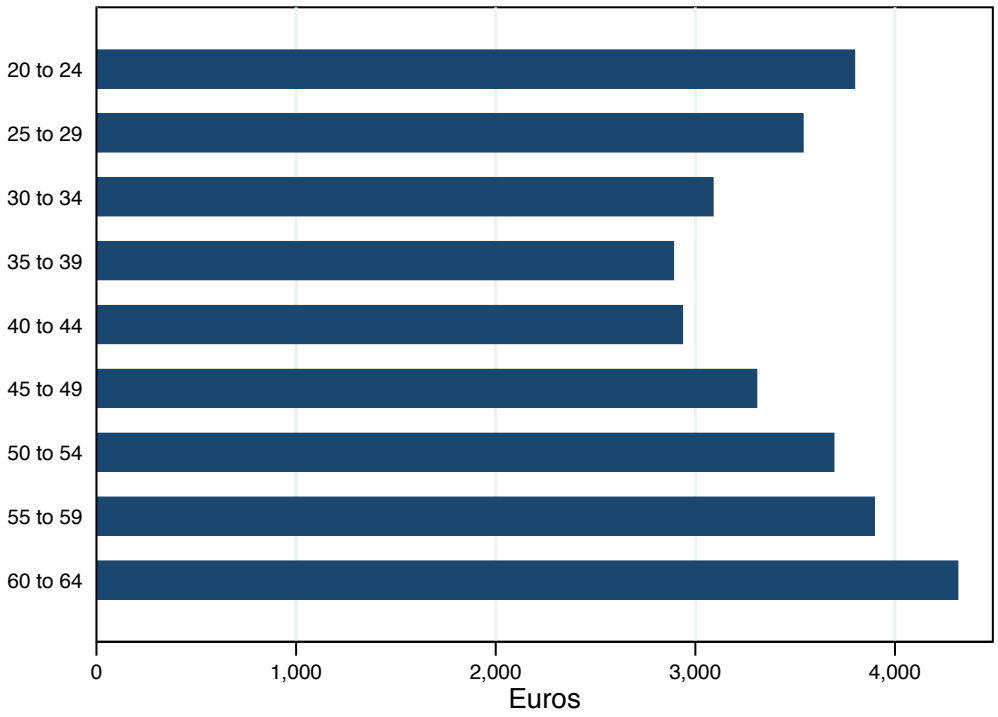
Figure 7
Effect on GDP of differentiated phasing out by age group

This figure shows the effects on GDP of of phasing out social distancing in age group individually, after 4 weeks instead of 6.

Panel A : % of GDP



Panel B : euros per released worker



Références

Acemoglu, D., V. M. Carvalho, A. Ozdaglar, and A. Tahbaz-Salehi (2012, 09). The network origins of aggregate fluctuations. *Econometrica 80*(5), 1977–2016.

Baqaee, D. R. and E. Farhi (2019). Networks, barriers, and trade. *Working Paper*.

Barrot, J.-N. and J. Sauvagnat (2016). Input Specificity and the Propagation of Idiosyncratic Shocks in Production Networks. *The Quarterly Journal of Economics 131*(3), 1543–1592.

Carvalho, V. M. and A. Tahbaz-Salehi (2018). Production networks : A primer. *Annual Review of Economics*.

Gerschel, E., A. Martine, and I. Mejen (2020, 3). Propagation of shocks in global value chains : the coronavirus case. *IPP Policy brief* (53).

Grassi, B. and J. Sauvagnat (2019, 12). Production networks and economic policy. *Oxford Review of Economic Policy 35*(4), 638–677.

Appendix

Table 2
List of Sectors

CODE A38	ACRONYM A38	DESCRIPTION A38
AZ	AGRICULTURE	agriculture, forestry and fishing
BZ	MINING	mining and quarrying
CA	FOOD	manufacture of food products, beverages and tobacco products
CB	TEXTILES	manufacture of textiles, wearing apparel and leather products
CC	WOOD	manufacture of wood and paper products, and printing
CD	COKE AND PETROLEUM	manufacture of coke and refined petroleum products
CE	CHEMICALS	manufacture of chemicals and chemical products
CF	PHARMACEUTICALS	manufacture of basic pharmaceutical products and pharmaceutical preparations
CG	PLASTIC	manufacture of rubber and plastics products, and other non-metallic mineral products
CH	METAL	manufacture of basic metals and fabricated metal products, except machinery and equipment
CI	COMPUTERS MANUF	manufacture of computer, electronic and optical products
CJ	ELECTRICAL EQUIPMENT	manufacture of electrical equipment
CK	MACHINE AND EQUIPMENT	manufacture of machinery and equipment n.e.c.
CL	TRANSPORT EQUIPMENT	manufacture of transport equipment
CM	FURNITURE	manufacture of furniture ; other manufacturing ; repair and installation of machinery and equipment
DZ	ELECTRICITY AND GAS	electricity, gas, steam and air conditioning supply
EZ	UTILITIES	water supply ; sewerage, waste management and remediation activities
FZ	CONSTRUCTION	construction
GZ	WHOLESALE AND RETAIL	wholesale and retail trade, repair of motor vehicles and motorcycles
HZ	TRANSPORT LOGISTICS	transportation and storage
IZ	HOTEL RESTAURANTS	accommodation and food service activities
JA	AUDIOVISUAL	publishing, audiovisual and broadcasting activities
JB	TELECOMMUNICATIONS	telecommunications
JC	IT SERVICES	computer programming, consultancy and related activities ; information service activities
KZ	FINANCE AND INSURANCE	financial and insurance activities
LZ	REAL ESTATE	real estate activities
MA	CONSULTING	legal and accounting activities ; activities of head offices ; management consultancy activities ; architecture and engineering activities ; technical testing and analysis
MB	SCIENTIFIC RESEARCH	scientific research and development
MC	TECHNICAL ACTIVITIES	advertising and market research ; other professional, scientific and technical activities ; veterinary activities
NZ	BUSINESS SERVICES	administrative and support service activities
OZ	PUBLIC ADMIN	public administration and defence ; compulsory social security
PZ	EDUCATION	education
QA	HUMAN HEALTH	human health activities
QB	SOCIAL WORK	social work activities
RZ	ARTS AND LEISURE	arts, entertainment and recreation
SZ	OTHER SERVICES	other service activities

Table 3
Sector characteristics and network statistics

(1)	(2)	(3)	(4)	(5)
Secteur	Sector Characteristics		Network Statistics	
	Final Demand	Employment	Upstreamness	Network Centrality
AGRICULTURE	2.7%	1.1%	2.09	0.032
MINING	0.1%	0.0%	2.43	0.002
FOOD	2.3%	4.6%	1.52	0.070
TEXTILES	0.4%	0.5%	1.43	0.007
WOOD	0.8%	0.4%	2.27	0.015
COKE AND PETROLEUM	0.0%	0.9%	1.69	0.015
CHEMICALS	0.5%	1.9%	1.47	0.027
PHARMACEUTICALS	0.3%	1.0%	1.04	0.011
PLASTIC	1.0%	0.7%	2.04	0.021
METAL	1.5%	1.3%	1.91	0.033
COMPUTERS MANUF	0.5%	0.9%	1.09	0.010
ELECTRICAL EQUIPMENT	0.4%	0.7%	1.28	0.008
MACHINE AND EQUIPMENT	0.7%	1.3%	1.25	0.015
TRANSPORT EQUIPMENT	1.3%	4.6%	1.14	0.052
FURNITURE	1.1%	1.7%	1.59	0.029
ELECTRICITY AND GAS	0.7%	1.4%	2.36	0.043
UTILITIES	0.7%	0.6%	2.17	0.020
CONSTRUCTION	6.5%	8.4%	1.35	0.112
WHOLESALE AND RETAIL	12.8%	11.8%	1.46	0.167
TRANSPORT AND LOGISTICS	5.1%	3.6%	1.92	0.080
HOTEL RESTAURANTS	4.0%	3.0%	1.48	0.042
AUDIOVISUAL	0.9%	1.3%	1.75	0.022
TELECOMMUNICATIONS	0.5%	1.0%	2.05	0.022
IT SERVICES	1.6%	2.2%	1.61	0.034
FINANCE AND INSURANCE	3.5%	2.7%	2.36	0.091
REAL ESTATE	1.4%	10.1%	1.37	0.128
CONSULTING	4.4%	2.5%	2.40	0.097
SCIENTIFIC RESEARCH	0.7%	2.4%	1.03	0.025
TECHNICAL ACTIVITIES	1.0%	0.3%	2.33	0.014
BUSINESS SERVICES	5.7%	2.0%	2.28	0.077
PUBLIC ADMIN	9.8%	7.8%	1.00	0.078
EDUCATION	7.7%	4.4%	1.26	0.053
HUMAN HEALTH	7.1%	6.2%	1.06	0.065
SOCIAL WORK	7.6%	3.3%	1.00	0.033
ARTS AND LEISURE	1.6%	1.7%	1.20	0.020
OTHER SERVICES	3.0%	1.3%	1.40	0.017
Moyenne	2.8%	2.8%	1.64	0.044
Min	0.0%	0.0%	1.00	0.002
Max	12.8%	11.8%	2.43	0.167

Figure 8
Cross-country correlation between telework and GDP change

This graph shows the correlation between the share of persons employed using computers with access to Internet and the change in GDP (in %) across 15 European countries.