Sector-Specific Shocks and the Expenditure Elasticity Channel During the COVID-19 Crisis

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Abstract

The COVID-19 economic crisis differs from past recessions in terms of the sectors and occupations that are being hit first. In this paper we propose a model with sectoral and occupational heterogeneity and non-homothetic preferences over sectors. That is, households' consumption bundles depend on income and they cut consumption on high income-elastic sectors when labor income falls. We compare a COVID-19 type shock affecting service sectors first to a more "standard" recession affecting manufacturing in our model with non-homothetic demand calibrated to match the U.S. economy. We obtain two main results. First, the increase in labor income inequality in the COVID-19 recession is one and a half times the increase in a normal recession due to the fact that contact intensive service workers are low income *and* work in high income-elastic sectors. Second, incorporating non-homothetic demand amplifies the depth of the recession by twice compared to the homothetic model, mainly through two distortions to the standard Euler equation but also through a third channel, the higher marginal propensities to consume of the low income, contact-intensive service workers.

1 Introduction

The economic downturn brought about by the COVID-19 pandemic is likely to differ from other recent downturns in potentially important ways. This paper emphasizes the central importance of sectoral and occupational heterogeneity for the propagation and depth of the COVID-19 shock in the U.S., and for its effects on income inequality.

To do this, we modify the dynamic stochastic general equilibrium model with non-homothetic preferences of Danieli (2020) to analyze the present crisis. This model features multiple sectors. Because of the non-homothetic preferences, consumers with different incomes consume different bundles of sector goods. The expenditure elasticities on each of the sectors are estimated from U.S. consumption data. The model also features a different occupational mix within each sector, calibrated to match the occupation shares within sectors in the U.S. Thus, sector-specific demand or productivity shocks fall disproportionately on occupations used intensively in that sector.

We divide occupations into healthcare, professional, non-contact intensive services, production/laborers, and contact-intensive service occupations. We find that the latter category, those workers most affected by coronavirus-related shutdowns, are concentrated in just a few sectors like arts, entertainment, recreation, accommodation, food services, and non-essential retail. These are not the sectors that typically suffer the most in U.S. recessions. Coskun & Dalgic (2020) find substantial heterogeneity in the sensitivity of employment in different industries to changes in aggregate employment from 1990-2018, with trade, transportation, utilities, manufacturing, and construction significantly outranking entertainment, retail, and other services in terms of correlation to the business cycle. However, according to the March Bureau of Labor Statistics Employment Situation report, nearly 459,000 jobs were lost in these leisure and hospitality sectors in Marhc, accounting for nearly two-thirds of the decline in non-farm payrolls.[1]

Previous research shows that the types of workers who are laid off can have an economically significant effect on the size of recessions (Patterson (2019)). Low wage workers' incomes are typically more sensitive to business cycle fluctuations and thus income inequality tends to rise in recessions (Heathcote et al. (2010)), though government transfers to low-income groups can mitigate this rise. Inequality itself can deepen recessions by reducing aggregate demand, since lower income individuals tend to have high-marginal propensities to consume (Auclert & Rognlie (2020); Ahn et al. (2018)). Neglecting sectoral heterogeneity can also result in welfare losses in the evaluation of optimal monetary policy (Kreamer (2019)).

The incorporation of non-homothetic preferences allows us to capture a channel that was important during the great recession: changes in consumer spending habits in response to the recession. For example, Jaimovich et al. (2019) find that changes in consumers' consumption baskets during recessions, specifically reductions in product quality, had significant amplifying effects on the depth and persistence of the great recession.

The economics profession has reacted swiftly to study various aspects of the COVID-19 crisis. Areas of research include the interaction of epidemiology and economic models (see Eichenbaum et al. (2020) Berger et al. (2020) and Kaplan et al. (2020)). Age and sectoral heterogeneity in the analysis of optimal policy responses to the pandemic (Glover et al. (2020)). Measurement of the anticipated effect on different occupations (Dingel & Neiman (2020) and Leibovici et al. (2020)). The effects of the crisis on gender equality in the labor market (Alon et al. (2020)). The use of stock market data to predict the magnitude of the slowdown (Gormsen & Koijen (2020)). The effects of various policies in a DSGE model with a COVID-19 type demand shock to demand for contact intensive services (Faria-e Castro (2020)). To this line we contribute a model similar to Faria-e Castro (2020) but with an emphasis on inequality and consumption heterogeneity.

To forecast patterns we expect to see in the current crisis, our main exercise with the model is to compare two collections of shocks: one collection to represent the COVID-19 crisis and one collection to represent recent past recessions. We model the COVID-19 crisis as:

1. A negative labor supply shock for all workers (alternately as a negative aggregate total factor

[1] https://www.bls.gov/news.release/pdf/empsit.pdf

productivity shock) calibrated to match a 4% decline in GDP on impact

2. A negative sector specific demand shock to the arts, entertainment, accommodation, food, and day care services sector of our model economy where contact intensive service workers are concentrated

3. A negative sector specific shock to the transportation sector which has also been hit hard

4. A positive demand shock for the healthcare sector

The negative demand shocks are calibrated such that the negatively effected sectors are hit five times harder than the other sectors initially.

For the "standard" recession modeled after U.S. downturns in the past 40 years or so, we similarly use a negatively labor supply shock to yielding a 4% decline in GDP on impact, but give a demand shock to non-essential manufacturing such that it is hit five times harder than other sectors. To be consistent we include a positive healthcare demand shock in the "standard" recession as well.

Our main result is that income inequality is likely to rise by twice as much during the COVID-19 recession as in past recessions. In particular, because of non-homotheticities, workers in contact-intensive occupations are hit with a "double-whammy" in the COVID-19 scenario: their labor income declines initially, but because they work mainly in a few sectors with high estimated expenditure elasticities, there are second round effects that reduce demand for the sectors they work in. Another driver of the rise in inequality is that manufacturing occupations are also hard hit during the COVID-19 crisis through demand effects, whereas in a standard recession professional occupations are the second-hardest hit.

The other main result is that incorporating non-homothetic preferences generates a decline in output that is twice as large for the same shock as a standard DSGE model with homothetic demand. Two changes to the standard Euler equation due to non-homothetic demand dampen the effect of monetary policy as households are less willing to substitute consumption at different points in time and make monetary policy less effective at combating a recession. A third channel through which the model generates a greater decline in output than a standard model with homothetic demand is the channel mentioned above that lower income households are hit with second round effect and have higher marginal propensities to consume.

The rest of the paper is organized as follows. In section 2 we describe the model. In section 3 we calibrate the model for the U.S. economy and describe the occupational distribution within sectors. Section 4 presents results of a COVID-19 shock in the model and compares these findings to a "typical" recession. Finally, section 5 discusses various policy options we plan to analyze in the context of the model.

2 Model

We use a two-asset New Keynesian (TANK) model with non-homothetic preferences and heterogeneous sectors and occupations to capture the effect of the COVID-19 crisis. Agents in the model belong to 5 different occupation groups: healthcare, professional, non-contact intensive services, production/laborers, and contact-intensive service occupations. There are two key differences between individuals in different occupations: their labor income and their asset position. While the latter is not an inherent part of the mechanism it will affect the individual response to an income shock and how these changes propagate to aggregate outcomes. This is especially true since workers in contact-intensive service occupations are more prone to have low liquid asset holdings and face borrowing constraints (Kaplan et al. (2020) and Mongey & Weinberg (2020)).

To capture this effect we use a TANK framework where four of the occupations (healthcare, professional, non-contact intensive services, production/laborers) belong to one big family with access to company profits and government bonds and contact intensive occupations are hand to mouth and consume fully their labor income and have no access to financial markets. While a fully heterogeneous agent framework might allow for us to capture more accurately the response of asset holdings for each type of occupation, a TANK framework does allow us to capture the key aggregate dynamics as discussed in Debortoli & Galí (2018) and is more tractable given the richness of the model.

Each type of agent has non-homothetic preferences over J sectors. Formally, the problem of the non contact intensive household, type $k =$ nc agent is the following:

$$\max_{\{c^k_{j,t}\}_{j\in J}, L^k_t, B^k_{t+1}} E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{k\,1-\theta}}{1-\theta} - \psi_t \sum_{o\in ns} n_o \frac{L_{o,t}^{1+\gamma}}{1+\gamma} \right]$$

$$\sum_{j\in J} p_{j,t} c^k_{j,t} + \frac{B^k_{t+1}}{1+i_t} \leq \sum_{o\in ns} n_o W_{o,t} L_{o,t} + B^k_t + T^k_t$$

$$C^k_t = \sum_{j\in J} \xi_{j,t}^{\frac{1}{\sigma}} c_{j,t}^{k\,\frac{\sigma-1}{\sigma}} C_t^{k\,\frac{\epsilon_j}{\sigma}+1} \tag{1}$$

$$\forall j:\ ln(\xi_{j,t}) = (1-\rho_\xi) ln(\xi_{j,ss}) + \rho_\xi ln(\xi_{j,t-1}) + u_{\xi,j,t},\ \ u_{\xi,t} \sim N(0,\sigma^2_\xi)$$

$$ln(\psi_t) = (1-\rho_\psi) ln(\psi_{ss}) + \rho_\psi ln(\psi_{t-1}) + u_{\psi,t},\ \ u_{\psi,t} \sim N(0,\sigma^2_\psi)$$

Where $c^k_{j,t}$ is households type k consumption of sector j at time t and C^k_t is a non homothetic CES consumption aggregate defined by equation (1). The components of this consumption aggregate are a taste parameter $\xi_{j,t}$ that follows an AR(1) process in logs, price elasticity σ that is common across sectors and an expenditure elasticity set of parameters $\{\epsilon_j\}_{j\in J}$ that differ across sectors and determine the expenditure elasticity of each sector[2] These preferences are identical to a standard CES aggregate if ϵ_j is identical for all sectors which we use as our benchmark homothetic model. The effect of ϵ_j on the expenditure elasticity of each sector can be seen in equation (2) that com-

[2]For detailed discussion of non homothetic CES preferences see Comin et al. (2019).

putes the elasticity of sector j with respect to all consumption expenditures $\sum_{j\in J} p_{j,t}c^k_{j,t} \equiv E^k_t$.

$$\eta_{c^k_{j,t},E^k_t} = \frac{dlogc^k_{j,t}}{dlogE^k_t} = \sigma + (1-\sigma)\frac{\epsilon_j}{\bar{\epsilon}^k_t} \tag{2}$$

Where $\bar{\epsilon}^k_t = \sum_j \frac{c^k_{j,t}p_{j,t}}{E^k_t}\epsilon_j = \sum_j s^k_{j,t}\epsilon_j$, which is the weighted average of elasticity parameters $\{\epsilon_j\}$ weighted by their share in household expenditures $s^k_{j,t}$. This elasticity is larger for larger value of ϵ_j and defines good as a luxury if $\epsilon_j > \bar{\epsilon}^k_t$. Notice that the elasticity varies across households and over time depending on the household consumption composition. In particular, it might be that a sector will transition from a luxury to necessity if the household's income increases enough.

$L_{o,t}$ denotes occupation $o \in O$ employment choice and n_o is their share in household k with $\sum_{o\in ns} n_o = 1$. ψ is the labor dis-utility parameter that follows an AR(1) in logs. The household chooses how to optimally allocate labor across the four occupations and then collects all labor income into a single budget constraint to make mutual decisions of consumption and savings. This problem describes the labor choice when no wage frictions are in place in order to simplify the description of the model and focus the discussion on the new presence of non-homotheticity. When simulating the model it is nevertheless key to introduce wage rigidities to get a reasonable representation of labor markets as will be discussed below. Lastly, B^k_t are one period bonds and T^k_t are transfers that include company profits and government transfers for $k = nc$ and only government transfers for $k = c$.

The problem of the contact intensive services household, type $k =$ c agent is the following, where the key difference in the lack of ability to hold bonds or corporate profits as part of T^k_t. Notice that all the preferences parameters are identical between the two types of household, therefore the differences in their outcomes only result from differences in wages and assets.

$$\max_{\{c^k_{j,t}\}_{j\in J}, L_{o,t}, B^k_{t+1}} E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C^{k\,1-\theta}_t}{1-\theta} - \psi_t \frac{L^{1+\gamma}_{o,t}}{1+\gamma}\right]$$

$$\sum_{j\in J} p_{j,t}c^k_{j,t} \leq W_{o,t}L_{o,t} + T^k_t$$

$$C^k_t = \sum_{j\in J} \xi^{\frac{1}{\sigma}}_{j,t} c^{k\,\frac{\sigma-1}{\sigma}}_{j,t} C^{k\,\frac{\epsilon(j)}{\sigma}+1}_t$$

$$\forall j:\ ln(\xi_{j,t}) = (1-\rho_\xi)ln(\xi_{j,ss}) + \rho_\xi ln(\xi_{j,t-1}) + u_{\xi,j,t},\ u_{\xi,t} \sim N(0,\sigma^2_\zeta)$$

$$ln(\psi_t) = (1-\rho_\psi)ln(\psi_{ss}) + \rho_\psi ln(\psi_{t-1}) + u_{\psi,t},\ u_{\psi,t} \sim N(0,\sigma^2_\psi)$$

2.1 Solution to the household problem with non-homothetic demand

The solution to type $k = nc$ household's problem can be split into three parts: an inter temporal problem, a intra temporal consumption vs leisure problem and an intra temporal allocation of consumption across sectors. The solution for type $k = c$ household includes only the intra-temporal parts of the solution but is otherwise equivalent.

The solution to the inter-temporal problem is characterized by the Euler equation written (3)

$$\frac{1}{C_t^{k\theta} P_t^k \bar{\epsilon}_t^k} = E_t \frac{\beta(1+i_t)}{C_{t+1}^{k\theta} P_{t+1}^k \bar{\epsilon}_{t+1}^k}, \text{if } k = nc \tag{3}$$

There are two components that differentiate this Euler equation from the standard one. First, the presence of $\bar{\epsilon}_t^k$, which is the expenditure share weighted average of the elasticity parameters $\{\epsilon_j\}$ discussed above. Second, the definition of P_{t+1}^k which is the household specific price index, equivalent to the price index for CES preferences, however adjusted for the non homothetic effect. This price index is defined by equation (4).

$$\begin{aligned} P_t^k C_t^k &= \sum_{j \in J} p_{j,t} c_{j,t}^k \\ P_t^k &= \left[\sum_{j \in J} \xi_j C_t^{k\epsilon_j - (1-\sigma)} p_{j,t}^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \end{aligned} \tag{4}$$

This price index differs from the standard CES price index by the presence of C_t^k, which means that the household's price index will increase as the consumption aggregate increases reflecting the desire to spend more on more expensive higher elasticity sectors.

These differences in the Euler equation suggest a significant deviation from the standard homothetic model that is the key to the new recession-amplifying mechanism suggested here because they distort the intertemporal elasticity of substitution. When the household balances total consumption across time periods, the non-homothetic Euler equation also implies balancing consumption *composition* across time periods. That is, when the household expects an economic recovery (specifically in labor income) in the future such that its total consumption will rise in the future, this implies more allocation toward high elasticity sectors in the future and therefore an increase in $\bar{\epsilon}_{t+1}^k$ and P_{t+1}^k.

Like in the homothetic baseline, this household will increase its total consumption expenditures today as usual to smooth consumption. But moreover, in the non-homothetic model, this shift in consumption expenditures will also translate into an increase in the expenditures allocated to high elasticity sectors, and therefore an increase in $\bar{\epsilon}_t^k$ and P_t^k. These differences imply a different intertemporal elasticity of substitution than simply $\frac{1}{\theta}$. The intertemporal elasticity of substitution (IES) in this setting is most clearly presented in the log linearized Euler equation described in equation (5).

$$\hat{Y}_t^k = E_t\left[\hat{Y}_{t+1}^k - \Theta_t^k\left(i_t - \sum_{j\in J}\tilde{s}_j^k\hat{\pi}_{j,t+1}\right)\right] \tag{5}$$

Where $\hat{x}_t$ means deviations from a non-distortionary steady state, $\hat{Y}_t^k = \sum_{j\in J}\hat{c}_{j,t}^k$ is the simple sum over all consumption of household k across all sectors. $\hat{\pi}_{j,t+1}$ is inflation in sector j and $\tilde{s}_j^k = s_{j,t}^k\eta_{c_{j,t}^k,E_t^k}$.

Θ_t^k is simply $\frac{1}{\theta}$ in the standard homothetic model. The expression for the Θ_t^k is given in equation (6). In this setting Θ has four components that reflect the different parts of the Euler equation that are effected by the change in the interest rate. The first is θ which is the standard IES parameter. The second is the steady state elasticity of the price index to changes in the consumption aggregate C_{ss}^k. The third is the steady state elasticity of the weighted average of expenditure elasticity parameters $\bar{\epsilon}_{ss}^k$ to changes in Css^k and the last is the change in total consumption $\hat{Y}_t^k$ as a response to changes in the consumption aggregate $\hat{C}_t^k$.[3]

$$\Theta_t^k = \frac{d\hat{Y}_t^k}{d\hat{C}_t^k}\left(\frac{1}{\theta + \eta_{P_{ss}^k,C_{ss}^k} + \eta_{\bar{\epsilon}_{ss}^k C_{ss}^k}}\right) \tag{6}$$

Notice that the new components of Θ_t^k mean that the response to changes in the real interest rate is household- and time-specific and will depend on the household consumption allocation across sectors. Potentially this elasticity can be larger or smaller than $\frac{1}{\theta}$, however with the model calibrated to the US economy and reasonable/standard values for θ, the elasticity is smaller and translates into a dampening effect to changes in the real interest rate so that monetary policy is less effective in dampening recessions.

We next turn to the household's labor supply decision. The solution to the household labor choice is given by equation (7). This equation differs from the standard labor choice condition by the same components $\bar{\epsilon}_t^k$ and P_t^k. This equation implies a different marginal rate of substitution between consumption and leisure than in the standard model, since the marginal benefit from an increase in total consumption expenditures is not only an increase in the consumption aggregate but also reallocation towards more elastic sectors. This implies a stronger wealth effect and a weaker response to wage changes.

$$\psi_t L_{o,t}^{\gamma} = \frac{W_t(1-\sigma)}{P_t^k C_t^{k\theta}\bar{\epsilon}_t^k} \tag{7}$$

Finally, the solution to the household intra-temporal allocation of consumption across sectors is given by equation (8). This equation demonstrates directly the effect of non homotheticity since demand for sectors j increases with the consumption aggregate C_t^k, and this increase is larger for sectors with higher value of ϵ_j.

$$c_{j,t}^k = \xi_{j,t}\left(\frac{p_{t,j}}{P_t^k}\right)^{-\sigma} C_t^{k\epsilon_j+\sigma} \tag{8}$$

[3] Full expressions for the elasticities are described in appendix A.

2.2 Production

Each of the J sectors is sold in a competitive market and is produced using a measure 1 of intermediate inputs denoted by $y_{i,j,t}$ and aggregated using a standard CES aggregator as described in equation (9). These intermediate inputs operate in a monopolistically competitive environment that is sector specific. i.e each input is only sold to a specific fixed sector j.

$$Y_{j,t} = \left[\int_{i \in I} y_{i,j,t}^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}} \tag{9}$$

Each intermediate input is produced using a Cobb-Douglass combination of the five occupations as described in equation (10) where $l_{ijo,t}$ is labor supplied by occupation o to intermediate input i that belongs to sector j at time t. α_{jo} is intensity of occupation o in the production of intermediate inputs that produce for sector j. Notice that this value is common to all i that produce for sector j. Lastly, Z_{jt} is a sector j specific TFP factor that follows an AR(1) process.

$$\begin{aligned} &y_{ij,t} = Z_{j,t} \prod_o l_{ijo,t}^{\alpha_{jo}} \\ &\forall j \,:\, ln(Z_{j,t}) = (1-\rho_z) ln(Z_{j,ss}) + \rho_z ln(Z_{j,t-1}) + u_{zj,t},\; u_{z,t} \sim N(0, \sigma_z^2) \end{aligned} \tag{10}$$

Each intermediate firm faces two choices. First, how to optimally allocate production across employees for any given output level. Second, how to set its prices and production to maximize profits given the demand from producer j and Rotemberg price rigidities. These problem are given by equations (11) and (12). In this setting the discount factor for the firms Λ_t is given by the stochastic discount factor for type $k = nc$ households since they are the shareholders. The cost of adjusting prices in this setting is paid in units of sector j output.

$$\begin{aligned} &\min \sum_o W_{o,t} l_{ijo,t} \\ &\text{s.t } exp(Z_t) \prod_O l_{ijo,t}^{\alpha_{jo}} \geq y_{ij,t} \end{aligned} \tag{11}$$

$$\max E_t \sum_{\tau=0}^{\infty} \Lambda_{t+\tau} \left[p_{ij,t+\tau} y_{ij,t+\tau} - MC_{ij,t+\tau} y_{ij,t+\tau} - \frac{\psi}{2} \left(\frac{p_{ij,t+\tau}}{p_{ij,t+\tau-1}} - 1 \right)^2 y_{j,t+\tau} \right] \tag{12}$$

2.3 Wage Rigidity

Since this model focuses on labor markets outcomes it is important to capture a reliable representation of wage setting and labor allocation. We do so by inducing wage rigidities following Erceg et al. (2000). We assume each occupation is composed of a measure one continuum of differentiated labor services, which are all used by the firms. Each period only a randomly selected subset of workers $1 - \xi_{w,o}$ can adjust their nominal wage. A labor company collects all the differentiated labor services from each individual in each occupation and translates it into occupation specific labor that is then used in the firms. The technology of the labor company is described by equation (13).

$$L_{o,t} = \left(\int_0^1 h_{om,t}^{\frac{\nu_w - 1}{\nu_w}} dm \right)^{\frac{\nu_w}{\nu_w - 1}} \tag{13}$$

The demand for each labor service is given by equation (14).

$$h_{om,t} = \left(\frac{W_{om,t}}{W_{o,t}} \right)^{-\nu_w} L_{o,t} \tag{14}$$

Where

$$W_{o,t} \equiv \left(\int_0^1 W_{om,t}^{1-\nu_w} dm \right)^{\frac{1}{1-\nu_w}} \tag{15}$$

Nominal wages are set by a union that represents each worker's specific type and occupation. They are taken as given by the firms and households. The union chooses an optimal $W_{o,t}^*$ wage for occupation o in a way that is consistent with utility maximization of the households, taking as given the demand schedule for the labor type and occupation as well as all choices made by other unions in all occupation and the path for consumption and prices. The union's optimization problem yields the following FOC described in equation (16).

$$\sum_{s=0}^{\infty} (\beta \xi_{w,o})^s \left[\frac{L_{o,t+s}}{C_{t+s}^{k\theta} \bar{\epsilon}_{t+s}^k} (1 - \sigma) \left(\frac{W_{o,t+s}^*}{P_{t+s}^k} - \lambda_w MRS_{o,t+s}^k \right) \right] \tag{16}$$

Where $MRS_{o,t+s}^k = \frac{\psi_t L_{o,t+s}^{\gamma} C_{t+s}^{k\theta} \bar{\epsilon}_{t+s}^k}{1-\sigma}$ and $\lambda_w = \frac{\nu_w}{\nu_w - 1}$. This solution is equivalent to the original Erceg et al. (2000) paper with two modifications. First, the wage determination process is occupation specific. Second, the marginal rate of substitution between consumption and labor and the price index are adjusted for non-homotheticity.

2.4 Monetary Policy

Monetary policy takes the form of a Taylor rule specified in equation (17). From a theoretical perspective, the correct form of inflation is a weighted average of sector specific inflation rates, where they are weighted by their share in household $k = nc$ expenditures multiplied by their expenditure elasticity for household $k = nc$ as discussed in Danieli (2020). However such a rule is hard to implement in practice since expenditure elasticities vary across households and are hard to estimate at the household level. Furthermore Danieli (2020) shows that the difference between the two inflation specifications is not significant.

$$i_t = \varphi i_{t-1} + (1-\varphi)\left[\phi_\pi \sum_{j\in J} s_{j,t}\hat{\pi}_{j,t} + \phi_x \hat{X}_t\right] + u_{mt} \tag{17}$$

2.5 Equilibrium

An equilibrium in the economy is defined by a set of prices $\{p_{j,t}\}_{j\in J}$ and allocations $\{\{c^k_{j,t}\}_{j\in J}\}_{k\in\{s,ns\}}, \{\{l_{jo,t}\}_{j\in J}\}_{o\in O}$ such that each type of household maximizes its utility given their budget constraints and labor bargaining process, intermediate firms in each sector maximize profits given price rigidities and the demand for their products, final good firms in each sector maximize profits and markets clear. Notice that since all intermediate firms in sector $j \in J$ will be making the same price and allocation decisions, the subscript i is dropped from the equilibrium description for notation simplification.

3 Quantitative Model

This section describes the classifications of sectors and occupations for the U.S. economy, as well as the estimates of the expenditure elasticities for each sector and the occupational mix across sectors. We also give the calibration of the rest of the parameters of the model.

3.1 Sector classification

For our sector classifications, we modify the existing 2-digit North American Industrial Classification System (NAICS) codes with special attention to the current crisis. For computational ease we combine sectors that are intuitively similar that also have similar estimated expenditure elasticities in an estimation including all traditional 2-digit NAICS sectors. For example, code 11, "Agriculture, Forestry, Fishing and Hunting" has a similar estimated elasticity to code 21, "Mining, Quarrying, and Oil and Gas Extraction" and to code 22, "Utilities" so we combine all three into a single sector in the model. Moreover, all three of these sectors are considered critical during the crisis.

For manufacturing and retail however, some subsectors are critical and thus labor demand and supply are mostly unaffected by the initial shock, while others subsectors are not. We separate these two broad sectors into four sectors in the model. Table 1 provides the full classification as well as the share of value added and the share of labor income using 2016 data for the U.S. We match the value added shares in the model by calibrating the sector taste parameters $\{\zeta_j\}_{j\in J}$. In addition we match relative sectoral prices in 2016 by calibrating the sector specific TFP $\{Z_j\}_{j\in J}$.

We use the CEX interview data and follow Aguiar & Bils (2015) in estimating the expenditure elasticities reported in column (3) in table (2). We deviate from their estimation process by using value added shares rather than expenditure shares by connecting the CEX data to the BEA's input-output tables following Buera et al. (2018). We apply the same sample restrictions as Aguiar & Bils (2015) and focus the estimation on Urban households with ages of the reference person between

Sector	VA share	Labor comp. share
Mining, utilities, agriculture, forestry, forestry, fishing, and hunting	0.039	0.021
Construction	0.043	0.049
Essential manufacturing	0.039	0.023
Non-Essential manufacturing	0.078	0.078
Essential retail	0.017	0.019
Non-Essential retail	0.101	0.092
Transportation	0.030	0.033
Health care and social assistance	0.066	0.103
Professional, finance, real estate, information and other services	0.400	0.316
Arts, entertainment, accommodation, food and day care services	0.047	0.057
Government and education (excl. day care)	0.140	0.209

Table 1: 11 sectors in the model. "VA share" is share of total value added, 2016. "Labor comp share" is share of total labor compensation, 2016. Data from the BEA.

25 and 64. We drop households if they report spending less than 100 dollars on food in 3 months per individual in the household, they have negative total or food consumption expenditure, total income is reported incomplete, they have not responded all (four quarterly) interviews, income is below 50% of minimum wage or if they earn money but do not work. To mitigate measurement error concerns, we drop the top and bottom 5% richest households according to their total income (after taxes). While these restrictions are important for consistency with Aguiar & Bils (2015), the estimation is robust to releasing most of them. We use data from the years 2000-2007, however the results are robust to other time periods as well. One potential problem with the CEX data is they do not include public spending on health and education which are fairly significant. Comin, Danieli and Mestieri (2020) impute public expenditures from hospital referral region medicare and medicare spending and expenditure per pupil at school district and show that the elasticities of these sector decrease a little, yet remain high. We then follow Comin, Danieli and Mestieri (2020) and use GMM estimation for the demand system specified by (8) to get the expenditure elasticity parameters $\{\epsilon_j\}_{j\in J}$ and price elasticity parameter σ presented in column (2) of table (2).

3.2 Occupation classification

We divide occupations into five broad categories with special attention to the nature of the COVID-19 crisis. We follow Leibovici et al. (2020) for guidance on "contact-intensive" occupations but account for whether some of these occupations are critical and thus not affected by shelter-in-place orders. The classification of Leibovici et al. (2020) uses O*NET data on each occupation's physical proximity to others at work and assigns an index value to each occupation in the American Community Survey (ACS). Barbers and cosmetologists score highest. By their calculations, high contact-intensive workers account for one fifth of total U.S. labor income. Our occupation categories are:

Sector	Elasticity Parameters ϵ_j	Expenditure Elasticity
Health care and social assistance	3.20	2.33
Arts, entertainment, accommodation, food and day care services	1.85	1.54
Government and education (excl. day care)	1.20	1.16
Non-Essential manufacturing	1.19	1.16
Professional, finance, real estate, information and other services	1	1.07
Transportation	0.98	1.03
Non-Essential retail	0.87	0.96
Construction	0.52	0.76
Mining, utilities, agriculture, forestry, forestry, fishing, and hunting	0.45	0.72
Essential manufacturing	0.21	0.58
Essential retail	0.12	0.52
σ	0.45	

Table 2: Estimated expenditure elasticities and elasticity parameters for each sector. Estimation is constructed using CEX interview data. Expenditure elasticities are estiamted following Aguiar and Bills (2015) methodology and elasticity parameters are estimated following Comin, Danieli and Mestieri(2020). Professional, finance, real estate, information and other services is normalized to 1.

1. Managerial and professional excluding:
   - Medical occupations
   - Contact intensive professional occupations as art/entertainment performers
2. Medical occupations, including health service occupations and excluding:
   - Dentists and dental assistants, optometrists and podiatrists
   - Dietitians and nutritionists
   - Therapists
   - Pharmacists
3. Technical, sales, and non contact-intensive service occupations as protective services
4. Production, craft, repair, operator, fabricators and laborers
5. Contact intensive occupations:
   - Services excluding protective service occupations and health services
   - Recreation and religious workers
   - Artists, entertainers, and athletes

3.3 Distribution of occupations within sectors

Table 3 gives the labor compensation share of each occupation in each sector based on U.S. data for 2016. These shares are used to calibrate the occupation intensities in each sector $\{\{\alpha_{jo}\}_{j\in J}\}_{o\in O}$. Several points are worth noting. Because contact-intensive service (CIS) workers are low paid, their labor income share in most sectors is quite low. The one exception is the arts, entertainment, accommodation, food and day care services sector where these workers are concentrated and account for 38% of labor compensation. Hence shocks to these workers can be modelled as specific shocks to this sector, which also employs professionals intensively (around 40% of employment compensation in this sector goes to professional workers).

Sector	CIS	Manuf.	NCIS	Med.	Prof.
Mining, utilities, agriculture, forestry, fishing, and hunting	0.011	0.471	0.186	0.001	0.331
Construction	0.059	0.620	0.0789	0	0.242
Essential manufacturing	0.012	0.468	0.181	0.001	0.338
Non-Essential manufacturing	0.024	0.584	0.158	0.001	0.233
Essential retail	0.043	0.117	0.748	0.001	0.091
Non-Essential retail	0.009	0.186	0.613	0.003	0.189
Transportation	0.022	0.613	0.214	0	0.151
Health care and social assistance	0.036	0.029	0.278	0.454	0.202
Professional, finance, real estate, information and other services	0.044	0.090	0.338	0.008	0.519
Arts, entertainment, accommodation, food and day care services	**0.380**	0.044	0.141	0.033	0.402
Government and education (excl. day care)	0.0359	0.031	0.259	0.016	0.658

Table 3: Share of labor compensation in each sector to each occupation. "CIS"=Contact intensive services, "NCIS"=Non-contact intensive services

3.4 Additional Model Parameters

Other model parameters that are standard and are taken from the literature are reported in table (4). We set a more persistent wage process for managerial and medical occupations since they are likely to have long term contracts that are not easily adjusted during a crisis. In the baseline model we use essentially fully rigid prices by setting the adjustment cost ψ very high. We do so because it yet unclear how prices respond in this crisis that is different from a standard recession. We will later examine the dynamics of the model with more flexible prices. In addition, since we don't want the results to be driven by changes in company profits we keep real profits fixed at their steady state level.

4 Results

This section discusses the results from various exercises with the quantitative model. One challenge is to approximate the forces of the COVID-19 crisis with the shocks available in the model and allow for a consistent comparison with previous recessions.

Many states and local governments have implemented shelter-in-places orders that can be modelled as a negative demand shock for sectors that are intensive in contact-intensive service occupations. Sectors with a large share of critical workers and occupations that can telework are not affected as hard initially by shelter-in-place orders (see Dingel & Neiman (2020) and Alon et al. (2020) for discussions of which occupations can telework and/or are critical). Even in places without explicit orders, to the extent that consumers understand that going out increases their

Table 4: Additional Parameters

β	$(1.03)^{-0.25}$	discount factor
θ	1	IES parameter
Θ_t^k	0.85	implied IES in steady state
$1/\gamma$	1	Frisch elasticity
ψ	1	labor coefficient
ν	12 (1.1 markup in SS)	intermediate goods substitution
ϕ_π	1.5	monetary policy- inflation
ϕ_x	0.5	monetary policy- output gap
φ	0.8	monetary policy- persistence
λ_w	1.285	wage markup
$\xi_{w,1}$	0.99	wage persistence - managerial and medical occupations
$\xi_{w,2}$	0.8	wage persistence- other occupations
ρ_ξ	0.9	Taste shock persistence
σ_ξ	1	Taste shock standard deviation
ρ_ψ	0.9	Labor dis-utility shock persistence
σ_ψ	1	Labor dis-utility shock standard deviation
n_l	0.088	Share of contact intensive occupations
$nh * nh1$	0.306	Share of managerial and professional occupations
$nh * nh2$	0.050	Share of medical occupations
$nh * nh3$	0.309	Share of technical, sales and non contact services occupations
$nh * nh4$	0.247	production/laborers

risk of infection (as in the model of Eichenbaum et al. (2020)), sectors with a large share of contact-intensive workers will suffer from this negative demand shock.

However, workers in contact intensive sectors are also more likely to get sick because of the nature of their jobs (second only to healthcare workers) and their productivity/labor supply is likely to decline as a result. Thus we can think of a supply and demand shock hitting sectors with a high share of contact-intensive sectors simultaneously, with opposite effects on relative prices. Since we lack real-time price data that would allow us to discipline the relative magnitudes of these shocks by matching price data, our main exercise uses fully rigid prices.

Another sector that has been hit extremely hard in this crisis is the transportation sector because using any means of public transportation and especially air-travel increases the chance of infection a great deal. Furthermore many restrictions on travel have been put in place preventing people from using means of transportation.

While contact intensive and transportation sectors are most affected by this crisis we can expect employees in other sectors to be affected directly as well. That is since working from home presents many challenges to employees in all sectors as lack of childcare or convenient work space. We model this as an aggregate increase in the dis-utility from work or, alternatively, a negative productivity shock.

In fact, the aggregate decline in output is expected to be extremely high, e.g., the analysis in Goldman Sachs from March 31[4] predicts a decline of 9% decline in Q1, 34% decline in Q2, and

[4]https://www.cnbc.com/2020/03/31/coronavirus-update-goldman-sees-15percent-jobless-rate-followed-by-record-rebound.html

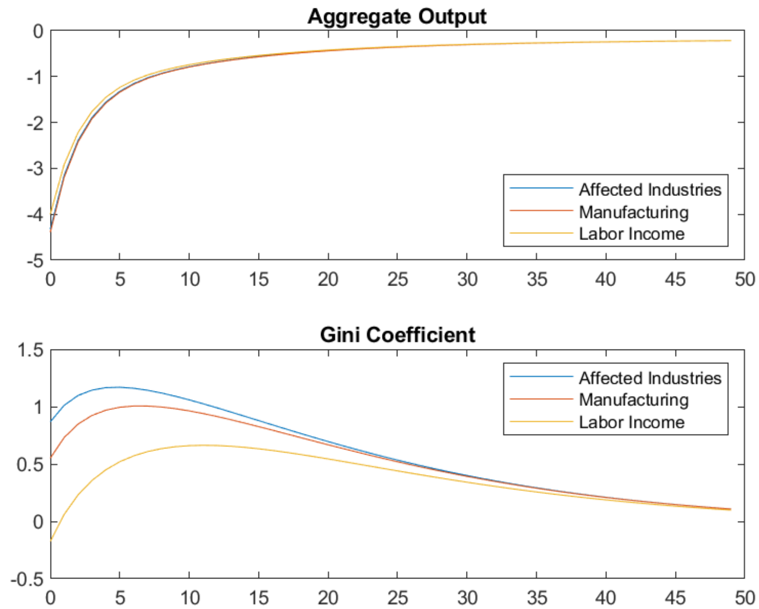


Figure 1: Impulse responses of GDP and inequality (Gini coefficient) at quarterly frequency. See text for description of the shocks in each case.

recovery of 19% in Q3.

We use a more conservative decline in our model and calibrate an aggregate shock to dis-utility from labor that leads to a 4% drop in GDP. We then add a sector specific demand shock that hits the contact intensive industry art, entertainment, accommodation, food and day care services as well as the transportation sectors five times as hard as other sectors. We calibrate the size of this shock using a homothetic model where all other sectors are affected uniformly. In addition, since demand for healthcare is peaking in this crisis for exogenous reasons we include a positive demand shock to the health care sector. We call this an "Affected Industries" recession in the figures below.

We compare the COVID-19 crisis to a similar size recession that follows a more standard pattern: a recession where the industry that is hit most is non-essential manufacturing (five times harder than the rest of the sectors initially) which has been usually the case in the US. The sizes of the sectors are comparable, since manufacturing is 7.8% of value added and art, entertainment, accommodation, food, day care and transportation are 7.7% of value added. We also keep the size of the shocks the same, therefore this can be viewed as a particularly strong, yet standard recession, which we label "Manufacturing" in subsequent figures. In addition we present the results for a recession with only the aggregate income shock (that is, with no sector-specfic shock to any sector) as a benchmark. We call this a "labor income" recession.

4.1 Labor income and inequality

Figure (1) presents the differences between the response of aggregate output and the Gini coefficient to each recession using our non-homothetic model.[5] We can see from the graph that there is no significant difference in the response of aggregate output between the two recessions in the non-homothetic model. However, the response of the Gini coefficient dramatically differs between the recession with the current crisis leading to an increase in inequality that is almost 50% larger than in a recession where the manufacturing is being hit the most and almost 100% larger than in a recession where there is only an aggregate shock. A 1% increase in the Gini coefficient in the COVID-19 crisis is equivalent to the average increase in inequality every three years in the US in the past decade making it economically significant both in absolute terms and in comparison to the alternative specifications.

We can examine these differential effects on inequality by looking at the income share of each occupation that is presented in figure (2). Because of the sector-specific shocks, the occupations used in these sectors are hit the hardest (contact intensive share of labor compensation falls by 2.5 percentage points relative to steady state in COVID-19 recession, production/laborer occupation's share of labor compensation falls by up to 0.8 percentage points in standard manufacturing recession). Perhaps the most interesting dimension of these figures is the second-hardest hit occupation in each case. In the COVID-19 recession, manufacturing occupation's share of labor income falls. In the standard manufacturing recession, the other occupations generally increase their income share. The COVID-19 hits low-occupation groups, contact-intensive services and manufacturing/laborers, hardest which explains the greater increase in inequality.

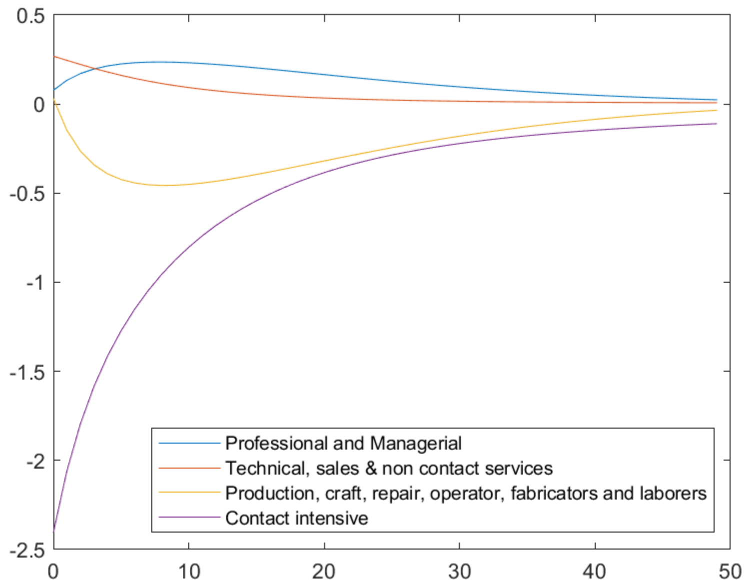
4.2 Role of non-homotheticity

As shown in figure (3), incorporating non-homothetic preferences amplifies all three different recessions we consider by about a factor of two. This is driven by a few factors.

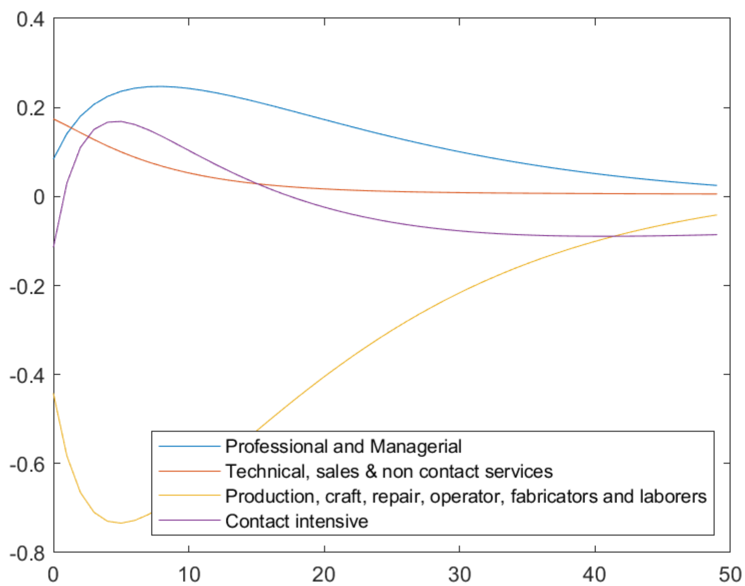
First, a lower inter-temporal elasticity of substitution making the household less responsive to monetary policy. This difference arises from the fact that the household total consumption expenditure choice implies reallocation toward less elastic sectors, which hurt the household utility further meaning he'll be less willing to do so following a change in the real interest rate.[6] Second, a negative effect on the price index relevant for the household that in given by equation (4). This price index decreases even though prices are almost fully rigid since it responds to changes in the consumption aggregate C_t^k as well, reflecting the need of the household to reallocate his consumption towards different sectors. This further lowers the household consumption expenditure choice. One way to balance this is to use a theoretically consistent inflation rate as shown in Appendix C, though this effect is fairly small.

[5] We focus our analysis on inequality in non-medical occupations, since medical occupation compensations are almost exclusively affected by exogenous forces in this crisis. The results however are not largely affected by including the medical occupations as well as can be seen in Appendix A.

[6] Potentially, this can result in either larger or smaller effects depending primarily on the household expenditure shares which are calibrated to match the US data. These effects are discussed in detail in Danieli (2020).



(a) COVID-19 Recession



(b) Standard Recession

Figure 2: Impulse responses of labor compensation shares of each non-medical occupation at quarterly frequency to COVID-19 shocks (panel a) and standard recession shocks (panel b) in the non-homothetic model.

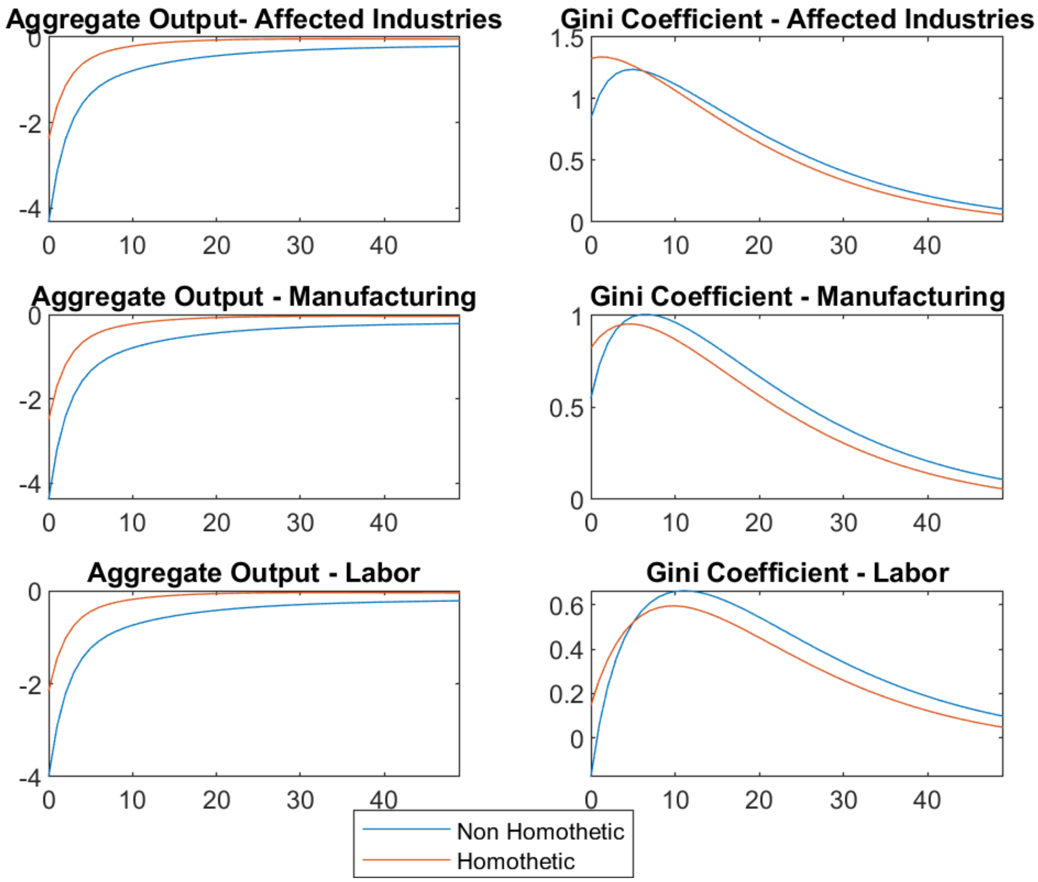


Figure 3: Impulse responses of GDP and Gini coefficient to 3 different recession shocks described in the text, at quarterly frequency in the non-homothetic model vs. a homothetic benchmark model where all $\{\epsilon_j\}_{j\in J}$ are set to $1-\sigma$

Lastly, this difference is also driven by the fact that apart from healthcare, the most expenditure-elastic sector is precisely the most contact-intensive sector and these are low-income hand-to-mouth households. The additional drop in demand for this sector in the non-homothetic model accounts for some of the amplification effect, though to a smaller extent than the other factors due to these workers' small share in the economy (8.8% of the labor force[7]). This can be seen by comparing the response in the total consumption of both types of employees that is presented in figure (4). This figure shows that the drop in consumption is larger for the contact intensive occupation, however the difference between the homothetic model and the non homothetic model is similar for both type of agents. Another way to examine the role of the hand to mouth assumption is by comparing

[7]Leibovici et al. (2020) estimate high-contact intensive occupations account for 21% of the U.S. workforce but do not account for critical workers (e.g. nurses and teachers) who will continue working despite shutdowns. To the extent that our estimate of the share of contact intensive workers is low, we can view our estimates of the effects on income inequality as a lower bound on the true value.

the results to a unitary household model where all agents belong to the same family. This is done in appendix D which shows that the effect on the aggregate results is fairly small when we relax the assumption that contact intensive service workers do not have access to financial markets.

However, the large decrease in consumption of contact intensive sectors in the non homothetic model has significant implications for inequality. This can be seen by comparing the labor income shares in the non-homothetic model (figure 2) to those in the homothetic model in figure 5. The drop for contact-intensive services is smaller (1.75 pp vs 2.4 pp) in the homothetic model because there is no feedback to more expenditure-elastic sectors through the non-homothetic demand channel.

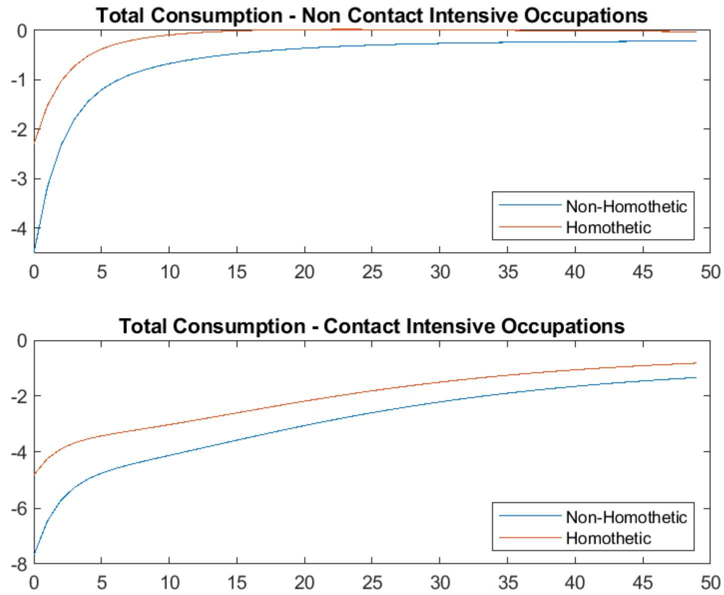
Another interesting characteristic of the relative labor shares and Gini coefficient is the hump shape that shows inequality peaking roughly one year after the shock in the non-homothetic version (figures 1 and 2). These are partly driven by a lower inter-temporal elasticity of substitution as well, but are primarily driven by income effects. When households are hit with a negative income shock, they cut consumption of the other income elastic sectors: non-essential manufacturing and government and education. These sectors employ most of the contact intensive workers outside of the leisure sector that is initially hit, so there is a second round effect on this occupation coming from non-homothetic demand.

After the income shock starts to wear off, households are keen to return to consuming these more elastic sectors so their share temporarily increases. However, households achieve this by cutting back on less elastic sectors such as construction which are intensive in production/laborers occupations who are the second poorest group of workers. Production/laborers are also a more significant part of the population, accounting for almost 25% of the labor force. This explains the delayed peak in inequality.

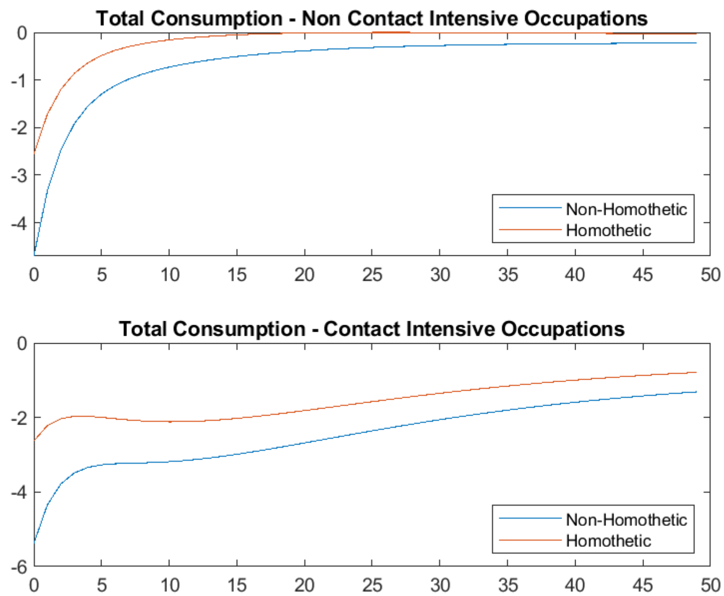
In a standard recession, this dynamic may hurt contact intensive occupations in the beginning of the recession, however it also means they quickly recover. In the current crisis, where the sectors they work in are hit especially bad, this is no longer the case. These dynamics can be seen in figure (6) that presents the response of sector value added shares in the current crisis comparing the homothetic and non homothetic models. The responses of sector value added *levels* are presented in appendix E.

5 Policy Experiments

In future versions we will explore policy experiments similar to those being proposed and/or implemented already in the U.S. These include tax rebates based on past income, which can be modelled by changing government transfers in the model, interest rate policy of the central bank, and government purchases. From these experiments we would mainly like to know the effects of different policies on income inequality and the depth of the recession. Outside the model are several other policies explored by Faria-e Castro (2020) such as changes to unemployment benefits and financial interventions like liquidity assistance to services firms.

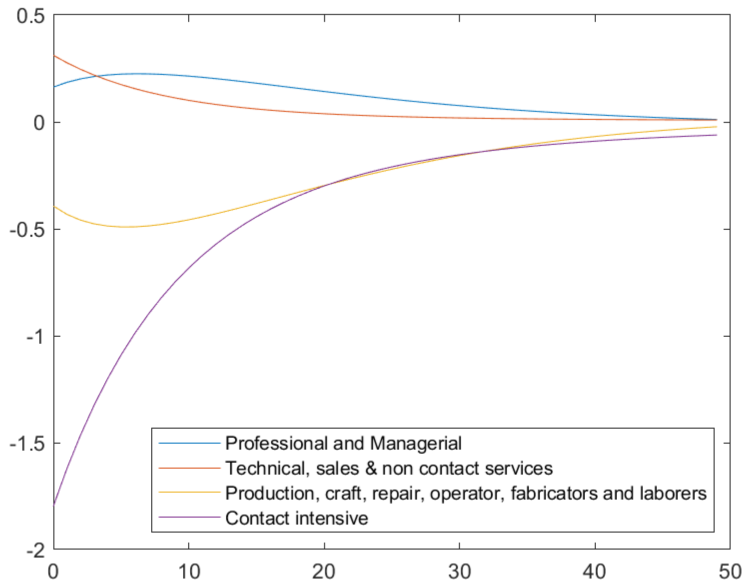


(a) COVID-19 Recession

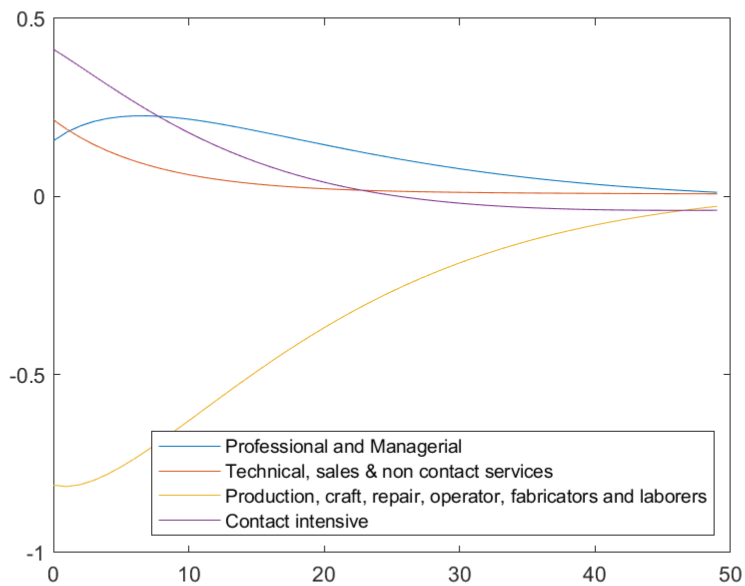


(b) Standard Recession

Figure 4: Impulse responses of total consumption by household type at quarterly frequency to COVID-19 shocks (panel a) and standard recession shocks (panel b) in the *homothetic* model.



(a) COVID-19 Recession



(b) Standard Recession

Figure 5: Impulse responses of labor compensation shares of each non-medical occupation at quarterly frequency to COVID-19 shocks (panel a) and standard recession shocks (panel b) in the *homothetic* model.

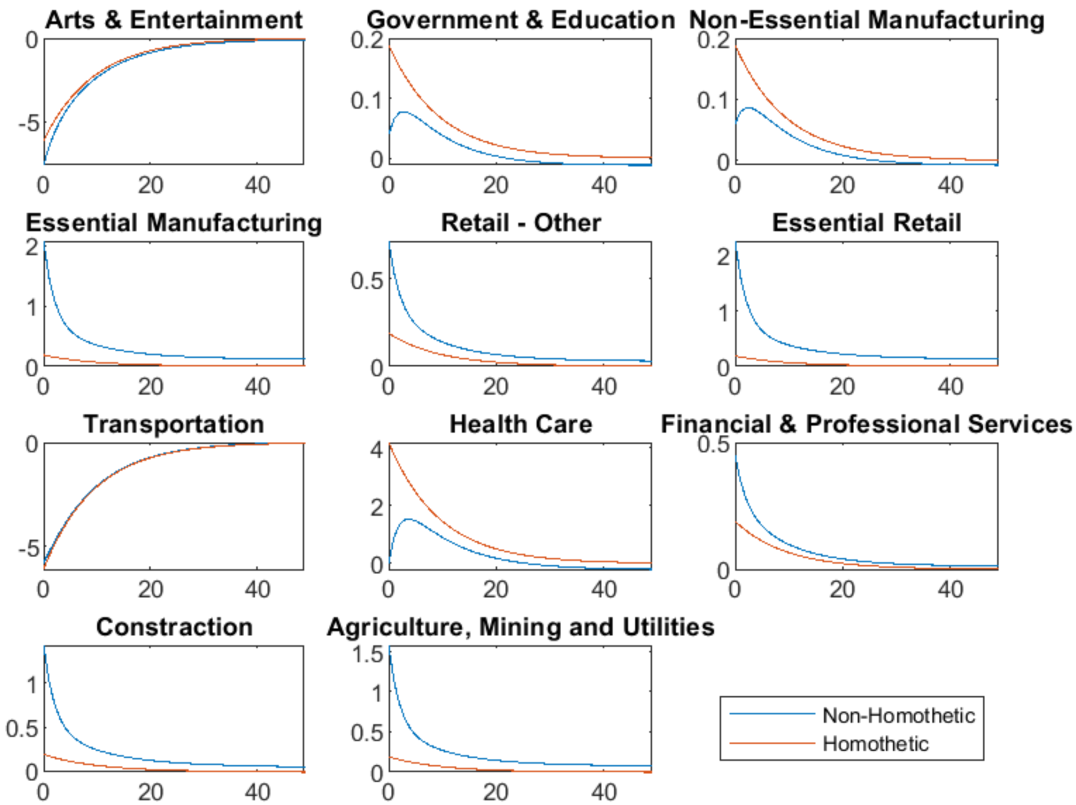


Figure 6: Impulse responses of sector value added shares at quarterly frequency in COVID-19 recession.

References

Aguiar, M., & Bils, M. (2015). Has consumption inequality mirrored income inequality? *American Economic Review*, *105*(9), 2725–2756.

Ahn, S. H., Kaplan, G., Moll, B., Winberry, T., & Wolf, C. (2018). When inequality matters for macro and macro matters for inequality. *NBER Macroeconomics Annual*, *32*(1), 1–75.

Alon, T., Doepke, M., Olmstead-Rumsey, J., & Tertilt, M. (2020). The impact of COVID-19 on Gender Equality. (March), 141–171.

Auclert, A., & Rognlie, M. (2020). Inequality and aggregate demand. (January), 33–42.

Berger, D., Herkenhoff, K., & Mongey, S. (2020). An SEIR Infectious Disease Model with Testing and Conditional Quarantine.

Buera, F. J., Kaboski, J. P., Rogerson, R., & Vizcaino, J. I. (2018). Skill-Biased Structural Change. (pp. 1–45).

Comin, D., Lashkari, D., & Mestieri, M. (2019). Structural Change with Long-run Income and Price Effects.
URL http://www.nber.org/papers/w21595%5Cnhttp://www.nber.org/papers/w21595.pdf

Coskun, S., & Dalgic, H. (2020). The Emergence of Procyclical Fertility: The Role of Gender Differences in Employment Risk. *CRC TR Discussion Paper Series*, (224).

Danieli, A. (2020). Expenditure Elasticity and Inequality Over the Business Cycle. (pp. 1–77).

Debortoli, D., & Galí, J. (2018). Monetary Policy with Heterogeneous Agents: Insights from TANK Models. *Unpublished Manuscript*, *649396*, 1–38.

Dingel, J., & Neiman, B. (2020). How Many Jobs Can be Done at Home? (March).

Eichenbaum, M., Rebelo, S., & Trabandt, M. (2020). The Macroeconomics of Epidemics.

Erceg, C. J., Henderson, D. W., & Levin, A. T. (2000). Optimal monetary policy with staggered wage and price contracts. *Journal of Monetary Economics*, *46*(2), 281–313.

Faria-e Castro, M. (2020). Fiscal Policy during a Pandemic. (March), 1–35.

Glover, A., Heathcote, J., Krueger, D., & Rios-Rull, J.-V. (2020). Health versus Wealth: On the Distributional Effects of Controlling a Pandemic.

Gormsen, N. J., & Koijen, R. S. J. (2020). Coronavirus: Impact on Stock Prices and Growth Expectations. (pp. 1–27).

Heathcote, J., Perri, F., & Violante, G. L. (2010). Unequal we stand: An empirical analysis of economic inequality in the United States, 1967-2006. *Review of Economic Dynamics*, *13*(1), 15–51.

Jaimovich, N., Rebelo, S., & Wong, A. (2019). Trading down and the business cycle. *Journal of Monetary Economics*, *102*(October), 96–121.

Kaplan, G., Moll, B., & Violante, G. L. (2020). Pandemics According to HANK.

Kreamer, J. (2019). Sectoral Heterogeneity and Monetary Policy.

Leibovici, F., Santacreu, A. M., & Famiglietti, M. (2020). Social Distancing and Contact-Intensive Occupations. *On the Economy, St. Louis Fed*, (March), 1–4.

Mongey, S., & Weinberg, A. (2020). Characteristics of workers in low work-from-home and high personal-proximity occupations. (March).

Patterson, C. (2019). The Matching Multiplier and the Amplification of Recessions.

A Intertemporal Elasticity of Substitution- Details

The expression for Θ_t^k is given by the following equation.

$$\Theta_t^k = \frac{d\hat{Y}_t^k}{d\hat{C}_t^k}\left(\frac{1}{\theta + \eta_{P_{ss}^k, C_{ss}^k} + \eta_{\bar{\epsilon}_{ss}^k C_{ss}^k}}\right) \tag{18}$$

The expression for each component is given in the set of equations (19).

$$\begin{aligned} \eta_{P_{ss}^k, C_{ss}^k} &= \frac{\bar{\epsilon}_{ss}^k}{1-\sigma} - 1 \\ \eta_{\bar{\epsilon}_{ss}^k, C_{ss}^k} &= \frac{var(\epsilon)_{ss}^k}{\bar{\epsilon}_{ss}^k} \\ \frac{d\hat{Y}_t^k}{d\hat{C}_t^k} &= \frac{\bar{\epsilon}_{ss}^k}{1-\sigma} \end{aligned} \tag{19}$$

We further analyze how each of these component changes with the household income and consumption allocation across sector. The elasticity of the price index to the consumption aggregate is increasing in $\bar{\epsilon}_{ss}^k$. $\bar{\epsilon}_{ss}^k$ is increasing in the household consumption expenditures, since this means more allocation to sectors with higher values of ϵ_j. The elasticity of $\bar{\epsilon}_{ss}^k$ is more complicated since it depends both on the weighted average of elasticity parameters $\bar{\epsilon}_{ss}^k$, and their weighted variance which is given by $\sum_{j\in J} s_{j,t}^k \epsilon_j^2 - \bar{\epsilon}_t^{k2}$. The variance of the elasticity parameters increases with consumption expenditures at first when the level of expenditures is very low and consumption is concentrated in low elasticity sectors, however it decreases when the expenditures level is very high and consumption is concentrated in high elasticity sectors. The effect of increase in expenditure is therefore undetermined. Lastly, $\frac{d\hat{Y}_t^k}{d\hat{C}_t^k}$ is increasing in $\bar{\epsilon}_{ss}^k$ and therefore in the consumption expenditures level. That is since with higher expenditures level, consumption is already concentrated in high elasticity sectors and therefore there is less room for reallocation between sectors to have an effect on the Euler equation. Overall, when the level of expenditures is higher there are two forces operating in opposite directions and last force who's effect is undetermined. We therefore analyze the effect on Θ_t^k using model simulations.

The condition for a smaller IES $\Theta < 1/\theta$ is given by equation (20), which shows that the inequality depends on the ratio between the two elasticities that push the value for Θ_t^k in different direction with an increase in C_t^k as discussed above. With reasonable model parameters this value is close to 2.

$$\theta < 1 + \frac{\eta_{\bar{\epsilon}_{ss}^k C_{ss}^k}}{\eta_{P_{ss}^k C_{ss}^k}} \tag{20}$$

B Gini index including medical occupations

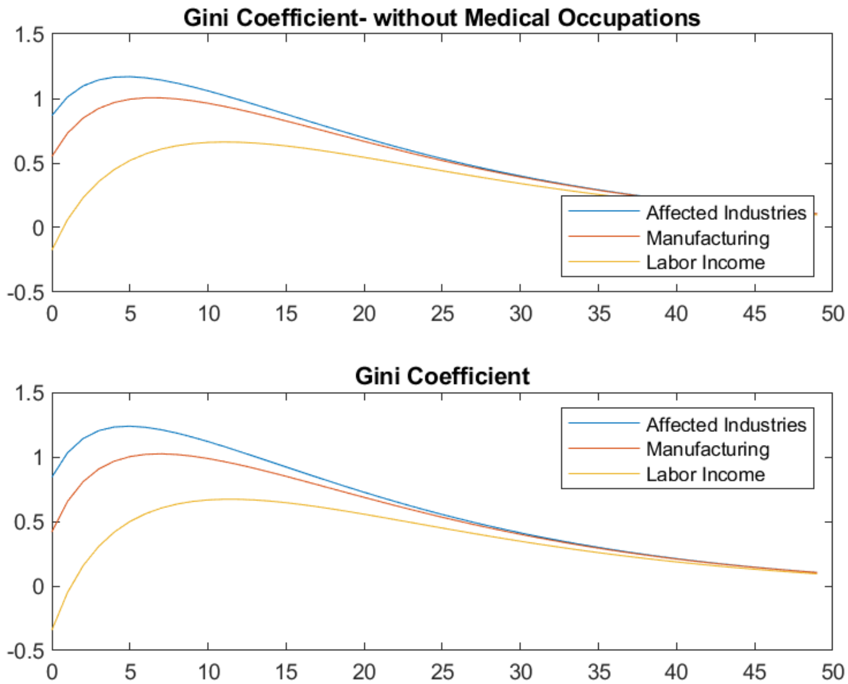


Figure 7: Impulse responses of Gini coefficient to different recession types at quarterly frequency with and without medical occupations in computation of the Gini.

C Theoretically Consistent Inflation Rate

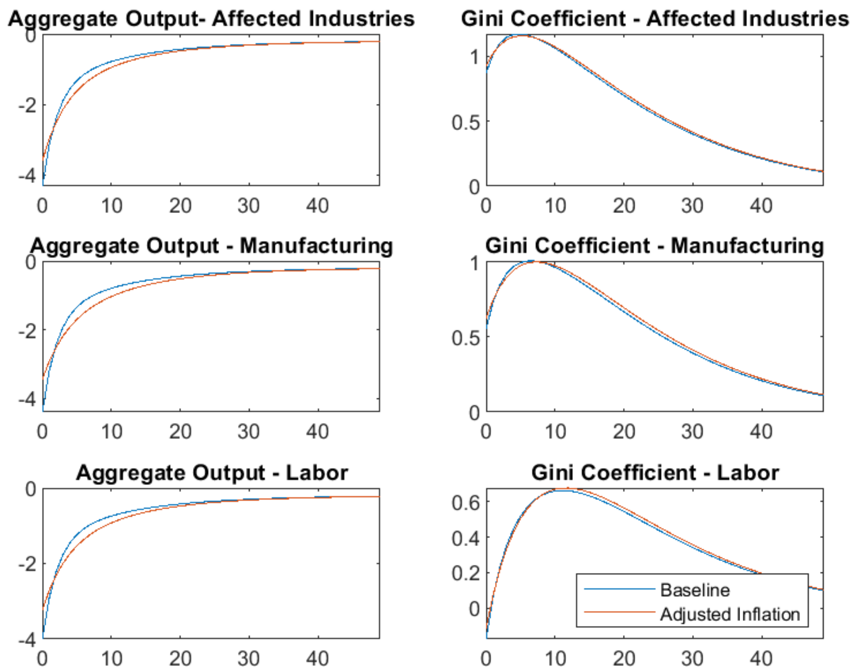


Figure 8: Impulse responses of output and Gini coefficient to different recession types at quarterly frequency with and without theoretically consistent inflation.

D Unitary Household

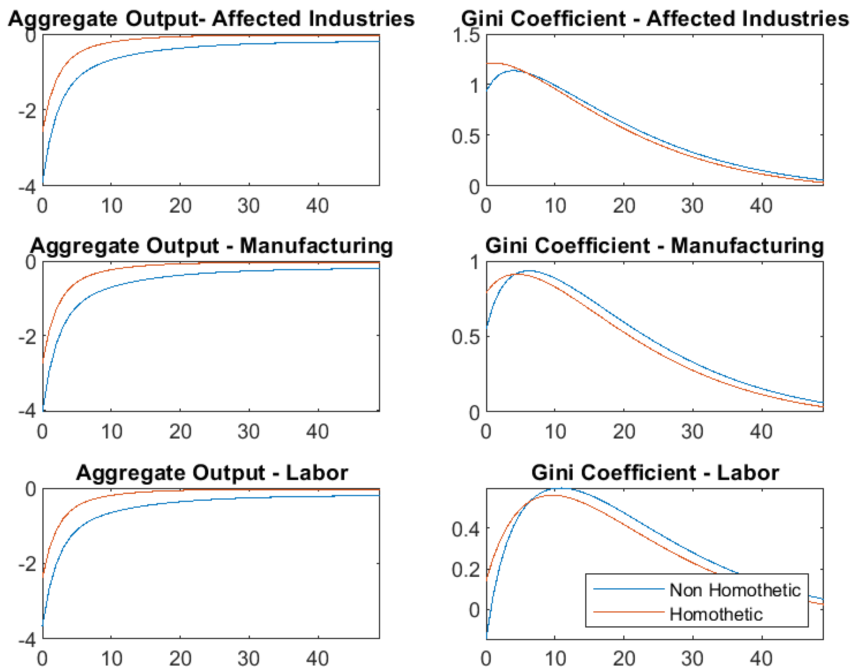


Figure 9: Impulse responses of output and Gini coefficient to different recession types at quarterly frequency with a unitary household model and comparing homothetic vs non homothetic preferences.

E Sector Level IRF

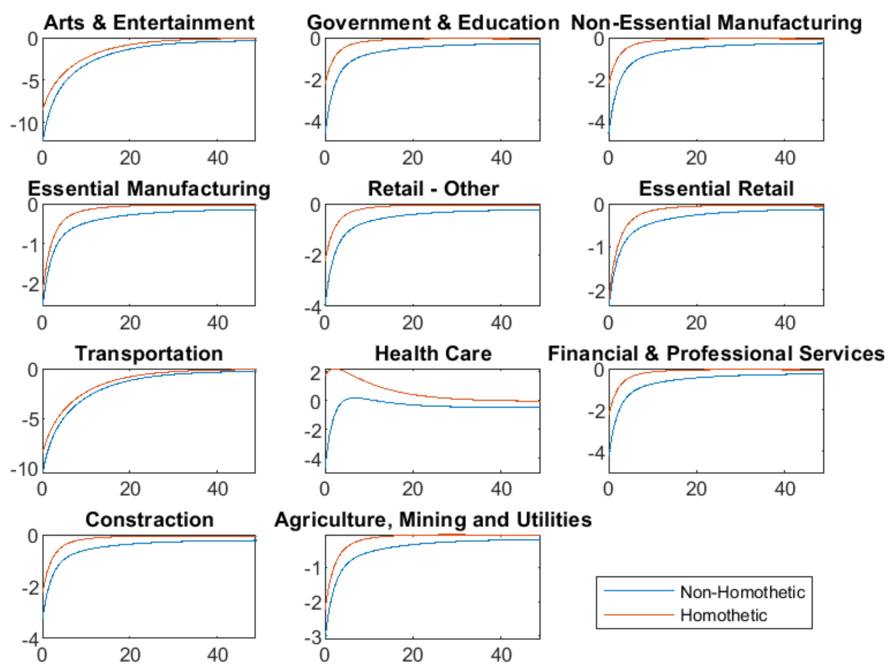


Figure 10: Impulse responses of sector levels at quarterly frequency with and without non homothetic preferences.