DISSECTING THE COVID-19 CRISIS IN FRANCE. THE ROLE OF THE JOB RETENTION SCHEME

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ABSTRACT

The Covid-19 epidemic and the measures implemented to stem the spread of the virus resulted in an economic crisis of an unprecedented scale and nature. In order to disentangle the main drivers of the evolution of GDP and household income observed in 2020 in France, we build a micro-founded model integrating the idiosyncrasies of the Covid-19 crisis (simultaneous supply and demand shocks, industry-level heterogeneity and input-output linkages, as well as an endogenous household income). Our model suggests a minor impact of the job retention scheme on total GDP during the first national lockdown (April 2020). The furlough scheme on its own kept GDP from falling by 0.3 pt out of the overall drop of 31 pts in April 2020. Its small impact can be explained by the importance of supply factors in curbing output, as furlough schemes are rather ill-fitted in the latter setting. Our model suggests that furlough schemes are more efficient at stabilizing GDP when demand shocks are sector-specific rather than driven by a drop in aggregate expenses. With only the classical social safety nets, household income would have decreased by 13.1%, which is much worse than the observed 4.7%.

KEYWORDS

Covid-19, input output, job retention.

JEL

C67, D57, E1.

RÉSUMÉ

L'épidémie de Covid-19 et les mesures mises en place pour endiguer la propagation du virus ont entraîné une crise économique d'une ampleur sans précédent. Afin de démêler les principaux moteurs de l'évolution du PIB et des revenus des ménages observée en 2020 en France, nous proposons un modèle intégrant les caractéristiques de la crise du Covid-19 (simultanéité des chocs d'offre et de demande, hétérogénéité sectorielle et réseaux de production, revenu endogène). Simulé entre avril 2020 et mars 2021, notre modèle suggère un impact mineur du dispositif d'activité partielle français sur la chute du PIB durant le premier confinement, à hauteur de 0,2 point sur une baisse globale de 31 points. Son faible impact s'explique par l'importance des facteurs d'offre dans la limitation de la production, et les mécanismes de sauvegarde de revenu permis par l'activité partielle plutôt mal adaptés à ce dernier contexte. Notre modèle suggère que l'activité partielle est plus efficace pour stabiliser le PIB lorsque les chocs de demande sont spécifiques à un secteur plutôt que lorsqu'ils sont provoqués par une baisse globale des dépenses dans l'économie. Enfin, sans dispositif, le revenu des ménages aurait diminué de 13,1 % en moyenne contre 4,7% observé sur la période.

MOTS CLEFS

Covid-19, rationnement, activité partielle, analyse entrées-sorties.

Code JEL

C67, D57, E1.

Dissecting the Covid-19 crisis in France. The role of the job retention scheme

By Magali Dauvin
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The Covid-19 epidemic and the measures implemented to stem the spread of the virus resulted in an economic crisis of an unprecedented scale and nature. In order to disentangle the main drivers of the evolution of GDP and household income observed in 2020 in France, we build a micro-founded model integrating the idiosyncrasies of the Covid-19 crisis (simultaneous supply and demand shocks, industry-level heterogeneity and input-output linkages, as well as an endogenous household income). Our model suggests a minor impact of the job retention scheme on total GDP during the first national lockdown (April 2020). The furlough scheme on its own kept GDP from falling by 0.3 pt out of the overall drop of 31 pts in April 2020. Its small impact can be explained by the importance of supply factors in curbing output, as furlough schemes are rather ill-fitted in the latter setting. Our model suggests that furlough schemes are more efficient at stabilizing GDP when demand shocks are sector-specific rather than driven by a drop in aggregate expenses. With only the classical social safety nets, household income would have decreased by 13.1%, which is much worse than the observed 4.7%.
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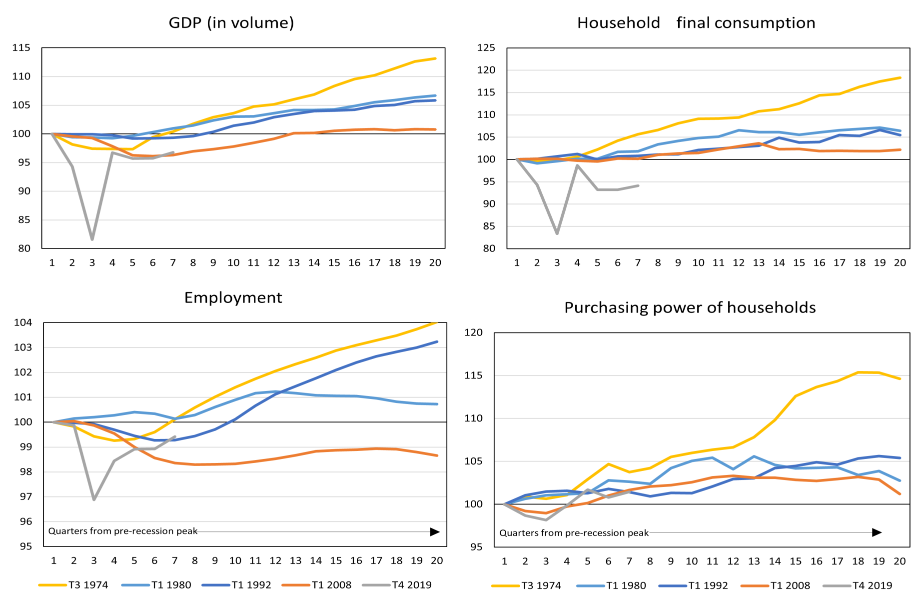
The Covid-19 pandemic and the measures implemented to stem the spread of the virus resulted in the hardest economic hit in recent history, because of both its unprecedented scale as well as its nature. Entire sections of the economy were shut down to ensure social distancing. For instance, in April 2020, French monthly GDP decreased by an unprecedented rate of 31% in France, and if we restrict to the business sector, the fall experienced was all the more dramatic: -50%. In 2020, French GDP fell by 9%, the biggest recession since World War 2.

In 2021 Q1, activity remained below its pre-crisis level (2019 Q4) by 4.7 pts, while employment was only down by 1.3 pts.[1] Household income has been rather resilient (Figure 1) thanks to the massive support provided by public authorities that has accounted so far, after seventeen months of ongoing restrictions, to 1.1 point of GDP. At the end of the same period, household income exceeded its pre-crisis level by 1.2 pts. If one compares the recent crisis with the recessions identified by the *Comité de datation des cycles économiques* of the French Economic Association (Aviat et al. (2021)). One can easily notice that it is a unique event.

Figure 1. Comparisons between the Covid-19 crisis and the Global Financial Crisis



Source: Insee, AFSE.

[1]All this, without mentioning the 'time bomb' of small and medium enterprise failures that could arise in the mid term once fiscal policy becomes less supportive (Gourinchas et al. (2020)).

The greater the number of the social interactions, the harder the impact. A second feature of the Covid-19 crisis lies in the sectoral heterogeneity of its effect, as a result of industries being differently affected by social distancing and rules. In 2020, value-added rose slightly in *Information and communication* (+1 %) and experienced a dramatic fall in *Accommodation and food services* (-42%), and in industries linked with mobility like *Transportation* (-23%) and the *manufacturing of transport equipment* (-28 %) and in sectors linked with leisure, like *Households' services* (-23%). Companies in accommodation and food services, cultural activities and air transport sectors were able to claim full compensation (ie. 100% of labor costs) for non-working hours.

The resilience of household income can be explained by the record support provided by public funds to private agents decided by the French government. This "whatever it takes" strategy was observed in several advanced economies, to different extents (Gourinchas et al. (2021)). According to the Stability Program 2021-2027, the emergency support measures put in place in 2020 in France accounted for 73 billion euros (3.0 pts of 2019 GDP), the impact of all automatic stabilizers left aside. Specifically, the job retention scheme was introduced in order to simultaneously preserve household income and labor relationships, accounting for almost 40% of support measures in 2020. This policy measure played a major role in the idiosyncrasies of the Covid-19 crisis. The job retention scheme offered firms a way rapidly to adjust the number of hours worked when activity got temporarily subdued and impelled employers to retain staff. This support scheme consisted in 70% compensation of the employees' gross wage for all non-working hours, with the remainder being provided by the employer. Overall, the employer's allowance (paid by the State and Unedic) covered 85% of its total labor cost (for non-working hours). Unemployment concerned 8% of active population on average in 2020, a figure that would have otherwise skyrocketed without this scheme. Household income has been relatively well preserved at the macroeconomic level.[2] Indeed, the pandemic has prevented consumers from making purchases if not deterring them from doing so. Some purchases were forbidden, mostly in services implying social interactions. This was particularly the case for goods and services considered as non-essential *per se* (restaurants, leisure, tourism) or those that automatically became less relevant with stay-at-home measures (fuel purchases and transport services). Also, regardless of non-pharmaceutical interventions, households changed their consuming habits or simply deferred their non-essential purchases. Goolsbee and Syverson (2021) find evidence of this kind of endogenous behavior in the US, and Ascari, Colciago and Silvestrini (2021) develop a model where asymmetric demand shocks can emerge across sectors in the context of an epidemic. Finally, heightened uncertainty about the course of the pandemic implied an increase in households' precautionary saving balances. The savings rate

[2] While gross primary income almost halved in 2020 Q2, gross disposable income suffered a 6.5% decrease.

reached an historical record of 27.4% of disposable income in 2020 Q2. According to the *Banque de France*, excess savings peaked at 142 billion euros by the end of Q1 2021.

Our goal is to evaluate what would have happened if companies had not been not incentivized to hoard labour in a rationed economy?

To answer this question we build a structural model that takes into account the main idiosyncrasies of the COVID-19 crisis. In particular the propagation of the diverse and simultaneous supply and demand shocks depend on the structure of production networks. Modern economies are characterized by a growing number inter-dependencies formed by firms in the formation of their value chains (Barrot and Sauvagnat (2016)). While there exists a classical literature on input-output relationships (Leontief (1936)), Leontief (1951) , Ghosh (1958)), a recent literature developed a modern approach of production networks. Carvalho and Tahbaz-Salehi (2019) summarizes the growing literature that models the linkages between firms. Our paper is closely related to Baqaee and Farhi (2020*a*), Baqaee and Farhi (2020*b*) and Baqaee and Farhi (2021). In order to model the propagation of the COVID-19 shocks our model is very close to Barrot, Grassi and Sauvagnat (2021) even if some differences persist (we include final demand shocks to our analysis, they allow prices to be flexible).

To this end, we propose a model that integrates all the main idiosyncrasies of the Covid-19 crisis: i) simultaneous supply and demand shocks, ii) industry-level heterogeneity and input-output linkages and iii) endogenous household income. Then, we retrieve *ex-post* both the supply and demand shocks that have been at work using the methodology presented in Dauvin and Sampognaro (2021). Finally, we build a counter-factual evolution of the French economy without the income insurance permitted by the job retention scheme, in order to capture its effect.

The outline of the paper is as follows. In Section I, the micro-founded model is described. Section II outlines the strategy for identifying the Covid-19 shock. In Section III, we evaluate the specific impact of the job retention scheme one the observed evolution of GDP and household income. Section IV concludes.

I. A model with simultanous supply and demand shocks with input-output linkages

In this section, we set up the basic model with two periods (the present and the future). The economy consists on a set of final consumers, J industries each one with one representative firm and an exogenous agent whose behavior is not modeled (investment, government purchases, exports).

Consumers. There is a continuum of consumers who are endowed with $\bar{L}$

units of labor and $\bar{K}$ units of capital goods.[3] We assume that all consumers are *Ricardian* and do not face any credit constraint. [4]

Consumers' intertemporal utility function may be written as:

$$U(C, C_*) = \frac{C^{1-\eta} - 1}{1-\eta} + \beta \frac{C_*^{1-\eta} - 1}{1-\eta}$$

where β is the pure rate of time preference, $1/\eta$ is the elasticity of intertemporal substitution of consumption and C and C_* are current and future aggregate consumption. The intertemporal budget constraint is:

$$p^C C + \frac{p_*^C C_*}{1+i} = R + \frac{R_*}{1+i}$$

where R, R_*, p^C and p_*^C are the income of the household and the ideal price index of the aggregate consumption bundle in the present and future, and i is the nominal interest rate.

The consumption of households is governed by their Euler equation:

$$C = C_* \left[\beta \left(1+i\right) \frac{p^C}{p_*^C}\right]^{-1/\eta}$$

Thus, current expenses of consumers ($E = p^C C$) are equal to:

$$E = \left[1 + (1+i)^{1/\eta - 1} \beta^{1/\eta} \left(\frac{p^C}{p_*^C}\right)^{1/\eta - 1}\right]^{-1} \left[R + \frac{R_*}{1+i}\right]$$

In this paper we will focus on the case $\eta = 1$, which is a focal point for the empirical literature, according to Baqaee and Farhi (2021). In that specific case the fraction of the wealth that the households consume in the present depends only on the rate of preference for the present:

$$E = \left(\frac{1}{1+\beta}\right) \left[R + \frac{R_*}{1+i}\right]$$

It is possible to model the intertemporal decision problem in a more detailed way, allowing for richer settings. We do not seek to understand how the savings rate is determined but rather the macroeconomic impact of its rise. Note that with $\eta = 1$, the ratio of expenses on current revenue defines the *savings rate* (s), which depends on three key figures: (i) the rate of time preference, (ii) the expectation of an income rise (g_R) and (iii) the interest rate (i):

[3]All the decisions related to the demand and the production of *new* capital goods are not modeled. The dynamic consequences of the impact of the Covid outbreak on the capital stock is out of the scope of this article. The demand for investment goods is included in the exogeneous final demand, which we define later.

[4]See Baqaee and Farhi (2021) for an extension when some consumers are credit constrained.

$$1 - s = \left(\frac{1}{1+\beta}\right)\left[1 + \frac{1+g_R}{1+i}\right]$$

Here, we assume that all the dynamics of savings are driven by a shock on the rate of preference for the present. This interpretation is compatible with consumers deciding to delay their purchases for a period when social interactions do not create a health risk. Ascari, Colciago and Silvestrini (2021) present a theoretical dynamic model where this kind of behavior emerges endogenously when the consumption of some goods increases the probability of contagion. Goolsbee and Syverson (2021) document this kind of behavior even in US counties where restrictive non-pharmaceutical interventions were not implemented. The determinants of current (R) and future (R_*) income will be specified later.

In each period, consumers maximize the following Cobb-Douglas utility function to assign their current budget:

$$U(C) = \prod_{j=1}^{J} C_j^{\chi_j} \text{ with } \sum_{\forall j \in J} \chi_j = 1 \text{ and } \chi_j > 0 \; \forall j$$

where χ_j is a preference parameter that determines the share of the consumers' budget allocated to goods from industry j.

The representative consumer budget income is equal to:

$$R = \sum_{j=1}^{J} w_j L_j + r_j K_j$$

where w_j is the wage rate paid by industry j, L_j the labor employed by industry j and r_j is the rate of return of capital goods (K_j) used by industry j.

For simplicity, the aggregate consumption (C) is modeled in the simplest way:

$$P^C C = (1-s)\,R = \sum_{j=1}^{J} (1-s)\,(w_j L_j + r_j K_j)$$

where $P^C = \prod_{\forall j} p_j^{\chi_j}$ is the aggregate price index of consumption and s is the savings rate from the household intertemporal problem.[5]

α_j denotes the share of the consumption good from sector j in aggregate consumption:

$$\alpha_j = \frac{p_j C_j}{\sum_{m=1}^{J} p_m C_m} = \chi_j$$

[5] s is strictly speaking a function of the rate of time preference β, the expectation of future income growth (g_R) and the interest rate (i). In a richer framework, the savings rate may also depend on the share of financially constrained households (see Baqaee and Farhi (2021)).

Exogenous final demand. Besides consumers, we suppose that there is an exogenous final demand accounting for demand in capital goods and purchases made by governments and from the rest of the world (including changes in inventories). In what follows, this final demand is considered as strictly exogenous. The exogenous final demand addressed to industry j is written d_j^*.

Producers. An industry j faces 3 types of demand: (i) final demand by consumers; (ii) the exogenous final demand; and (iii) demand from other industries for intermediate consumption. The representative firm of industry j produces a good using primary inputs with the following nested-CES production function:

$$Q_j = A_j \left[\beta_j^L L_j^\rho + \beta_j^K K_j^\rho + \left(1 - \beta_j^L - \beta_j^K\right) M_j^\rho \right]^{1/\rho}$$

Where A_j is the TFP of industry j, L_j labor, K_j capital goods and M_j intermediate goods used by industry j. $\beta_j^L + \beta_j^K$ illustrates the share of value-added in the production process. ρ determines the elasticity of substitution between intermediate goods and primary factors (equal to $\frac{1}{1-\rho}$).

The bundle of intermediate goods is itself defined as a CES function:

$$M_j = \left[\sum_{j=1}^{J} \iota_{ij} M_{ij}^{\frac{\theta}{1+\theta}} \right]^{\frac{1+\theta}{\theta}}$$

The input weight ι_{ij} captures the relative importance of intermediate goods from sector i in the technology of industry j. θ represents the elasticity of substitution among intermediate goods.[6]

Competitive equilibrium. In the competitive equilibrium, the unitary price of a good from industry j is given by the marginal cost of production (mc_j):

$$(1) \quad mc_j = \frac{1}{A_j} \left[(\beta_j^L)^{\frac{1}{1-\rho}} w_j^{\frac{-\rho}{1-\rho}} + (\beta_j^K)^{\frac{1}{1-\rho}} r_j^{\frac{-\rho}{1-\rho}} + (1 - \beta_j^L - \beta_j^K)^{\frac{1}{1-\rho}} P_j^{M\,\frac{-\rho}{1-\rho}} \right]^{1-\frac{1}{\rho}}$$

where P_j^M is the price index of intermediate goods used by industry j, which is defined as :

$$P_j^{M^{-\theta}} = \left[\sum_{h=1}^{J} \iota_{jh}^{1+\theta} mc_h^{-\theta} \right]$$

[6]The nested-CES technology allows for richer patterns of substituability than the original Leontief model ($\rho = -\infty$, $\theta = 0$), depending on the values of ρ and θ. For instance, one could write the model using a Cobb-Douglas technology ($\rho = 0$, $\theta = 1$).

In this setting, the share of expenses on intermediate goods (ω_j^M) and on the wage bill (ω_j^L) in the production of j in value are :

$$\omega_j^L = \frac{w_j L_j}{p_j Q_j} = \frac{(\beta_j^L)^{\frac{1}{1-\rho}} w_j^{\frac{-\rho}{1-\rho}}}{(\beta_j^L)^{\frac{1}{1-\rho}} w_j^{\frac{-\rho}{1-\rho}} + (\beta_j^K)^{\frac{1}{1-\rho}} r_j^{\frac{-\rho}{1-\rho}} + (1-\beta_j^L-\beta_j^K)^{\frac{1}{1-\rho}} P_j^{M\frac{-\rho}{1-\rho}}}$$

$$\omega_j^K = \frac{r_j K_j}{p_j Q_j} = \frac{(\beta_j^K)^{\frac{1}{1-\rho}} r_j^{\frac{-\rho}{1-\rho}}}{(\beta_j^L)^{\frac{1}{1-\rho}} w_j^{\frac{-\rho}{1-\rho}} + (\beta_j^K)^{\frac{1}{1-\rho}} r_j^{\frac{-\rho}{1-\rho}} + (1-\beta_j^L-\beta_j^K)^{\frac{1}{1-\rho}} P_j^{M\frac{-\rho}{1-\rho}}}$$

$$\omega_j^M = \frac{P_j^M M_j}{p_j Q_j} = \frac{(1-\beta_j^L-\beta_j^K)^{\frac{1}{1-\rho}} P_j^{M\frac{-\rho}{1-\rho}}}{(\beta_j^L)^{\frac{1}{1-\rho}} w_j^{\frac{-\rho}{1-\rho}} + (\beta_j^K)^{\frac{1}{1-\rho}} r_j^{\frac{-\rho}{1-\rho}} + (1-\beta_j^L-\beta_j^K)^{\frac{1}{1-\rho}} P_j^{M\frac{-\rho}{1-\rho}}}$$

Hence :

$$\frac{L_j}{M_j} = \left(\frac{\beta_j}{1-\beta_j}\right)^{\frac{1}{1-\rho}} \left(\frac{w_j}{P_j^M}\right)^{\frac{-1}{1-\rho}} \tag{2}$$

We can define the share of expenses on intermediate input i in total intermediate goods consumption made by industry$j$ (γ_{ij}) as:

$$\gamma_{ij} = \frac{X_{ij}}{\sum_{h=1}^{J} X_{hj}}$$

At the competitive equilibrium:

$$\gamma_{ij} = \frac{mc_i^{-\theta} \iota_{ij}^{1+\theta}}{\sum_{h=1}^{J} \iota_{hj}^{1+\theta} mc_h^{-\theta}} = \left(\frac{mc_i}{P_j^M}\right)^{-\theta} \iota_{ij}^{1+\theta}$$

In this nested-CES framework, γ_{ij} depends on the relative price of input i and the technological weight ι_{ij}.

A simple re-writing of the model allows one to compute the technical coefficient a_{ij}, which measures the weight of input i in total production of industry j:

$$a_{ij} = \omega_j^M \times \gamma_{ij} = (1-\omega_j^L-\omega_j^K) \times \gamma_{ij}$$

All key variables defining the competitive equilibrium of this simple economy $P^C C$, $p_j Q_j$, α_j, ω_j^L, ω_j^K, ω_j^M and a_{ij} are directly observable in National Accounts produced by national statistical institutes in advanced economies.

A. *Integrating the Covid-19 shock to the model*

The Covid-19 shock modelling is largely inspired by Gourinchas et al. (2020). In the rest of the paper we use the following notation: $\hat{x}$ represents the change in variable x between its pre-Covid level (x) and its value during the pandemic (x'). We represent this change by the following ratio $\hat{x} = \frac{x'}{x}$.

Four essential shocks characterize the shocks at work during the pandemic: (i) supply constraints that preclude firms from reaching their optimal input demand; (ii) a savings rate shock; (iii) an idiosyncratic final demand shock; (iv) the job retention scheme. We add them to the model of input-output linkages presented in the former subsection.

First, with the pandemic outbreak, employees considered as "non-essential workers" are unable to produce and supply-chain disruptions make firms unable to reach their optimal level of intermediate goods. These supply shocks limit output of the representative firm in sector j. We call $\nu_j \in [0; 1]$ the share of employees that can be mobilized in the production process during the pandemic outbreak.

Second, the household savings rate may be impacted by the deferring of purchases or by prudence behavior in a context of high uncertainty. The savings rate evolves during the pandemic as $\widehat{s}$.[7] However, this is not the only effect of Covid-19 on final demand. Third, firms face a shock on their exogenous final demand, and consumers may redirect their purchases during the pandemic. The effect of these factors are heterogeneous among industries. The change in the composition of the consumption basket from households could be modeled through a change in χ_j. Moreover, the shift in the demand from the unmodeled agents (rest of world, governments, demand for new capital goods) is modeled through an exogenous final demand shock $(\widehat{d^*F*_j})$.

Turning to the furlough scheme, it has a counterpart in households' budget constraint. We suppose that the scheme does not impact the level of employment but the level of *productive* employees. Productive employees are paid their full wage $w'_j L'_j$ while unproductive employees receive a share τ of their pre-Covid wage bill: $\tau w_j \left(L_j - L'_j \right)$. In our exercise, we stabilize revenue in the business sector, while in the government sector revenues are paid regardless of the drop in activity.

[7]In our setting: $\widehat{s} = f(\widehat{\beta}, \widehat{g_R}, \widehat{i})$. Without loss of generality we consider that $\widehat{g_R} = \widehat{i} = 1$ and interpret the evolution of the savings rate as arising from a temporary shift in the preference for the future.

$$R' = \sum_{j=1}^{J} \left(w'_j L'_j + \tau w_j \left(L_j - L'_j \right) \right) + r'_j K'_j$$

$$R' = \sum_{j=1}^{J} \left[L'_j \left(w'_j - \tau w_j \right) + \tau w_j L_j \right] + r'_j K'_j$$

Then, the job retention scheme acts as an income insurance in the sense that a share of households income is guaranteed ($\tau w_j L_j$) while another share depends on the evolution of wages and capital return and on the number of effectively productive factors ($L'_j \left(w'_j - \tau w_j \right) + r'_j K'_j$).

Finally, firms may suffer a TFP shock linked with the mandatory and unexpected use of telecommuting. We suppose $\widehat{A_j} = 1$ as there is little empirical evidence of a productivity shock during the pandemic (see Batut and Tabet (2020) for the French case, Barrot, Grassi and Sauvagnat (2021) make a similar assumption in the US case). We can also think that the digitalization of production processes forced by the pandemic may improve productivity. For the moment we keep this kind of shock outside the scope of our work.

B. Industry behavior during the pandemic

We suppose that during the pandemic firms cannot adjust their prices and factor prices remain fixed ($\widehat{p_j} = \widehat{w_j} = \widehat{r_j} = 1 \ \forall j$). Moreover, the pre-Covid demand for primary factors limits the choice set of firms during the Covid outbreak. All pricing decisions were made under the macroeconomic conditions of the pre-Covid scenario.

From equations 1 and 2 it is straightforward to see that:

$$\widehat{mc}_i = 1 \ \forall i \Longrightarrow \widehat{\gamma_{ij}} = 1$$

Moreover, under constant returns to scale this implies that $\widehat{\omega_j^L} = \widehat{\omega_j^K} = \widehat{\omega_j^M} = 1$, regardless of ρ and θ. In a fixed price setting, any substituability assumption suggests that the input-output structure is unchanged, as in the original Leontief model.

To describe the behavior of one industry during the Covid-19 episode it is unnecessary at this stage to differentiate the source of demand the industry faces. Total demand to industry j (d_j) is equal to $d_j = \sum_{\forall i \in J} a_{ij} Q_i + \alpha_j P^C C + d_j^*$ and d'_j before Covid, and during the pandemic it is equal to d'_j. In this context the representative firm should solve the following optimization problem:

$$
\begin{aligned}
\underset{L'_j, M'_j}{\text{minimize}} \quad & w_j L'_j + P_j^M M'_j \\
\text{subject to:} \quad & A_j \left[\beta_j L'^{\rho}_j + (1-\beta_j) M'^{\rho}_j \right]^{1/\rho} \geq d'_j \\
& L'_j \leq \nu_j L_j \\
& K'_j \leq K_j
\end{aligned}
$$

Two theoretical cases may arise:

◇ Industry j is binded by supply: $L'_j = \nu_j L_j \Longrightarrow \widehat{L_j} = \nu_j$.
If all prices remain unchanged then equation (2) shows that the ratio L_j/M_j is constant. Thus, $\widehat{M_j} = \widehat{L_j} = \widehat{K_j} = \nu_j \Longrightarrow \widehat{Q_j} = \nu_j$. With fixed prices, the firm cannot modify the share of labor and intermediate goods, this would be a departure from the initial iso-cost function. The industry binded by the supply shock is forced to scale down its production process.

◇ Industry j is constrained by total demand: $Q'_j = d'_j \Longrightarrow \widehat{Q_j} = \widehat{d_j}$. Again, industry j can reach its optimal labor demand and will keep proportions stable: $\widehat{M_j} = \widehat{L_j} = \widehat{K_j} = \widehat{d_j}$.

It can be shown that the threshold separating industries constrained by supply and demand is given by $\widehat{d_j} = \nu_j$. More precisely, if $\widehat{d_j} < \nu_j$ then the industry is limited by demand and in the other case it is bounded by the supply shocks.

The main implications of our setting (*ie.* including nested-CES technology and CES utility functions, fixed prices and wages) lie in the fact that each industry is constrained by the biggest shock it faces, and the latter determines the proportion by which all relevant variables change in response to a shock. In other words, we have: $\widehat{\gamma_{ij}} = \widehat{\omega_L} = \widehat{\omega_K} = \widehat{\omega_M} = \widehat{a_{ij}} = 1$. Therefore, the crucial hypothesis here is that input-output relationships remain unchanged during the pandemic outbreak, hence we are able to use pre-Covid data for calibration purposes.

C. *It all comes down to a model with rationed agents*

Once one has understood the behavior of each industry facing simultaneous supply and demand shocks, one can find the economy's equilibrium conditions in a simple matrix form. The structure of this economy differ from the classic Leontief model to the extent that some productions are endogenous on the left-hand side $(Q'_1, \ldots, Q'_k, R')$ while some are exogenous $(\nu_{k+1} Q_{k+1}, \ldots, \nu_J Q_J)$. Moreover, several elements of the final demand are endogenous in the right-hand side of the equation $(d^{*'}_{k+1}, \ldots, d^{*'}_J)$. To solve the model, the only trick is to rearrange the matrix to have all endogenous variables to the left-hand side (supply for demand-constrained industries and demand for supply-constrained industries) and all exogenous variables to the right-hand side (demand shocks for demand-constrained industries and supply shocks for supply-constrained industries)[8].

II. Identifying supply and demand shocks during the Covid-19 outbreak in France

In this section we aim to decompose the determinants of the evolution of GDP and of household income month-by-month since the first national-level lockdown in France in April 2020 until March 2021. In this section we will try to identify the active supply and demand shocks that emerged during those months, in compatibility with the published data by the national statistical institute (Insee) and the structure of our micro-founded model. Obviously, the identification of the shocks is model-dependent. Next we present the data need and then describe the identification procedure and finally give the main results concerning the effect of the 3 identified shocks (savings rate and idiosyncratic demand and supply shocks).

A. Data

To calibrate the input-ouptut structure of the French economy, we used the data from the Symmetric input-output table (SIOT) published with the National Accounts by Insee. The latest data available cover the year 2017. Originally this data is published at the level A38 of National Accounts nomenclature, but as there is not available data for added value at this level for the Covid-19 crisis period we aggregate the data in order to have an SIOT with 17 industries.

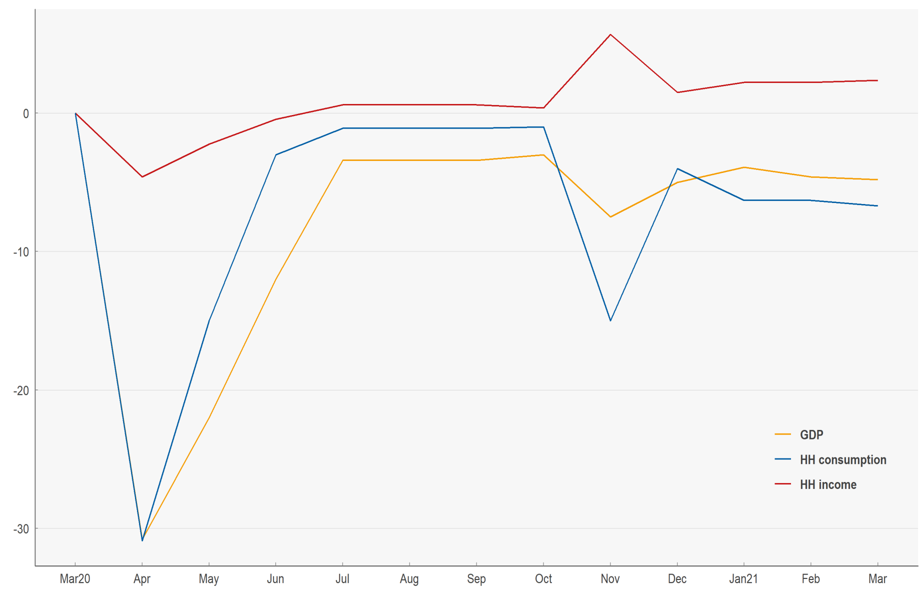
Data on monthly production at the industry level and on consumers consumption have been retrieved from Insee's *Notes de conjoncture*, and should be considered as estimations (Figure 2).

Figure 3 illustrates the changes in consumer spending patterns at the macroeconomic level induced by the Covid-19 crisis. For instance, during the first lockdown in April 2020, products related to stay-at-home activities (agri-food, real estate, information and communication) were much more used compared to usual times, while transportation services and goods as well as services linked to social activities were much less represented in the usual consumption basket (downgraded more than 60% for HZ, C4 and IZ). The former is explained by maintained consumption even as overall consumption fell. Household consumption of transportation and food and accommodation remained the most affected spending categories throughout the crisis.

We need data on household income month-by-month in order to compute the savings rate of household, however, this is available only on a quarterly basis at

[8]More details in Appendix A.A1

Figure 2. GDP and Household consumption and income during the Covid-19 crisis



Notes: In % difference with pre-Covid level.

Source: Insee.

the highest frequency. To circumvent this issue, we proxy monthly income that is compatible with the quarterly data retrieved and the infra-quarterly evolution compatible with the evolution of the published household consumption in a way that minimizes the infra-quarterly variation of the savings rate.[9]

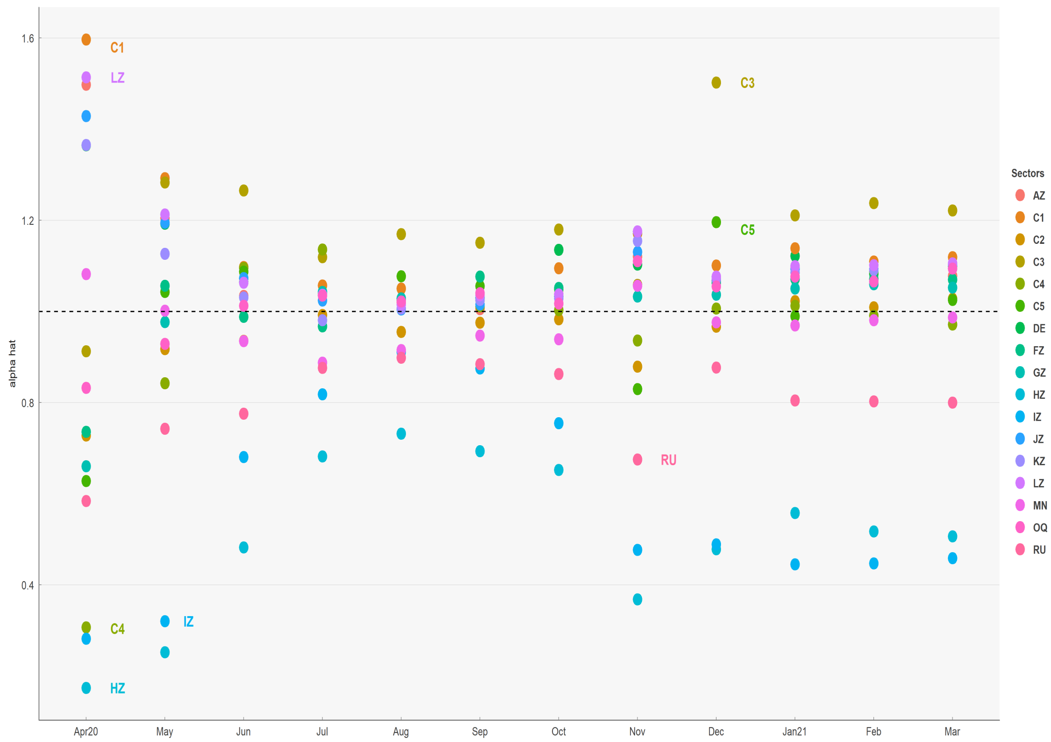
Lastly, the Acemo-COVID survey was used in order to have data on the binding shocks by industry. The statistical department of the Labor Ministry publishes monthly data on their survey asking firms how the Covid crisis is affecting them and how they are responding to the different shocks. All industries are covered by the survey, except *Agriculture* and all firms of *Households' services* and *Non-market activities* are concentrated in a single industry. In particular we used the companies' answer to the following question : *If your activity was reduced (in terms of employees), would you say that the sanitary crisis has directly impacted your activity because of i) reduced prospects; ii) administrative closures; iii) supply*

[9]The precise formula of the approximation is:

$$R_m - R_0 = (R_q - R_0) \times \frac{C_m - C_0}{C_q - C_0}$$

where R_m is the households' income of month m, R_q the observed households' income of quarter q, R_0 the pre-Covid reference income, C_m is the households' consumption in month m retrieved from Insee's reports and C_q is the households' consumption in quarter q observed in national accounts.

FIGURE 3. CHANGE IN HOUSEHOLDS' CONSUMPTION PREFERENCES ($\hat{\alpha}$)



Sources: Notes de conjoncture, Insee, authors' calculation.

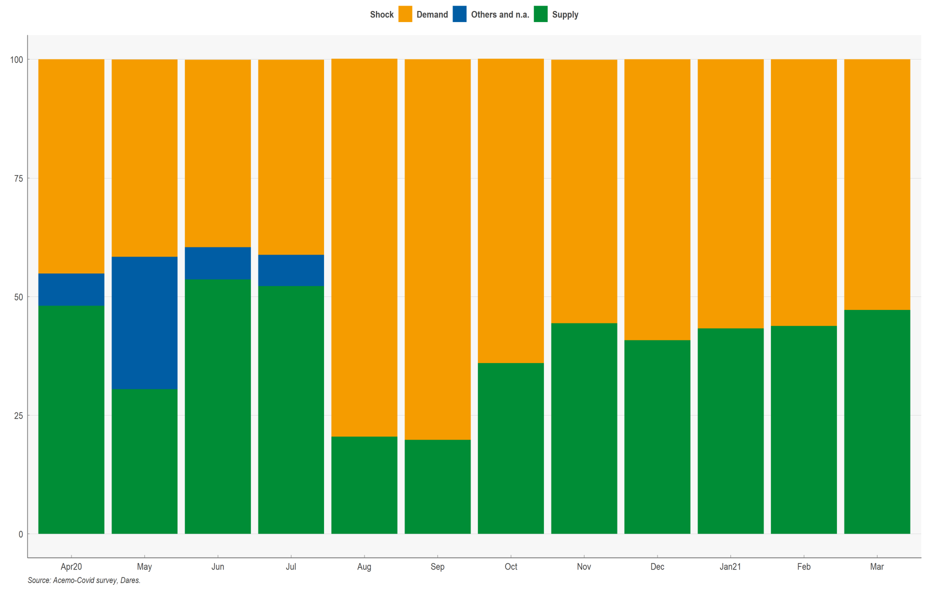
Notes: The dashed line represents an unchanged share of good j in the consumption basket, ie. $\frac{\alpha_j'}{\alpha_j} = \hat{\chi}_j = 1$. AZ: Agriculture, forestry and fishing, DE: Mining and quarrying; energy, water supply, sewerage, waste management and remediation activities, C1: Manufacture of food products, beverages and tobacco products, C2: Manufacture of coke and refined petroleum products, C3: Manufacture of electrical, computer and electronic equipment; Manufacture of machinery, C4: Manufacture of transport equipment, C5: Other manufacturing, FZ: Construction, GZ: Wholesale and retail trade; repair of motor vehicles and motorcycles, HZ: Transportation and storage, IZ: Accommodation and food service activities, JZ: Information and communication, KZ: Financial and insurance activities, LZ: Real estate activities, MN: Professional, scientific, technical, administrative and support service activities, OQ: Public administration and defence, education, human health and social work activities, RU: Other services activities.

disruptions, or iv) labour shortage? Figure 4 depicts the responses retrieved over the period spanning from April 2020 to May 2021 for the whole economy.

B. *Identifying the sectoral binding constraints*

The structural model described in Section I is very easy to solve once the supply and demand constraints have been identified. We use an external source of information in order to classify the binding constraints for each industry month-

FIGURE 4. CAUSES OF REDUCED ACTIVITY IN THE FRENCH ECONOMY



Notes: In % employees

Source: Acemo-COVID survey, Dares.

by-month. Notice that in the current exercise we are not seeking the effect of the shocks $(\widehat{s}, \widehat{d_j^*}, \widehat{\chi_j})$ on final production, household income and final consumption by industry (Q_j,R and C_j). Here we seek to identify the exogenous shocks on production, consumption and HH income. In Dauvin and Sampognaro (2021) we proposed an iterative procedure, very easy to implement, in order to recover the active exogenous shocks. We identify the supply-binded industries using an external source of information: the Acemo-COVID survey. In this survey firms should respond to the causes of reduced activity, which can be classified as demand or supply driven (see Figure 4).

Once we have identified the sectors constrained by supply factors, our structural model lets us directly identify the supply shock the industry is facing:

$$\nu_j = Q_j^{\widehat{observed}}$$

We can also recover directly from our data the observed savings rate $s' = s^{observed}$ and compute for each product the new demand shifter $\chi_j' = \frac{p_j C_j^{observed}}{\sum_{\forall i} p_i C_i^{observed}}$.

Observed data let us recover directly the following shocks: ν_j,$\widehat{s}$ and $\widehat{\chi_j}$. We still need to retrieve $\widehat{d_j^*}$ and $\widehat{R^*}$. This is possible using our iterative procedure:

1. For each industry constrained by demand factors, set an initial value for the exogenous shock $\widehat{d_j^*} = \widehat{d_j^*}^S$ and $\widehat{R^*} = \widehat{R^*}^S$. Set $\nu_j = Q_j^{observed}$, $s' = s^{observed}$ and $\chi'_j = \chi_j^{observed}$.
2. Simulate the structural model and recover the equilibrium production Q_j^S and HH income R^S.
3. Compare the vector of simulated production Q^S with the observed production Q.
4. If there exists at least one sector j where $|Q_j^S - Q_j^{observed}| > 0.5\%$ and if $|\sum_{\forall j} Q_j^S - Q_j^{observed}| > 0.1\%$ or if $|R^S - R^{observed}| > 0.5\%$ then modify the guess of your exogenous shocks $\widehat{d_j^*}^S$ and $\widehat{R^*}^S$ and restart the procedure, up to the thresholds defined in this step.

Once this procedure has been carried out, we obtain the final demand shocks and the exogenous HH income, which together with the supply shocks and the shocks on preferences of consumers identified, allows us to reproduce the sectoral fall in production observed during the Covid crisis.

C. The difficulty to dissect the Covid-19 crisis

During the Covid crisis, there was much discussion about whether the recession caused by the virus was due to supply or demand factors. The model we have built, and our methodology for identifying the shocks that are effectively operational, should allow us to measure the quantitative contribution of each of these shocks. Nevertheless, this is not an easy task. Given the complexity of the crisis, and the simultaneity of all these shocks, it is difficult to give a clear and precise answer. However, our structural model being non-linear, the calculation of the contributions of a particular shock to the final result is particularly difficult to perform.

We classify the shocks introduced in our model in three groups: (i) supply shocks (including ν_j); (ii) macroeconomic demand (including $\widehat{s}$ and $\widehat{R^*}$); and (iii) sectoral demand shocks (including $\widehat{d_j^{*F}}$ and $\widehat{\chi_j}$). In order to compute the marginal impact of each group of shocks we compute the following formula (g_i representing the group of shock i):

$$\text{Marginal Contribution}_1 = Q_j(\widehat{g_1}, g_2, g_3) - Q_j(g_1, g_2, g_3)$$

Then, the marginal contribution of the second group would be:

$$\text{Marginal Contribution}_2 = Q_j(\widehat{g_1}, \widehat{g_2}, g_3) - Q_j(\widehat{g_1}, g_2, g_3)$$

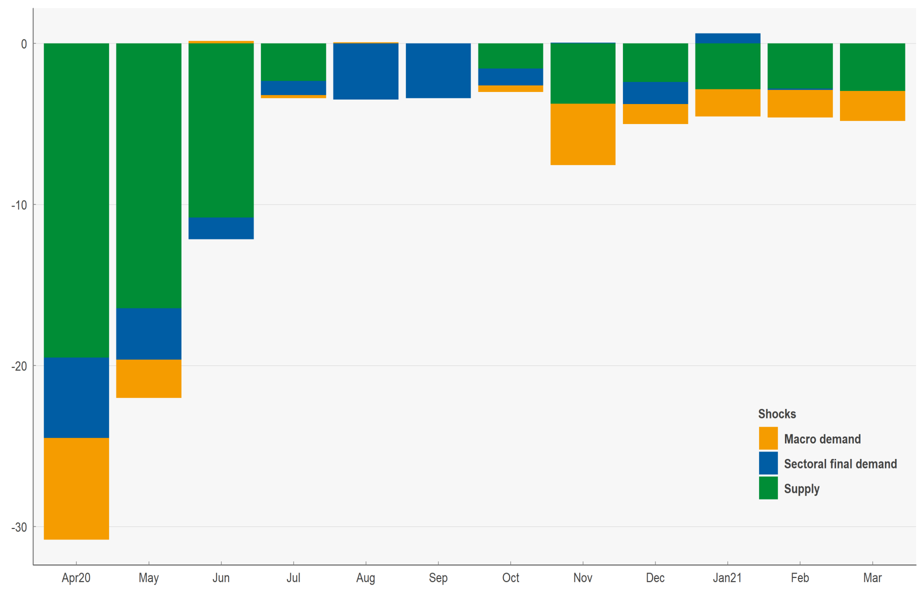
And finally,

$$\text{Marginal Contribution}_3 = Q_j(\widehat{g_1}, \widehat{g_2}, \widehat{g_3}) - Q_j(\widehat{g_1}, \widehat{g_2}, g_3)$$

Notice that $Q_j(\widehat{g}_1, \widehat{g}_2, \widehat{g}_3) = Q_j^{obs}$ by construction. The problem with this methodology is that the marginal contribution of each depends on the ordering of the simulation of the different group of shocks even if we consider that all these shocks are simultaneous.

In order to tackle this problem - in an imperfect way - we simulate all the possible orderings of these three group of shocks[10] and then we compute the mean marginal contribution of each group of shocks. Results are shown in Figure 5 and Table 1.

Figure 5. Contributions to reduced activity



Notes: In % points

Source: DARES, Acemo-COVID survey.

III. The role of the job retention scheme in sustaining GDP and household income

France, as all the major advanced economies, implemented massive transfers to private agents in order to preserve their balance sheets. Despite a historic recession, household income at the aggregate level increased in 2020.[11] The job

[10]With 3 groups of shocks we simulate $3! = 6$ orderings.

[11]French households experienced an increase of their disposable income by 16 billion euros while companies and the public sector suffered respective losses of 62 and 111 billion euros (Source: Insee).

TABLE 1—CONTRIBUTION OF SHOCKS TO GDP DROP

	Supply	Macro demand	Sectoral final demand	Total
April 20	-19.5	-6.3	-5.0	-30.8
May	-16.4	-2.4	-3.2	-22.0
June	-10.8	0.1	-1.4	-12.0
July	-2.3	-0.2	-0.9	-3.4
August	0.0	0.1	-3.5	-3.4
September	0.0	0.0	-3.4	-3.4
October	-1.6	-0.4	-1.1	-3.0
November	-3.7	-3.8	0.1	-7.5
December	-2.4	-1.2	-1.4	-5.0
January 21	-2.8	-1.7	0.6	-3.9
February	-2.8	-1.7	-0.1	-4.6
March	-3.0	-1.8	0.0	-4.8

Source: Authors' calculation.

retention scheme had a very important role in preserving household income, especially for employees. Moreover, the scheme helped to maintain the contractual relationships active during the pandemic outbreak, and firms could adjust their labor demand immediately. This last feature of the scheme is particularly important in order to ensure a fast recovery once the temporary social distancing measures are lifted. In this paper, we will neglect the last effect.

Let's notice that preserving the contractual relationship between employers and employees can have two important effects of different sign: (i) as it gives the assurance to employees that their jobs will be preserved after the crisis, this may limit precautionary savings and sustain aggregate demand during the pandemic outbreak; (ii) nevertheless, if the Covid crisis is longer than expected - as it ultimately has been - preserving contractual relationships may prevent the reallocation of labor between industries. Hence, resources cannot move from Covid-hit industries to Covid-winners (*i.e.* delivery, electronic retail).

In this Section we will use our model in order to quantify the impact of the job retention scheme on the preservation of aggregate consumption, and by consequence on total GDP, thanks to the power of the scheme to preserve the income of employees, despite a massive cut in labor demand emanating from firms.

A. Building a counterfactual

The major difficulty in order to analyze the specific role of the job retention scheme during the Covid outbreak is that France has a solid welfare state, with important automatic stabilizer, that preserve household income in case of economic shocks (see André, Germain and Blanchet (2021)). In the absence of such a scheme, employees' income would have been relatively well preserved by classic unemployment insurance schemes or minimum income guarantees (*i.e.* RSA). We cannot simply consider that the 27 billion euros (1.1 point of pre-Covid GDP) of expenses related to the job retention scheme related expenses quantify properly the causal effect of the scheme on household income. Stated in terms of our micro-founded model, we cannot state that $\tau = 0$ before the Covid outbreak.

In order to simulate a Covid economy without the job retention scheme we should simulate to what extent the French social system would have preserved employees' income. According to the data published by the statistical office of the Labour Ministry DARES, by the end of September 2018 six million of people were registered in *Pôle Emploi* and available to work. Among them, 4.9 million individuals didn't work in the preceding month. Taking into account that almost 30% of them do not benefit from any social protection safety net, their average income is equal to one-fifth of the mean wage of the French economy (see Table 2). Among full beneficiaries from classical unemployment schemes, the revenue is very well preserved: their income is almost half of the average wage (more precisely 31%).

Table 2—Compensation of individual job seekers registered as of 30 September 2018

	Individual in '000	Mean income in euros	Mean monthly income in % of mean wage
Total (Categories A,B,C)	**6033**	–	–
Total excluding compensable not compensated	**4926**	**602**	**19**
of which ...			
Unemployment insurance benefits	2471	990	31
Other UI benefits from the State	382	480	15
w/o UI benefits but benefiting from RSA	659	507	16
w/o UI benefits without RSA	1414	0	0

Source: DARES *via* Pôle Emploi, Authors' calculation.

It is a well-known result in economics that unemployed individuals are not randomly selected; we cannot simply consider that these figures would apply to Covid-hit jobs. Given the massive economic shock linked with the Covid-19 crisis, it is hard to think that individuals who would have lost their job during the Covid outbreak would have been comparable with the pre-crisis unemployed population. As the Covid crisis affects almost every industry and firm (especially at the inception of the crisis by April 2020), it is hard to think that most of the affected employees would not have enough accumulated social rights to have the right to benefit from a substantial protection from classical unemployment schemes. In that sense, the average protection would have been closer to 31% than to 19%.[12]

[12] The average replacement rate of unemployment insurance in France is close to 70%, near to the level of income protection granted by the job retention scheme. If all *potential* unemployment generated

For the rest of the paper we will consider that $\tau = 0.31$ in the pre-Covid world.

B. Results

In order to assess the quantitative impact of the job retention scheme during the Covid crisis; we simulate the identified related shocks ($\widehat{d^{F*}}$, R^*, ν, $\widehat{s}$) in a context where $\tau' = 0.7$ rather than 0.31.

For April 2020, our results lead to a very disappointing impact of the job retention scheme on total GDP (Table 3). According to our model, the overall GDP increased by 0.3 pt in link with the furlough scheme. Obviously, this was not the main objective of the scheme, so we cannot judge it exclusively on the basis of this figure. With only the classical social safety nets, household income would have decreased by 13.1%, which is much worse than the observed 4.7%. Finally, the impact of the furlough scheme is significant for HH consumption. Without the extra safety net the drop would have been 38%, which must be compared with a drop of "only" 32%. The scheme erases one-seventh of the consumption shock in April 2020.

We tried to understand the disappointing impact of the job retention scheme on GDP during the first month of the Covid recession. If we simulate simultaneously all the shocks alternatively with $\tau = 0.7$ and $\tau = 0.31$, then our model suggests that the job retention scheme copes with 1% of the recession. If we simulate each kind of shock in isolation, we understand better when a furlough scheme may be more efficient in order to stabilize GDP. If the economy is subject only to an aggregate consumption shock ($\widehat{s}$) the scheme decreases the GDP loss by 5% (from 27.2 to 25.9). The scheme is much more efficient to cope with idiosyncratic sectoral demand shocks. In that case the GDP drop is reduced by 13% (from 5.4 to 4.7). Last but not least, the extension of the temporary layoff scheme tempers the supply shocks by only 1%. It is noteworthy that a revenue support measure is totally unable to increase production in supply-constrained industries, whatever the level of expenses on the scheme (see the last 2 columns of Table **??**). Moreover, if this type of scheme is better suited to stabilize demand shocks, it is better suited against idiosyncratic demand shocks than shocks to the savings rate of household. If households are limiting their purchases (precautionary savings or delaying purchases in order to limit social interactions), giving them more income would not be efficient in order to tackle the recession.

by Covid-19 had the benefit of a full UI scheme, the job retention scheme could be seen exclusively as an extension of UI benefits rights and not as a supplementary income protection granted during the temporary Covid outbreak.

Table 3—Impact of the job retention scheme on ...

	... GDP	... HH revenue	... consumption
April 20	0.3	8.2	5.9
May	0.1	6.1	5.3
June	0.1	3.8	3.7
July	0.1	1.3	1.2
August	0.6	1.6	1.5
September	0.6	1.6	1.5
October	0.3	1.5	1.5
November	0.2	2.5	2.0
December	0.4	1.9	1.8
January 21	0.4	1.6	1.5
February	0.4	1.9	1.7
March	0.5	2.0	1.8

Source: Authors' calculation.

We propose to evaluate the share of the Covid-19 induced recession that was prevented by the extension of social safety net (noted JRS) and in particular the role of the job retention scheme. For a variable y we compute the following formula:

$$JRS = \frac{y(\nu_j, s', R'^*, d_j'^{*F}, \chi_j', \tau = 0.7) - y(\nu_j, s', R'^*, d_j'^{*F}, \chi_j', \tau = 0.31)}{y(\nu_j, s', R'^*, d_j'^{*F}, \chi_j', \tau = 0.31) - y(s, R^*, d_j^{*F}, \chi_j, \tau = 0.31)}$$

The denominator of JRS represents the spontaneous reaction of y, according our structural model without change in the social safety nets. This figure gives a first insight of the spontaneous diffusion of the Covid-19 related shocks. The numerator gives the specific impact - given a set of shocks- of the rise of τ. According to our model the job retention scheme had a minor role in GDP stabilization, specially during the first national lockdown (around 1 % of the GDP losses were prevented by this scheme according to our model. Nevertheless, our model may be not suitable to compute the impact of the scheme on GDP. First, we treat the final demand in term of investment goods as totally exogenous and not dependent on the level of demand that emanates from households. Second, an important share of the drop of GDP comes from a halt to world trade, totally orthogonal to the job retention scheme. Third, stopping the provision of public goods (*i.e.* school closures) also explains a significant share of the Covid-19 recession, specially during the first national lockdown. Again, this drop in production is impossible to stop with public support to HH income. In fact, our model is more suitable to study the impact of the job retention scheme on HH consumption.

In terms of household consumption, our model suggests that the job retention scheme was more effective in stopping the fall in household consumption (see Table 4). Let's notice that the job retention scheme is less efficient to stabilize household consumption during the months were supply shocks were particularly binding: it is very hard to stabilize consumption when production is constrained. In the same way it is very hard to stabilize consumption when the shock on the preference for the future are unfavorable: it's very hard to lean against the wind in this very specific context. According to our model, the job retention scheme is particularly effective during months when activity is penalized by idiosyncratic sectoral demand shocks (June, July and October 2020).

Notice that our results may present a lower bound for the stabilization impact of the job retention scheme. If the job retention scheme reduces uncertainty about future income and reduces the risk of unemployment, there car be a neglected negative link between the savings rate (s) and the share of current income preserved by the public facilty.

Even with these precautions in mind two main results emerge: (i) it's very hard to stabilize household consumption and GDP with quantitative restrictions on production; (ii) it's very hard to lean agains the wind if there is a surge in the preference for the future; and (iii) a job retention scheme seems very well fitted to cope against temporary, sectoral shocks. Even if it is besides the scope of our model, this kind of scheme may block the transition between industries in case of longer sectoral shocks.

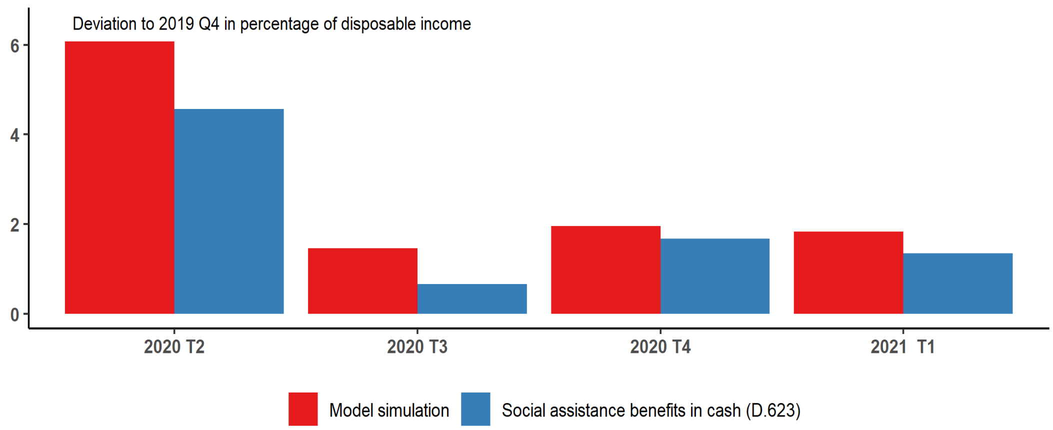
Table 4—Share of the Covid-19 losses compensated by the job retention scheme

Month	GDP	HH Consumption
April 2020	1.3%	21.6%
May	0.9%	33.6%
June	0.8%	59.4%
July	2.4%	44.0%
October	8.3%	50.6%
November	3.8%	12.2%
December	8.4%	28.9%
January 2021	7.7%	15.8%
February	7.7%	18.3%
March	8.3%	18.4%

Source: Authors' calculation.

Constraints on the economy changed in line with the pandemic. Hence, one could argue there are no reasons to believe that the same support rate was applied to household income throughout the year under study. We show that although $\tau = 0.7$ stands for an average, our hypothesis and the counterfactual chosen mimic rather well the amount of income safeguarded by the scheme. Figure 6 depicts the evolution of *social assistance benefits in cash* retrieved from households' non-financial accounts (D.263, blue bars) wherein the scheme appears. At the height of the crisis, they were up by 4% of disposable income compared to the pre-crisis period (17.1 billion euros).[13] Our model (red bars) fares quite well in replicating the impact of the scheme on households' revenues.

FIGURE 6. INCOME SAFEGUARDED BY THE THE JOB RETENTION SCHEME



Source: Insee, Households' quarterly accounts (S.14), authors' calculation.

The amount of compensation is estimated to have reached 35.5 billion euros spanning 17 months, which corresponds to 1.1% of 2020 GDP (source: Acemo-COVID survey), which is rather close to what our model predicts (36.9 billion euros).

Then, the disappointing global impact of the job retention scheme on GDP observed in April 2020 is explained by the importance of supply shocks during the first month of the Covid recession. This result is in line with Guerrieri et al. (2020), which shows that in the context of a supply shock of great magnitude and incomplete markets, the multiplier effect of such a policy never exceeds 1.

IV. Conclusion

The Covid-19 epidemic and the measures implemented to stem the spread of the virus resulted in an economic crisis of an unprecedented scale and nature. In 2020, French GDP fell by 9%, the biggest recession since World War 2. Besides the massive cuts in production, the general level of employment has "only" fallen by 3.1 points so far, and, contrary to former recessions, the recovery of employment has been rather fast. household income has been rather resilient (by 2021

[13]Partial activity allowances amounted to 15.1 billion euros in 2020 Q2. Source: Tab4 in the Acemo-COVID survey (August 2021).

Q1, household income was even higher than its level at the pre-recession peak). The resilience of household income can be explained by the massive support to private agents decided by the French government, a strategy observed in all advanced economies. In particular, a furlough scheme was put in place in order to simultaneously preserve household income and labor relationships.

In order to disentangle the main drivers of the evolution of GDP and household income observed in 2020 in France, we build a micro-founded model that integrates all the main idiosyncrasies of the Covid-19 crisis (simultaneous supply and demand shocks, industry-level heterogeneity and input-output linkages, endogenous household income). Once the theoretical model is clear, we use it in order to evaluate *ex-post* the size of supply and demand shocks that emerged month-by-month during 2020 using the methodology exposed in Dauvin and Sampognaro (2021).

While business leaders indicated that supply disruptions caused the biggest threat to activity during the months of April 2020, May-June 2020 and April-May 2021, lack of demand has been considered as the most binding factor overall during the last fourteen months. As the crisis lasts, the supply shocks' effects are more concentrated among a reduced number of industries. At the beginning of the Covid-19 outbreak, supply constraints had a maximum impact affecting 14 out of 17 industries by June 2020. During summer 2020, supply constraints disappeared at the end of the first national lockdown. By March 2021, only 4 industries were constrained by supply factors. The Covid-19 crisis was at the beginning a massive supply-driven crisis that progressively became a smaller demand-driven crisis. In the period following our analysis, supply constraints are re-emerging.

In April 2020, our model suggests a very disappointing impact of the job retention scheme on total GDP. According to our model, the overall GDP increased by 0.2 pt linked with the massive deployment of the furlough scheme. Obviously, this was not the main objective of the scheme, so we cannot judge it exclusively on the basis of this figure. With only the classical social safety nets, household income would have decreased by 12.9%, which is much worse than the observed 4.6%. This result is explained by the fact that furlough schemes are ill-adapted in order to cope with supply shocks. According to our simulations, this kind of scheme is best adapted to cope with temporary idiosyncratic demand shocks. On average, the scheme allowed to safeguard almost 3 points of disposable income spanning the period April 2020 - March 2021.

Nevertheless, our model does not take into account all the potential effects of the job retention scheme on GDP. Preserving the contractual relationship between employers and employees gives the assurance to employees that their job will be preserved after the dissipation of the shocks. This may limit precautionary savings and sustain aggregate demand during the pandemic outbreak. This tends to bias downwards the impact of the job retention scheme on GDP. Nevertheless, if the Covid crisis is longer than expected - as it ultimately has been - preserving contractual relationships may prevent the reallocation of labor between industries. Hence, resources cannot move from Covid-hit industries to Covid-winners. Explicitly modelling savings rates and labor mobility may help to improve the evaluation of the scheme.

Moreover, allowing for flexible prices may give another adjustment levy to industries. In particular, supply-constrained industries may depart from their initial iso-cost curve and modify the composition of their production process to unconstrained factors (more labor, other inputs). In particular, Baqaee and Farhi (2020*b*) show that under idiosyncratic shocks the modification of the input-output linkages is an important mechanism of adjustment under flexible prices. With a lasting crisis, where shocks may not be seen as temporary, this kind of adjustment may become more important, and it will be needed to be incorporated into every structural model that tries to understand the dynamics of this historical crisis.

Appendix

A1. Matrix solution of the model with input-output linkages with simultaneous supply and demand shocks

We explain the equilibrium with input-output linkages and endogenous demand from the representative household.

For each product i, market-clearing conditions are defined such that:

$$p_i Q_i = \sum_{\forall j \in \{1,...,J\}} a_{ij} p_j Q_j + \alpha_i PC + d_i^* \ \forall i \in \{1, ..., J\}$$

The amount of households' consumption is related to their income, which depends on the outputs of each of the sectors.

$$R = \sum_{j=1}^{J} \left(\omega_j^L + \omega_j^K\right) p_j Q_j = \sum_{j=1}^{J} \omega_j^{VA} p_j Q_j$$

Then, as $\alpha_j = \chi_j$ and $P^C C = (1-s) R$ we have:

$$p_i Q_i = \sum_{j=1}^{J} a_{ij} p_j Q_j + \chi_i (1-s) \sum_{j=1}^{J} \left(\omega_j^L + \omega_j^K\right) p_j Q_j + p_i d_i^* \ \forall j \in \{1, ..., J\}$$

These $J+1$ can be written in a matrix form:

(A1)
$$\begin{pmatrix} p_1 Q_1 \\ \vdots \\ p_J Q_J \\ R \end{pmatrix} = \begin{pmatrix} a_{1,1} & \cdots & a_{1,J} & \chi_1 \left(1-s\right) \\ \vdots & \ddots & \vdots & \vdots \\ a_{J,1} & \cdots & a_{J,J} & \chi_J \left(1-s\right) \\ \omega_1^L + \omega_1^K & \cdots & \omega_J^L + \omega_J^K & 0 \end{pmatrix} \begin{pmatrix} p_1 Q_1 \\ \vdots \\ p_J Q_J \\ R \end{pmatrix} + \begin{pmatrix} p_1 d_1^* \\ \vdots \\ p_J d_J^* \\ 0 \end{pmatrix}$$

It is straightforward to see that we can compute the pre-crisis equilibrium very close to the classical Leontief solution $\mathbf{pQ} = \left(\mathbf{I} - \tilde{\mathbf{A}}\right)^{-\mathbf{1}} \mathbf{pd}^*$ where $\tilde{A}$ is a slightly modified Leontief matrix to take into account the endogenous consumers' demand (column $J+1$) and income (row $J+1$) as there can be guessed from Equation A1. In the classical literature of input-output economics, this model is known as the *closed Leontief model.*

This economy is shocked by the Covid-19 outbreak. This translates into a series of J exogenous final demand shocks $(\widehat{d_j^*})$, J supply shocks ν_j, a savings rate shock $(\widehat{s})$ and the change in the determinants of household income, which depend partially on pre-Covid labor demand, through the impact of the job retention scheme.

Let's consider that the first k industries are constrained by their final demand and $J-k$ industries whose output is limited by the supply shock. Moreover, we saw that under the assumptions coherent with our structural model, under fixed price and wages, the input-output structure of the economy remains unchanged $(\widehat{p_j} = \widehat{w_j} = \widehat{\gamma_{ij}} = \widehat{\omega_j^L} = \widehat{\omega_j^K} = \widehat{\omega_j^M} = \widehat{a_{ij}} = 1)$. The equilibrium of the Covid-19 economy can be expressed as:

$$\begin{pmatrix} p_1 Q_1' \\ \vdots \\ p_k Q_k' \\ p_{k+1} Q_{k+1} \nu_{k+1} \\ \vdots \\ p_J Q_J \nu_J \\ R' \end{pmatrix} = \begin{pmatrix} p_1 d_1^* \widehat{d_1^*} \\ \vdots \\ p_k d_k'^* \widehat{d_k^*} \\ p_{k+1} d_{k+1}'^* \\ p_J d_J'^* \\ \tau R \end{pmatrix} +$$

$$\begin{pmatrix} a_{1,1} & \cdots & a_{1,k} & a_{1,k+1} & \cdots & a_{1,J} & \chi_1 \left(1-\widehat{s}s\right) \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots \\ a_{k,1} & \cdots & a_{k,k} & a_{k,k+1} & \cdots & a_{k,J} & \chi_k \left(1-\widehat{s}s\right) \\ a_{k+1,1} & \cdots & a_{k+1,k} & a_{k+1,k+1} & \cdots & a_{k+1,J} & \chi_{k+1} \left(1-\widehat{s}s\right) \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots \\ a_{J,1} & \cdots & a_{J,k} & a_{J,k+1} & \cdots & a_{J,J} & \chi_J \left(1-\widehat{s}s\right) \\ \omega_1^L (1-\tau) + \omega_1^K & \cdots & \omega_k^L (1-\tau) + \omega_k^K & \omega_{k+1}^L (1-\tau) + \omega_{k+1}^K & \cdots & \omega_J^L (1-\tau) + \omega_J^K & 0 \end{pmatrix} \begin{pmatrix} p_1 Q_1' \\ \vdots \\ p_k Q_k' \\ p_{k+1} Q_{k+1} \nu_{k+1} \\ \vdots \\ p_J Q_J \nu_J \\ R' \end{pmatrix}$$

The structure of this economy is very close to the classic Leontief model, but now we have some endogenous productions to the left-hand side $(Q_1', \ldots, Q_k', R')$ and also some exogenous productions $(\nu_{k+1} Q_{k+1}, \ldots, \nu_J Q_J)$. At the same time we have some endogenous demands in the right-hand side of the equation $(d_{k+1}', \ldots, d_J')$.

To solve the model, the only trick is to rearrange the matrix to have all endogenous variables to the left-hand side (supply for demand-constrained industries and demand for supply-constrained industries) and all exogenous variables to the RHS (demand shocks for demand-constrained industries and supply shocks for supply-constrained industries)

$$\mathbf{X^{end}} = \mathbf{M}^{-1} \times \mathbf{N} \times \mathbf{X^{exo}}$$

With:

$$\mathbf{X^{end}} = \begin{pmatrix} p_1 Q'_1 \\ \vdots \\ p_k Q'_k \\ p_{k+1} d'^*_{k+1} \\ \vdots \\ p_J d'^*_J \\ R' \end{pmatrix} \; ; \; \mathbf{X^{exo}} = \begin{pmatrix} p_1 d^*_1 \widehat{d^*_1} \\ \vdots \\ p_k d'^*_k \widehat{d^*_k} \\ p_{k+1} Q_{k+1} \nu_{k+1} \\ \vdots \\ p_J Q_J \nu_J \\ \tau R \end{pmatrix}$$

$$\mathbf{M} = \begin{pmatrix} 1 - a_{1,1} & \cdots & -a_{1,k} & 0 & \cdots & 0 & -\chi_1 \left(1 - \widehat{s}s\right) \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots \\ -a_{k,1} & \cdots & 1 - a_{k,k} & 0 & \cdots & 0 & -\chi_k \left(1 - \widehat{s}s\right) \\ -a_{k+1,1} & \cdots & -a_{k+1,k} & -1 & \cdots & 0 & 0 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots \\ -a_{J,1} & \cdots & -a_{J,k} & 0 & \cdots & -1 & 0 \\ -\omega_1^L(1-\tau) - \omega_1^K & \cdots & -\omega_k^L(1-\tau) - \omega_k^K & 0 & \cdots & 0 & 0 \end{pmatrix}$$

$$\mathbf{N} = \begin{pmatrix} 1 & \cdots & 0 & a_{1,k+1} & \cdots & a_{1,J} & 0 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & \cdots & 1 & a_{k,k+1} & \cdots & a_{k,J} & 0 \\ 0 & \cdots & 0 & -(1 - a_{k+1,k+1}) & \cdots & a_{k+1,J} & 0 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & \cdots & 0 & a_{J,k+1} & \cdots & -(1 - a_{J,J}) & 0 \\ 0 & \cdots & 0 & \omega_{k+1}^L(1-\tau) + \omega_{k+1}^K & \cdots & \omega_J^L(1-\tau) + \omega_J^K & 1 \end{pmatrix}$$

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