STOCKHOLM SCHOOL OF ECONOMICS
Department of Economics
5350 Master's thesis in economics
Academic year 2021–2022

Consumption Shifting, Working from Home, and the Hidden Losers of Infection Mitigation in Pandemic Times

Adam J:son Lindh (24086) and Wilmer Niva Printz (24230)

Abstract. We construct a heterogeneous agent model exploring the intersection of economic behavior and epidemiological risk during a pandemic. The model combines realistic infection dynamics with an economic block where utility maximizing agents shift behavior to avoid infection risk. Agents work in one of four occupations, differing in the contagiousness of the goods they produce, and in the productivity of working from home. The model contributes to understanding the mechanisms behind empirical observations of the heterogeneous impacts of the recent pandemic, providing insight on what groups might need special support in these special times. In particular, we find consumption to shift away from social interaction intensive goods, resulting in a negative demand shock on social sector workers. On the opposite, workers producing goods less associated with infection risk are relatively better off in pandemic times. Adding to this heterogeneity, workers also differ in their ability to simultaneously stay productive and avoid workplace infection risk, causing further divergence in impacts across groups, especially in the case of a lockdown.

Keywords: COVID-19, infinitely lived agents, heterogeneous agents, inequality

JEL: E0, H0, I1

Supervisor:	Sampreet Goraya
Date submitted:	December 5, 2021
Date examined:	December 16, 2021
Discussants:	Olle Törnquist and Sandra Ågren
Examiner:	Magnus Johannesson

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1 Introduction

Since emerging, COVID-19 has impacted society in a drastic fashion, leaving its mark in a wide range of ways. As opposed to a financial shock, the global pandemic has shown to be more multifaceted, with frequent lockdowns, constrained traveling as well as the promotion of digital work and education methods.

With the pandemic shock limiting social interactions, there is a certain discrepancy regarding the character of the shock on individuals and organizations when compared to other global incidents. For instance, age and health status are factors indicating whether one belongs to at-risk groups, i.e., those most in danger of dying if infected by the virus. In the economic aspect of the shock, type of occupation plays a critical role. While some can remain productive working isolated from infection risk in a gloomy summer house, others must be physically present to perform their job. As well, while artists no longer have an audience to play for, streaming services can bloom in times of isolation. This paper sets out to explore the possible heterogeneous effects of COVID-19 across these occupational dimensions.

We construct a heterogeneous-agent model combining a macroeconomic block with realistic epidemiological dynamics. The pandemic block of the model stems from the SIR-model tradition, originally introduced by Kermack and McKendrick (1927). In a typical SIR-model, agents go through the three health states susceptible (S), infected (I), and recovered (R). The pandemic gets initiated by injecting a small fraction of infected individuals in an otherwise susceptible population. From that point, the pandemic evolves endogenously partly depending on the market activities of agents. The economic block consists of infinitely lived agents working with producing one of two goods, regular or social, differing in their infection risk when consumed. Agents within these two sectors are in turn employed in an either flexible or rigid occupation, differing in to what extent working from home (WFH) is a good substitute to working on-site in terms of productivity. As a result, there are four occupational types, regular-flexible, regular-rigid, social-flexible, and social-rigid. Crucially, and as opposed to related work by, e.g., Krueger et al. (2020); we assume agents to be locked in their respective occupation, to illustrate aspects of path dependency and friction in the labor market.

In our baseline model, susceptible agents endogenously want to shift their consumption away from social consumption out of fear to become infected, resulting in social sector workers getting affected by the decreased demand through their wage and employment. In the other sector, regular workers flourish in the increased demand of their goods. Later, in two numerical examples where we firstly make people work from home in proportion to the infection rate in society, and secondly impose a lockdown scenario constraining on-site working and the production of social goods, the heterogeneity of impacts become two-dimensional. Now, adding to the regular/social inequality, agents in flexible occupations are relatively better off than agents in rigid occupations due to their ability to avoid infection risk and staying relatively productive while working from home. These heterogeneous impacts are our main findings and gives an important insight into what groups policymakers must protect in pandemic times. Lastly, as a numerical exercise, we explore the policy trade-off between minimizing the economic blow and keeping death rates low, by simulating scenarios with different lockdown lengths.

2 Literature Review

A vast majority of the studies on the economic impacts of COVID-19 highlight similar patterns in terms of socioeconomic disparity and self-mitigation. In this section we will address a selection of the existing literature related to the scope of our study.

The distributional impact of the COVID-19 crisis Prior to the outbreak in the US, the COVID-19-virus was to some extent attributed the epithet of a great equalizer, relating to the non-discriminatory health risk passing the social classes. However, as the pandemic evolved, existing economic inequalities were magnified and the concept became criticized (see Mein (2020)). In the existing literature, economists have set out to identify and explore the distributional impacts of COVID-19 in the US (see e.g., Adams-Prassl et al. (2020); Beland et al. (2020); Mein (2020); Dua et al. (2021); Alon et al. (2020a); Chetty et al. (2020)), and in the western world at large (see e.g., Guven et al. (2020); Clark et al. (2020); Fana et al. (2020); Benzeval et al. (2020); Gustafsson and McCurdy (2020); Joyce and Xu (2020); Blundell et al. (2020); Andersen et al. (2020); Campa et al. (2020)), and find income and occupation as significant explanatory variables. In the field of research that touch upon the applied macroeconomic history of past pandemics and recessions from an inequality perspective (see e.g., Furceri et al. (2020)), the role of capital in production has been secondary in importance (see e.g., Barro et al. (2020); Jordà et al. (2020)). Instead, automatic stabilizers and discretionary policies have played a key role in mitigating the repercussions that mainly affected the unskilled labor (see Paulus and Tavessa (2020); Dolls et al. (2011)). In the growing field of research that targets the relationship between occupational aspect and COVID-19, both in the short-term and long-term (see Palomino et al. (2020); Dingel and Neiman (2020); Mongey et al. (2021); Bick et al. (2020); Barrero et al. (2021); Bonacini et al. (2020) the ability to work from home has been highlighted as a common denominator among social groups that are relatively better off.

Simulation, policy and inequality In regards to modeling, the quantitative analysis of COVID-19 can be roughly divided into three sub-fields, an epidemiological block, a macroeconomic block, and an intersecting area. Within the macroeconomic block there are extensive studies modelling the short-term consequences of discretionary policies, both those implemented globally and from a counter-factual perspective (see e.g., Brewer and Tavessa (2020); Figari and Fiorio (2020); Brunori et al. (2020); Brewer and Gardiner (2020): Agostinelli et al. (2020); Li et al. (2020); Alon et al. (2020b). The approach has typically been through micro-simulations where results have shown a coherence in the importance of government intervention and the heterogeneous abilities to self-mitigate (see e.g., ODonoghue et al. (2020); Almeida et al. (2020); Beirne et al. (2020): Brewer and Gardiner (2020)).

The macroeconomics of epidemics The combined epidemiological building block and macroeconomic building block is dominated by different specifications and augmentations of the SIR-model (see Kermack and McKendrick (1927)). In the standard SIR-model, agents transition dynamically through mutually exclusive stages of being susceptible, infected, or recovered. The model can also be expanded to include multiple stages [1]. In the combined modeling of epidemiology and preference-driven households (SIR-macro models), studies have modelled dimensions of fiscal stimulus, monetary policy, government trade-offs and the sub-optimal behaviours of the virus externality (see e.g., Eichenbaum et al. (2021); Krueger et al. (2020); Acemoglu et al. (2020); Bairoliya and Imrohoroglu (2020); Jones et al. (2020); Kaplan et al. (2020)).

[1] e.g., see the SIRV-model in Schlickeiser and Kröger (2021).

3 The SIR-macro model

In this section we establish the standard for the model economy preceding the pandemic. Thereafter, we present the dynamics of the pandemic outbreak in the model economy and the combined SIR-macro model.

3.1 The pre-pandemic economy

3.1.1 Time and demography

Time is discrete and each period t represents one week in the economy. The population is modelled as a continuum of individuals. The size of the initial population is normalized to 1, and agents are infinitely lived apart from the risk of dying from COVID-19, in which case the population size decreases below 1.

3.1.2 Households

Agents belong to one out of four occupations that are heterogeneous across two dimensions, sector of employment $\nu \in (regular, social)$ and level of flexibility $\xi \in (flexible, rigid)$. The sectors are defined as producers of either regular or social goods, differing in their infection risk in consumption. Within each sector, working in a flexible or rigid occupation decides an agent's relative productivity of working from home compared to on-site work. Further, each occupation is associated with a unique overall labor productivity.

Table 1: Occupation types

	Flexible	Rigid
Regular sector	Reg-flex	Reg-rig
Social sector	Soc-flex	Soc-rig

There is no mobility across occupations, meaning that the size of occupation groups are only subject to change in cases of mortality.

Utility Function At any point in time, t, a representative agent maximizes

$$\max_{\{c_t^{reg}, c_t^{soc}\}} U_t \equiv \sum_{i=1}^{\infty} \beta^{i-1} u(c_{t+i-1}^{reg}, c_{t+i-1}^{soc}), \tag{1}$$

where

$$u(c_t^{reg}, c_t^{soc}) = ln(c_t^{reg}) + \theta ln(c_t^{soc}). \tag{2}$$

In a given period, agents experience utility from consuming regular and social goods. The θ parameter is constant and stipulates the weight attached to social consumption. In the pre-pandemic steady state, the consumption decision is static since the current action of the agent does not affect future periods - the agents simply exhaust their current income on current consumption. Once the set of pandemic conditions are introduced, agents must take their health into consideration and respond dynamically to the progression of the pandemic.

Budget constraint The individual's budget constraint is defined in eq.(3). The LHS of the equation illustrates how the agent can spend their money on either regular or social goods, at prices p^r and p^s. On the RHS of the expression is the disposable income that is captured by the product of the sector specific wage rate w^ν, the occupation specific productivity $z^{\nu,\xi}$, and effective time supplied $n^{\nu,\xi}$.

$$\overbrace{p_t^{reg} * c_t^{reg} + p_t^{soc} * c_t^{soc}}^{\text{feasible allocation}} \leq \underbrace{w_t^\nu * z^{\nu,\xi} * n_t^{\nu,\xi}}_{\text{disposable income}} \tag{3}$$

Time Endowment Agents are endowed with one unit of time that can be used working on-site or WFH,

$$1 = h_t^{on-site} + h_t^{WFH}. \tag{4}$$

However, working on-site and working remote are not perfect substitutes. Instead, WFH is assumed to be associated with a lower productivity. The occupations with a high ability to substitute working on-site with WFH will face a lower loss in productivity compared to those of a rigid occupation type. The elasticity when substituting the labor supply is defined in eq.(5) where the Ω^ξ represents the relative productivity of WFH compared to on-site work, and E_t^ν is the sector specific employment, which in the pre-pandemic state is normalized to 1 in both sectors. Therefore, the effective time supplied, as mentioned in eq.(3), is given by

$$n_t^{\nu,\xi} = (h_t^{on-site} + \Omega^\xi * h_t^{WFH})E_t^\nu, \tag{5}$$

where

$$0 < \Omega^{rig} < \Omega^{flex} < 1.$$

Henceforth, we combine eq.(4) and eq.(5) through $h^{on-site}$ and we will apply the representation in eq.(6) for n throughout the model.

$$n_t^{\nu,\xi} = (1 + (\Omega^\xi - 1) * h_t^{WFH})E_t^\nu. \tag{6}$$

3.1.3 The Firms

The economy consists of two representative firms, one in the social sector and one in the regular sector. Each of the firms behaves according to the dynamics of perfect competition. Firm profits Π_t are specified as the difference between revenue coming from selling their output at the market price and total labor costs.

$$\begin{aligned} \Pi_t^{reg} &= p_t^{reg} * Y_t^{reg} - w_t^{reg} * N_t^{reg} \\ \Pi_t^{soc} &= p_t^{soc} * Y_t^{soc} - w_t^{soc} * N_t^{soc}. \end{aligned} \tag{7}$$

Aggregated production Y of good ν is defined as a linear function of the aggregate effective labor units supplied in that sector, N^ν. The TFP captures the total productivity within society, and the production function is defined as

$$Y_t^\nu = TFP * N_t^\nu. \tag{8}$$

In equilibrium, firms will optimize production by producing until they get zero profit, i.e., $\Pi^\nu = 0$.

3.2 Pre-pandemic steady state

This subsection will address the conditions of a competitive equilibrium and its implication for the agents' maximization problems in the pre-pandemic state.

Consumption decision The system of equations involved in the household optimization problem consists of two considerations, regular and social consumption. As previously mentioned, the problem is static in the pre-pandemic state since there is no way of affecting future utilities. The Lagrangian w.r.t. consumption is formed below where μ represents the Lagrange multiplier.

$$\begin{aligned}\mathcal{L} = &\Big(ln(c_t^{reg}) + \theta * ln(c_t^{soc})\Big) \\ &- \mu\Big(p_t^{reg} * c_t^{reg} + p_t^{soc} * c_t^{soc} - w_t^{\nu} * z^{\nu,\xi} * (1 + (\Omega^{\xi} - 1) * h_t^{WFH}) * E_t^{\nu}\Big)\end{aligned} \tag{9}$$

The partial derivatives of the Lagrangian w.r.t. the consumption of social and regular goods in period t yield the following set of first order conditions,

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial c_t^{reg}} &= (c_t^{reg})^{-1} - \mu * p_t^{reg} = 0 \\ \frac{\partial \mathcal{L}}{\partial c_t^{soc}} &= \theta * (c_t^{soc})^{-1} - \mu * p_t^{soc} = 0,\end{aligned}$$

that can be rearranged into an expression of the optimal allocation of goods for a representative agent in the pre-pandemic steady state,

$$c_t^{soc} = \frac{\theta * p_t^{reg}}{p_t^{soc}} * c_t^{reg}. \tag{10}$$

By combining the optimal allocation of goods stipulated by eq.(10), with the budget constraint of eq.(3), we obtain the optimal demanded amount of consumption of each good in period t as a function of prices and employment levels.

$$c_t^{reg} = \frac{w_t^{\nu} * z^{\nu,\xi} * (1 + (\Omega^{\xi} - 1) * h_t^{WFH}) * E_t^{\nu}}{p_t^{reg} * (1 + \theta)} \tag{11}$$

$$c_t^{soc} = \frac{\theta * w_t^{\nu} * z^{\nu,\xi} * (1 + (\Omega^{\xi} - 1) * h_t^{WFH}) * E_t^{\nu}}{p_t^{soc} * (1 + \theta)}. \tag{12}$$

Labor supply The optimal allocation of labor supply for a representative agent is trivial from eq.(11) and eq.(12). Since the consumption of both goods are strictly decreasing functions of h_t^{WFH} (since $\Omega^{\xi} < 1$), it follows that the maximum point is at the lower endpoint of the time endowment constraint. Hence, we let all agents work exclusively on-site in all non-pandemic periods, by setting $h^{WFH} = 0$.

Goods market clearing condition In the pre-pandemic steady state, prices are static and clear both goods markets. The production is determined by the aggregated labor supply and the employment levels. The aggregate relative demand is given by

$$C_t^{soc} = C_t^{reg} * \theta * p_t^{reg} / p_t^{soc}, \tag{13}$$

and production must satisfy,

$$Y_t^{soc} = C_t^{soc} \tag{14}$$

$$Y_t^{reg} = C_t^{reg}. \tag{15}$$

By substituting equation (14) and (15) into equation (13), we get the following relationship between the production proportions and the relative price:

$$\frac{p_t^{reg}}{p_t^{soc}} = \frac{Y_t^{soc}}{\theta * Y_t^{reg}}. \tag{16}$$

The θ is set to equal the pre-pandemic fraction of social good output to regular good output, such that the relative price becomes unity in the pre-pandemic state. The absolute prices are normalized to one in the pre-pandemic state.

Labor market clearing condition When the goods markets have cleared, workers have accumulated $p_t^{reg} * Y_t^{reg}$ in funds to the regular goods firm, and $p_t^{soc} * Y_t^{soc}$ to the social goods firm. By the dynamics of perfect competition, workers are paid their marginal product of labor,

$$w_t^{reg} = p_t^{reg} * \frac{Y_t^{reg}}{N_t^{reg}}$$

$$w_t^{soc} = p_t^{soc} * \frac{Y_t^{soc}}{N_t^{soc}}$$

where N^{reg} and N^{soc} are the sums of labor efficiency units ($z_t^{\nu,\xi} * n^{\nu,\xi}$) that have been supplied in production in each firm at period t.

3.3 SIR dynamics

The laws of motion governing the pandemic is based on the SIR model developed by Kermack and McKendrick (1927). We sow the seeds of the pandemic when we set a small fraction of the population as infected (I). From that point, the pandemic evolves endogenously through the SIR dynamics. People go from susceptible (S), to infected (I), to either being recovered (R) or deceased (D). Once recovered, agents are assumed to be immune to the disease forever.

The health state parameters, S_t, I_t, and R_t, are the fractions of the initial population that are susceptible, infected, and recovered in period t. In the transitory dynamics, the fraction of the population that is newly infected in every period is given by T_t, where π_1, π_2, and π_3 are the constant strengths of the three infection channels; (1) infection through shopping/consuming social goods, (2) infection through working on-site, and (3) infection from random meetings with infected individuals otherwise not captured by the model.

$$T_t = \pi_1 * (C_t^{s,soc}) * (C_t^{i,soc}) + \pi_2 * (H_t^{s,on-site}) * (H_t^{i,on-site}) + \pi_3 * S_t * 0.8 * I_t \tag{17}$$

In words, eq.(17) defines the fraction of newly infected as the additive function of encounters between susceptible and infected individuals in social consumption, at the workplace, and randomly in the complement (e.g., interactions in the neighborhood). $C_t^{s,soc}$ and $C_t^{i,soc}$ constitute the aggregate amount of social consumption by susceptible and infected individuals respectively, while $H_t^{s,on-site}$ and $H_t^{i,on-site}$ are the aggregate amounts of on-site working hours of susceptible and infected individuals respectively.

On the individual level, eq. (18) illustrates how a susceptible agent can affect the risk of becoming infected through the consumption decision.

$$\tau_t = \pi_1 * c_t^{soc} * (C_t^{i,soc}) + \pi_2 * (h_t^{on-site}) * E_t^{\nu} * (H_t^{i,on-site}) + \pi_3 * 0.8 * I_t. \tag{18}$$

In words, the more an agent consumes social goods, and the more they work on-site, the higher is their probability of becoming infected. While the allocation of consumption is a fully endogenous decision in the model, $h_t^{on-site}$ is exogenous and will be set to 1 in our baseline model. In subsequent numerical examples, we will relax this assumption.

As seen in eq.(19), the pool of susceptible agents decreases by the number of newly infected every period.

$$S_{t+1} = S_t - T_t \tag{19}$$

We assume that people are infected for exactly two weeks and that they either, subject to exogenous probabilities π_d and π_r, end up as deceased or recovered. Further, in accordance with Eichenbaum et al. (2021), we assume 80% of infected individuals to be asymptomatic. In our model, asymptomatic infected individuals are assumed to believe they are susceptible, and act as such. Oppositely, symptomatic infected individuals are temporarily excluded from market activities and assumed to experience zero utility during the two weeks as infected.

The amount of infected in the next period, I_{t+1}, is given by the current amount of infected adjusted for the newly infected and those either deceased or recovered.

$$I_{t+1} = I_t + T_t - T_{t-2} \tag{20}$$

In similar fashion, the subset of recovered R_{t+1} equals the previous amount of recovered, and the amount of infected that recovered.

$$R_{t+1} = R_t + \pi_r * T_{t-2} \tag{21}$$

The total population size is equal to the previous population size adjusted for the deceased agents.

$$Pop_{t+1} = Pop_t - \pi_d * T_{t-2}. \tag{22}$$

3.4 Competitive equilibrium of the pandemic

In pandemic times, a representative susceptible (or asymptomatic infected) agent can adapt their behavior to avoid infection risk. The lifetime utility function that a susceptible (or asymptomatic infected) agent maximizes is given by,

$$U_t^s = u^s(c_t^{reg}, c_t^{soc}) + \beta[(1 - \tau_t)U_{t+1}^s + \tau_t * U_{t+1}^i], \tag{23}$$

where U^s_{t+1} is the discounted expected lifetime utility from next period onward if the agent remains susceptible into next period, and U^i_{t+1} is the discounted expected lifetime utility from next period onward if the agent gets infected into next period, and τ_t the probability of getting infected into next period[2].

After the second period as sick, an agent is either dead or recovered, and the agents are aware of the associated probabilities. Recovered agents are assumed to know that they are immune forever, and maximize the following lifetime utility function.

$$U^r_t = u^r(c^{reg}_t, c^{soc}_t) + \beta U^r_{t+1} \tag{24}$$

Consumption decision When making their consumption decision, susceptible agents take the infection risk of social consumption into consideration. Asymptomatic infected agents act as susceptible, and symptomatic infected agents are temporarily excluded from market activities. Recovered agents solve the static problem without any infection risk, like in the pre-pandemic steady state.

When arranging the Lagrangian equation for the consumption decision of susceptible agents, we apply eq.(23) as the target function and eq.(3) and eq.(18) as the binding constraints. Further, we substitute eq.(5) into the budget constraint and end up with the following expression,

$$\begin{aligned}\mathcal{L} =& u^s(c^{reg}_t, c^{soc}_t) + \beta[(1-\tau_t)U^s_{t+1} + \tau_t * U^i_{t+1}]\\ &- \mu_1[w^\nu_t * z^{\nu,\xi}(1 + (\Omega^\xi - 1)h^{WFH}_t) * E^\nu_t - p^{reg}_t * c^{reg}_t - p^{soc}_t * c^{soc}_t]\\ &- \mu_2[\tau_t - \pi_1 * c^{soc}_t * (C^{i,soc}_t) - \pi_2 * (h^{on-site}_t) * E^\nu_t * (H^{i,on-site}_t) - \pi_3 * 0.8 * I_t].\end{aligned} \tag{25}$$

The partial derivatives w.r.t. both types of consumption and the risk of getting infected yield the following set of first order conditions,

$$\begin{aligned}\frac{\partial\mathcal{L}}{\partial c^{reg}_t} =& \frac{1}{c^{reg}_t} + \mu_1 * p^{reg}_t = 0\\ \frac{\partial\mathcal{L}}{\partial c^{soc}_t} =& \frac{\theta}{c^{soc}_t} + \mu_1 * p^{soc}_t + \mu_2\pi_1 * C^{i,soc}_t = 0\\ \frac{\partial\mathcal{L}}{\partial \tau_t} =& \beta(U^i_{t+1} - U^s_{t+1}) - \mu_2 = 0.\end{aligned}$$

By combining the conditions we get that,

$$c^{soc}_t = \frac{\theta}{\frac{p^{soc}_t}{p^{reg}_t * c^{reg}_t} - (U^i_{t+1} - U^s_{t+1})\beta * \pi_1 * C^{i,soc}_t} \tag{26}$$

which is the relationship between social and regular consumption today that maximizes a susceptible agent's expected lifetime utility. Substituting eq.(26) into the budget constraint and solving for c^{soc}_t, the optimal level of social consumption is given by the second degree equation

$$c^{soc}_t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \tag{27}$$

[2]See the appendix for the mathematical properties of the recursive variables.

and substituting that into the budget constraint and solving for c_t^{reg} gives us the level of regular consumption in optimum[3].

$$c_t^{reg} = \frac{w_t^{\nu} z^{\nu,\xi} E_t^{\nu}(1 + (\Omega^{\xi} - 1)h_t^{WFH})}{p_t^{reg}} - \frac{p_t^{soc}}{p_t^{reg}} * \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \tag{28}$$

where

$$\begin{cases} a = & p_t^{soc} * (U_{t+1}^i - U_{t+1}^s)\beta\pi_1 C_t^{i,soc} \\ b = ((1+\theta)p_t^{soc} - (U_{t+1}^i - U_{t+1}^s)\beta\pi_1 C_{t,1}^{soc} w_t^{\nu} z^{\nu,\xi} E_t^{\nu}(1 + (\Omega^{\xi} - 1)h_t^{WFH})) \\ c = & -\theta w_t^{\nu} z^{\nu,\xi} E_t^{\nu}(1 + (\Omega^{\xi} - 1)h_t^{WFH}). \end{cases}$$

An seen in the expressions above, the demand of a susceptible agent now depends, among other things, on their reluctance to becoming infected $(U_{t+1}^i - U_{t+1}^s)$ and their beliefs about the aggregated social consumption of infected $C_t^{i,soc}$ which they base on behaviors of last period and current infection levels. The higher infection levels, and the more agents value remaining susceptible, the more they will shift away from social consumption.

Market clearing condition In pandemic times, prices and employment must adjust simultaneously to satisfy the market clearing condition. It is of importance to distinguish between the price effect and the employment effect of a change in demand, since employment is associated with infection risk in the workplace. On the one hand, by assuming constant employment and letting prices absorb the full recoil of a demand increase (decrease), infection in the workplace would be underestimated (overestimated). On the other hand, by letting prices be fixed and having employment absorb the full demand increase (decrease), infection in the workplace would be overestimated (underestimated). As a middle ground assumption, we proceed with letting price and employment equally share the impact of changes in demand in each sector. Thus, prices will equal the employment rate in their respective sector.

In practice, the following loop will be run in MATLAB to satisfy market clearing. First, prices and employment rates will be guessed by an auctioneer, implying wage rates in each sector. Second, agents will given the current proposed wage, employment, and prices report their demand of each good. Third, the auctioneer will aggregate the reported demands of all individuals, compare it with the supply associated with the currently proposed employment levels, and update the proposed prices and employment rates if markets do not clear. If the demand of a goods is higher than supply, the auctioneer increases the price of that good and the employment rate in that sector by a small amount, leading to a slightly lower demand and higher supply of the good, and vice versa if demand is too low. This process will be repeated until supply equals demand for both goods within a sufficiently small margin.

4 Model parameters

In this section we address the parametization of the epidemiological and macroeconomic building block of the model. In order to shed light on the laissez-faire repercussions of the COVID-19 dynamics, the model parameters are mainly set to resemble Swedish data. At the end of the section we will introduce and define a set of alternative scenarios and policy possibilities.

[3]Note, as we obtain two possible solutions for c^{soc}, we proceed with the only plausible solution of $c^{soc} = \frac{-b+\sqrt{b^2-4ac}}{2a}$

4.1 Epidemiological Model

4.1.1 SIR

Case fatality rate Because of the assumption that infected individuals are infected for exactly two weeks and then with certainty either die or recover, the π_d parameter is perfectly analogous to a real life case fatality rate, i.e., the fraction of infected people who end up dying from the infection. The case fatality rate is retrieved from the Public Health Agency of Sweden based on the onset cases with covid-symptoms in the Stockholm region between the 21 March and 30 March 2020. The study reports a case point estimate of 0.6 percentage within a confidence interval of 0.4-1.1 percentage[4] (Folkhälsomyndigheten (2020)). Relating to the bias of under-reporting that stems from the hidden statistics in the fraction of infectious citizens, we suspect that the point estimate may be upward biased. As a cautionary measure, and to match the rate used by Eichenbaum et al. (2021) and estimates from Salje (2020), we choose a case fatality rate of 0.5%.

Transmission of the virus The set of parameters capturing the transmission channels of the virus, i.e., π_1, π_2, and π_3, are retrieved by replicating and making minor adjustments[5] to the estimates of Eichenbaum et al. (2021). The approach is based on the previous work of Ferguson et al. (2006) that argue that the transmission of respiratory diseases is weighted at 30:33:37 in the household, general community, and schools and workplaces respectively. We assume the fraction of transmissions related to social consumption and work to be roughly 1/6 and 1/6 respectively, with the rest going through the random interaction channel. To find the absolute parameter values, π_1 and π_2 will at first be set to 0, while π_3 is calibrated such that 60% of the population will at some point contract the virus, in accordance with the Merkel scenario discussed in Eichenbaum et al. (2021) (see Bennhold and Eddy (2020)). Next, π_3 will be multiplied by 2/3, and π_1 and π_2 will be set to satisfy

$$
\begin{aligned}
\frac{\pi_1 (C^{soc})^2}{\pi_1 (C^{soc})^2 + \pi_2 (H^{on-site})^2 + \pi_3} &= \frac{1}{6} \\
\frac{\pi_2 (H^{on-site})^2}{\pi_1 (C^{soc})^2 + \pi_2 (H^{on-site})^2 + \pi_3} &= \frac{1}{6},
\end{aligned}
$$

where the aggregated on-site hours supplied and aggregate social consumption are based on the pre-infectious levels[6]. As an result, we proceed with the following set of parameters for the SIR-macro model. Henceforth, the case where π_1 and π_2 are set to 0 is referred to as the simple SIR model.

[4]By splitting the data-set on the basis of age, the corresponding point estimates and confidence interval for the age groups 0-69 years and >69 is 0.1 (c.i. 0.1-0.2) and 4.3 (c.i. 2.7-7.7) respectively.

[5]The adjustment from the US data and Eichenbaum et al. (2021) is related to the fraction of transmissions that occur in schools and workplace. We apply the suggested weight of 10 per student and 4 per worker, motivated by the intensity and spread of interaction by Lee et al. (2010), and map it to the population of workers and students in Sweden. The estimate of the average number of workers and students (pre-school to university) is based on the Swedish Labor Force Survey 2018 published by Statistics Sweden and the reporting of the Swedish National Agency for Education school year 2017/2018. The average number of workers and students are reported to be 5097,4K and 2334,1K respectively. Workers are defined as the total employment in the labor force, and students as the sum of preschool, preschool class, elementary school, upper high school and the number of full-time student and part-time students at the age 20 to 65. Hence, approximately 47% of the school and work-node stems from the workplace (5097.4*4/(5097.4*4+2334,1*10)). In society, the fraction of virus transmission from the workplace alone is approximated to 17%.

[6]see Eichenbaum et al. (2021)

$$\begin{cases} \pi_1 = 1.2051 * 10^{-8} \\ \pi_2 = 0.1557 \\ \pi_3 = 0.6229 \end{cases}$$

4.1.2 The model's basic reproduction number

To test the intensity and pace of the epidemic and the epidemiological building block we direct attention to the basic reproduction number $\mathcal{R}_0$ as a diagnostic. The statistic captures the width of infections caused in a lifetime by an agent, in a susceptible population ($S_t = Pop_t = 1$). The statistic is given by,

$$\mathcal{R}_0 = \sum_{t=1}^{\infty} \gamma(1 - \pi_r - \pi_d)^{t-1} = \frac{\gamma}{\pi_r + \pi_d},$$

where $(1 - \pi_r - \pi_d)$ is the probability of remaining susceptible each period, and γ is the ratio of newly infected (T_0) to total infected (I_0) when the pandemic begins.

As a point of reference, $\mathcal{R}_0$ is typically estimated by either tracking individual-level data on the secondary infections caused by an infected, or, by picking a rate that matches the aggregated empiric data (see, e.g., Blower et al. (2007)). As in Eichenbaum et al. (2021), we apply the later of the approaches. The implied rate given the assumptions of parameters is $\mathcal{R}_0 = 1.4910$. The implied value is consistent with the estimated interval of Riou and Althaus (2020). To account for the uncertainties in estimating $\mathcal{R}_0$ and the typically broad range of identified reproduction numbers, we will loosen on some of the dependent restrictions in the section covering robustness tests and sensitivity analysis.

4.2 Economic Model

4.2.1 Production

Sector In order to approximate the fraction of firms producing social and regular goods, we aggregate all Swedish economic activity on the industry level by the intensity of human interaction throughout the consumption process. The intensity of human interaction is based on our own back-of-the-envelope analysis of the allocation of Kaplan et al. (2020). The allocation across sectors is conducted within the framework of Swedish Standard Industrial Classification (SNI) 2007.

The process of sector division is approached on the level of letter-classification (A-U), and regarding industries of an ambiguous nature, we approach the 2-digit standard. However, as industries are clustered into subgroups in our data sets[7], the allocation is approximated. As a rule of thumb, such industries that are left in between subgroups, will belong to both sectors, and we assume that each fraction is of equal size[8]. The classification of sectors are illustrated in Table 2 on the level of letter-classification.

Occupation In the model economy we assume that all agents belong to one of four occupations. The groups differ in the sector they work in, i.e., produce either social (soc) or regular (reg) goods, and the degree of flexibility in substituting working from home with working on-site, i.e., rigid or flexible. Further, each occupation group face a unique budget constraint where the wage and the flexibility parameter Ω^{ξ} parameter are binary on the basis of sector and substitution-ability respectively, and the productivity parameter

[7]The Labor Force Surveys of 2018 reports the labor participation distribution as comprised in the following set of industry codes {01-03, 05-33+35-39, 41-43, 45-47, 49-53, 55-56, 58-63, 64-82, 84+99, 85, 86-88, 90-98}.

[8]e.g., Wholesale trade and reparation, Transportation and storage and Activities of extraterritorial organisations and bodies.

Table 2: Classification of 2-digit SIN 2007 industries into a regular sector and social sectors

SNI 2007 Code	**Sector** regular goods	**SNI 2007 Code**	**Sector** social goods
A 01-03	Agriculture, forestry, fishing, and hunting	G 45-47	Wholesale trade and reparation
B 05-09	Mining and quarrying	H 49-53	Transportation and storage
C 10-33	Manufacturing	I 55-56	Accommodation and food service activities
D 35	Electricity, gas, steam and air conditioning supply	0 84	Public administration
E 36-39	Water supply and sanitation	P 85	Education
F 41-43	Construction	Q 86-88	Human health and social work activities
G 45-47	Wholesale trade and reparation	R 90-93	Arts, entertainment and recreation
H 49-53	Transportation and storage	S 94-96	Other service activities
J 58-63	Information and communication	T 97-98	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
K 64-66	Financial and insurance activities	U 99	Activities of extraterritorial organisations and bodies
L 68	Real estate activities		
M 69-75	Professional, scientific and technical activities		
N 77-82	Administrative and support service activities		
0 84	Public administration		
U 99	Activities of extraterritorial organisations and bodies		

Note: if an industry contain sub-groups of industries with ambiguous belonging, the industry average is divided by two, and each half adds to the weighted sector average. E.g., as wholesale trade and reparation include both B2B and B2C we assume that the industry belongs to both sectors. Similar reasoning is made with e.g., transportation and storage that include both passenger transport and freight transport.

$z^{\nu,\xi}$ is occupation-specific. A representative agent χ is captured by $\chi^{\nu,\xi} \in \{\Omega^{\xi}, w^{\nu}, z^{\nu,\xi}\}$ in terms of differentiation. The $z^{\nu,\xi}$ parameters are targeted to match income levels of each occupation observed in the empirical data.

In order to assess the distribution of workers along the flexibility dimension, and the degree of substitution between WFH and on-site, we apply the estimates of Dingel and Neiman (2020) on the shares of jobs where working on-site can be substituted with working from home. We manually map the estimates to match Swedish data.

The employment share in each sector is retrieved from Swedish employment data from the 2018 Labour Force Surveys (LFS). The shares reported in our study are based on the participation at the labor market across industries during 2018. The average monthly salary within each occupation group is retrieved from Statistics Sweden based on 2018 data by SNI 2007. Table 3[9] compiles the Ω^{ξ} and $z^{\nu,\xi}$ parameter values for all occupations, as well as the fraction employed across occupation types.

[9]See the extended version of Table 3 in the appendix labeled as Table 10.

Table 3: The set of parameters of the heterogeneous agents

Occupation Type	Wavg. Ω^a	Rel. Salary^b	Adj. Salary z^c	Monthly Salary	Empl. (%)^d
Reg-flex	0.60	1.22	9 175	39869	25.3
Reg-rig	0.26	1.10	8 309	36103	25.9
Soc-flex	0.60	1.00	7 543	32774	17.3
Soc-rig	0.26	0.96	7 269	31585	31.5

[a] The weighted omega parameter proxies as the share of jobs that can be done working from home (see the unweighted column in Table 3: Share of jobs that can be done at home, by industry (Dingel and Neiman (2020), p.8).
[b] The relative salary is the relationship between the pre-pandemic salaries by occupation type, with the salary of a representative social-flexible worker as base.
[c] Adj. Salary is the weighted pre-pandemic salary of the occupation type. The target value is expressed in SEK and definied as the monthly salary adjusted to a weekly level (*7/(365/12)). The value also operates as the productivity of the agent.
[d] Empl.(%) is the fraction of the initial population that belong to each occupational type.

Technology As in Eichenbaum et al. (2021), the production functions are linear and we have excluded the capital input. Hence, the outputs are constant in return to labor. For simplicity, we assume that both sectors share production technology and normalize the total factor productivity (TFP) to one. As a consequence, all variance in output stems from the inherent productivity of the workers, and their ability to effectively substitute labor hours.

4.2.2 Households

The bias in present consumption is represented by the β parameter and set at $0.96^{\frac{1}{52}}$ in accordance with Krueger et al. (2020) and consistent with Laibson (1997). The θ parameter, i.e., the weight attached to social consumption, is set at Y_{soc}/Y_{reg} to make the relative price of regular and social good be equal to unity in the pre-pandemic equilibrium. At that level, the relative income levels between the sectors are consistent with the empirical observations in terms of average salary and sector participation.

4.2.3 Value of a statistical life

The set of parameters in the model implies that the value of a statistical life (VSL) can be proxied as VSL $\in$ [9.3 − 11.7] million SEK depending on occupation, based on the present discounted value of lifetime income in the pre-pandemic steady state. In a review of the empirical literature by Hultkrantz and Svensson (2012) the VSL in Sweden is identified in the interval of [9 − 1121] million SEK, and narrowed down to [9 − 98] million SEK after applying a stricter set of selection criterias (see Hultkrantz and Svensson (2012); Biausque et al. (2011)). Within the Swedish public sector, the recommended VSL estimate to apply when conducting cost-benefit analysis is 44 million SEK (Trafikverket (2020)). Hence, the implied VSL of the model strikes in the ball park of the field of research[10].

4.3 Cases and policy scenarios

Cases and model specifications The outcome of the baseline model will be compared to a set of cases based on three types of self-mitigating measures that are represented as deviations from the main baseline calibrated SIR-macro model. The first case is the SIR-macro model as specified by the baseline calibration

[10] n.b., there is some uncertainty in the discourse related to the VSL. The reported interval and the market-based approach is flawed but offers a rough sketch of the lower bound (see e.g. Gruber (2005)).

where agents respond endogenously to the pandemic by reallocating the optimal consumption bundle. In the second case, the simple SIR model, agents cannot affect the risk of infection and will allocate consumption in the same proportions as in the pre-pandemic competitive equilibrium, and work entirely on-site, i.e., $\pi_1 = \pi_2 = H^{WFH} = 0$. The third case (the WFH-case) is an extension of the SIR-macro model where agents are set to supply labor accordingly to a pre-specified function of the infection rate at time t. In rigid occupations, agents are set to work fives times the infection rate of their time endowment from home (e.g. they work 25% from home if there is 5% infection in the economy). In turn, agents in flexible occupations are set to choose the average between the WFH level of rigid agents (meaning taking on an equal workplace infection risk) and the level of WFH that would yield the same productivity loss. Since agents in flexible occupations are more productive at home than agents in rigid occupation, the resulting WFH level is higher for those in flexible occupations, making them better off both economically and health wise in this regard.

$$h^{WFH}_{t,rig} = 5 * I_t$$
$$h^{WFH}_{t,flex} = \frac{5 * I_t}{2} + \frac{(\Omega^{rig} - 1)h^{WFH}_{t,rig}}{2(\Omega^{flex} - 1)}$$

Policy scenarios To direct the discretionary policy implication of the model environment, we evoke a set of numerical experiments that will be implemented in the baseline SIR-macro model. The ambition of the experiments is to observe the counter-factual outcomes of government interventions, and its consequences within the model framework.

First, a baseline lockdown scenario is constructed similar to that of Kaplan et al. (2020), consisting of a workplace component and a social sector component. In the workplace, 50% of all offices are proxied to be closed, and thus 50% of all labor must be supplied from home. The social sector component consists of a constraint on social sector employment to half of its pre-pandemic level to illustrate the shutdown of many social interaction intensive market activities. We assume the length of the lockdown to be 12 weeks starting from the first week with an infection rate above 2%. We refer to the calibration without any lockdown as a laissez faire scenario and it acts as a benchmark to the homespun lockdown scenario[11].

Second, the described lockdown scenario will be simulated with different lockdown lengths, ranging from 0 to 40 weeks. The simulations will result in a pandemic possibility frontier (PPF) in the spirit of Kaplan et al. (2020), illustrating the trade-off policymakers face between economic loss (both on aggregate and across occupations) and total mortality. In this manner, we can abstain taking a stand on how to optimally balance economic and health outcomes. Instead, the PPF provides a range of outcomes leaving it to the beholder to form an opinion. In addition, the results will be compared to a vaccine scenario with the presumption that all traces of the virus will be eradicated after two years, at $t = 104$.

[11] See Figure 12 in the appendix for a graphical illustration of the WFH sequence that constitutes the lockdown scenario, the WFH-cases and the baseline calibrated SIR-macro model.

5 Results

The result section will report the output of the model economy based on the baseline calibrated parameters, as well as relevant results from the cases and scenarios described in section 4. To begin with, we present the results of the SIR-transition dynamics, prior to commenting on the macroeconomic outcomes and heterogeneity in occupation. Lastly, we present the results from our lockdown scenarios.

5.1 SIR trajectory

SIR-macro model Figure 1 illustrates the proportion of susceptible, infected, and recovered as fractions of the initial population in the SIR-macro model. The pandemic stagnates after circa 40 weeks and reaches its peak in about 20 weeks after the initial injection. At time $t = 50$, circa 53 percent of the initial population has at some point gone through infection and reached the recovered state.

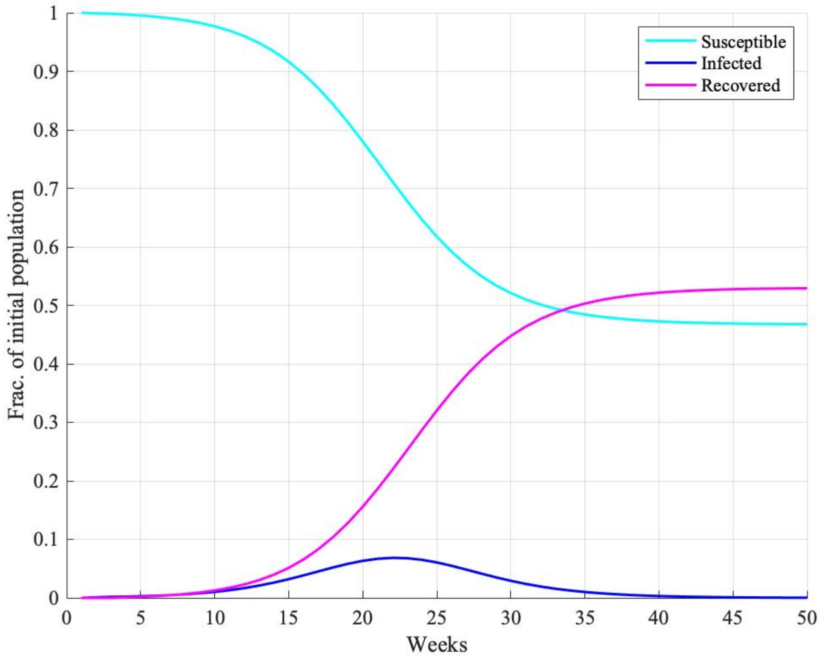

Figure 1: SIR-macro model: epidemiology trajectory

Case comparison When comparing the infection spread across cases, Figure 2 shows that the SIR-macro WFH-case generates lower infection rates, and a larger share of the population remain susceptible, while the simple SIR model generates more aggressive infection rates. Hence, as dimensions of mitigation are added to the simple SIR model, fewer agents contract the virus. The cumulative deaths measure in Figure 2 translates the mortality rate of the model to the Swedish working age population, showing that our baseline model predicts circa 17000 deaths in Sweden. As of December 5th 2021, roughly 15000 people has died from COVID-19 in Sweden, close to the number predicted by the WFH-case.

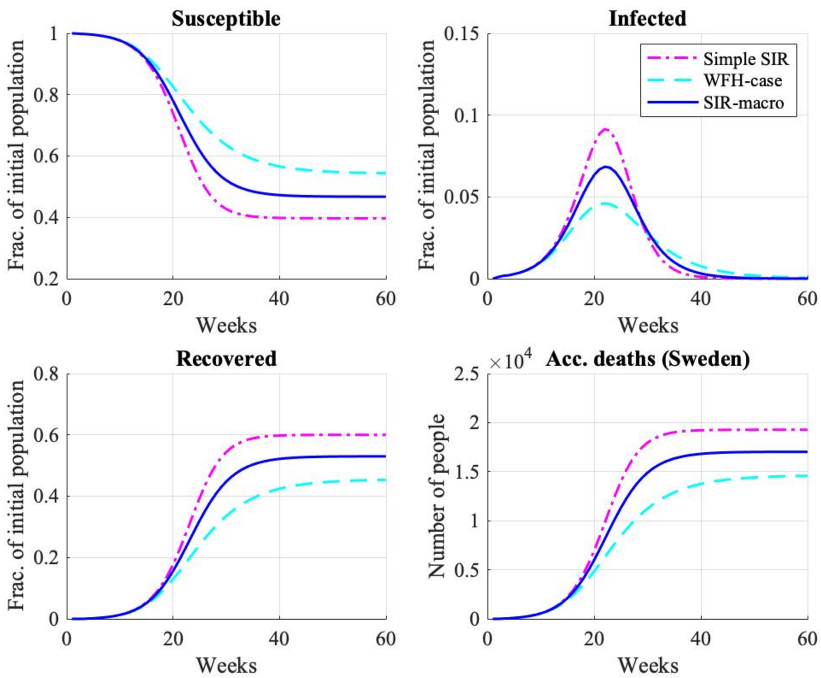

Figure 2: Simple SIR model vs. SIR-macro model vs. WFH-case

5.2 Macroeconomic outcomes

Figure 3 compiles the output and prices/employment by sector and by case. Importantly, as demand chocks are assumed to equally affect price and employment, they are identical throughout, except for temporarily in the upcoming lockdown scenarios. In the simple SIR model, there is no WFH and no consumption shifting, meaning the decline in output is strictly related to the symptomatic infected agents being excluded from working, and people dying. This leads to very small decreases in output in each sector, while both employment and price in both sectors remain equal to 1. The economic impact of the pandemic is thus fully homogeneous across occupations in the simple SIR model. In the SIR-macro versions, agents shift the optimal consumption bundle, creating a substantial decline (increase) in output and employment of the social (regular) sector, and the price of social (regular) goods. In the WFH-case, prices and employment rates are not as affected as in the baseline SIR-macro case, since infection mitigation does not exclusively happen through consumption shifting, but also through WFH. Regarding output, both sectors are worse off in the WFH case than in the baseline due to the foregone productivity of people working from home.

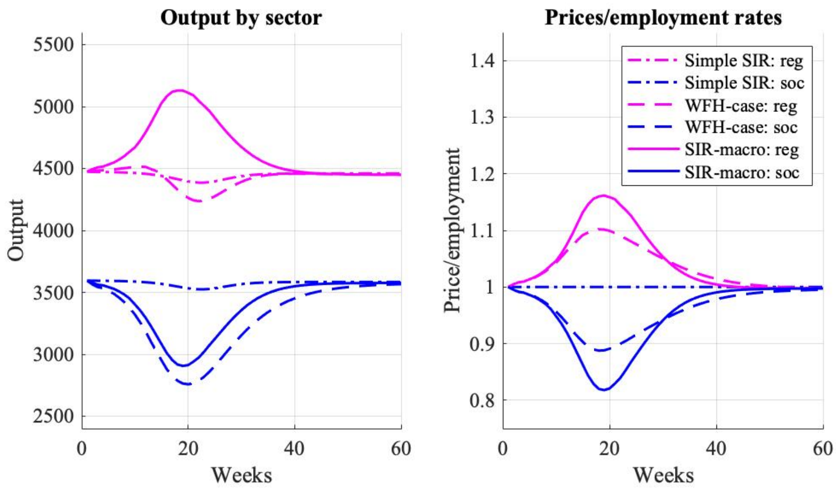

Figure 3: Aggregated market output, price levels, and employment rates

5.3 Inequality

5.3.1 Health dimension

With regards to health inequality, Figure 4 plots the infection curves by occupation in the SIR-macro model and the WFH-case. It reveals that the SIR-macro model predicts that agents of high-income types get more infected, which exclusively happens due to higher income and thus higher consumption of both goods, leading to more infection through social consumption. The WFH-case tells a similar story. Again, workers in the regular sector get more infected due to higher consumption levels. However, it is possible to discern a minimal increase in the difference between the flexibility and rigidity in each sector, where rigid occupations get slightly more infected due to more on-site working. However, since they lose more income than agents in flexible occupations, their infection through social consumption decreases more. It appears these two effects roughly offsets each other. Overall, flexible and rigid workers face similar infection risks, independent of the sector.

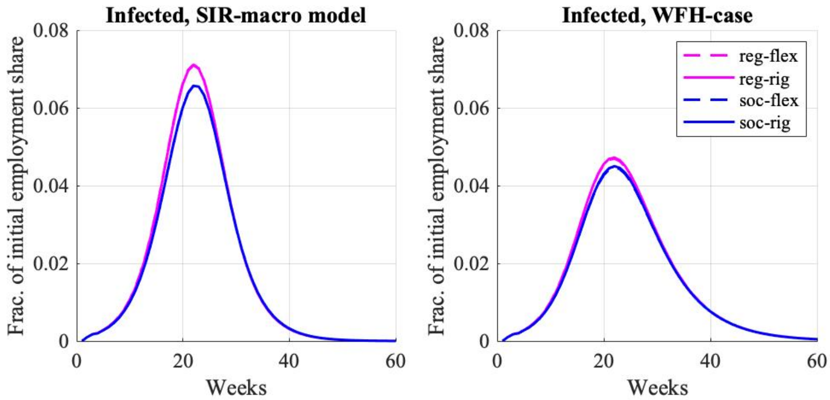

Figure 4: Infected trajectory by occupation: SIR-macro model vs. WFH-case

5.3.2 Economic dimension

The economic subsection of the inequality results will shed light on the aspects of heterogeneity in the three cases, income, welfare, and the Gini coefficient.

Income We analyse income inequality in Figure 5 by comparing how income develops across the four occupations relative to their pre-pandemic levels. To make this a purely economic measure and not depending on death rates, we only analyse the income of alive agents, weighting together the income of susceptible, infected, and recovered in each occupation.

By definition, in the simple SIR model, living agents will only lose income if symptomatically infected, which happens to an equal extent in all occupation leading to homogeneous income effects. In the SIR-macro model, the social sector is worse off due the change in demand related to the imposed infection risk on social goods, while regular sector workers enjoy higher wages and employment. In the WFH-case, regular workers get lower income than in the SIR-macro model for two reasons. First, infection mitigation through consumption shifting is not as strong since some infection mitigation happens through WFH, leading to less of a demand boost. Second, WFH of agents in the regular sector decreases income due to lower productivity. This effect differs across the flexible/rigid occupations as seen in the graph, where the flexible occupation is better off due to higher WFH productivity. In the social sector, the same two forces are of opposite directions. First, social sector workers are better off than in the baseline SIR-macro model since the negative demand shock is not as severe due to consumption shifting not being as aggressive. Second, they are worse off due to productivity losses of WFH, which again affects the rigid occupation more. Crucially, it is the assumption of inability to shift occupation that creates unequal income effects.

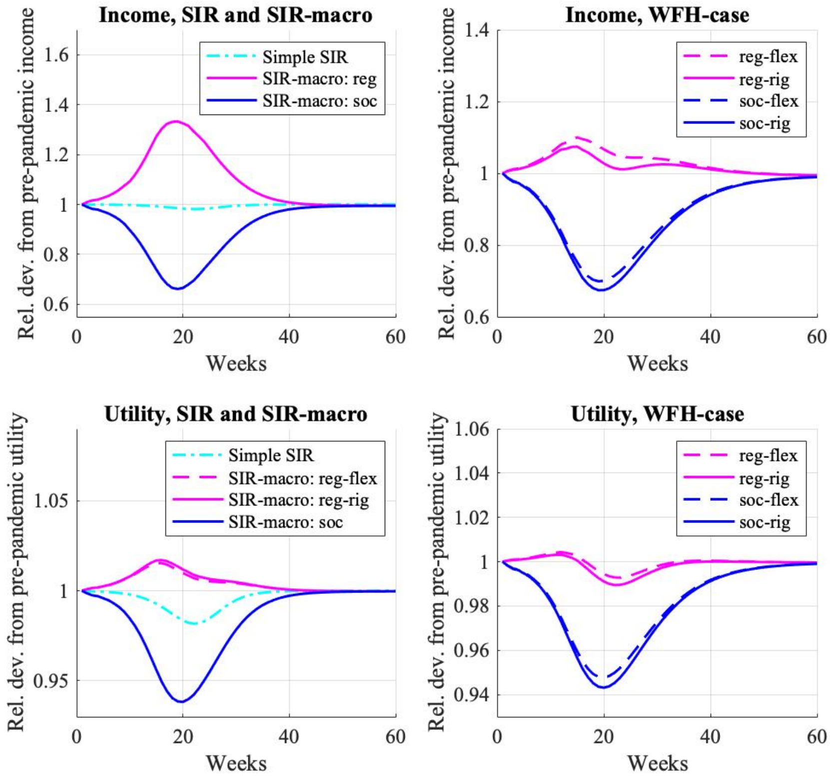

Figure 5: Income and utility: Simple SIR model vs. SIR-macro model vs. WFH-case

Utility The utility is expressed in terms of pre-pandemic levels and weighted by the health state. By Figure 5 we find that occupation types within the regular sector in the baseline SIR-macro model are better off during the pandemic than in normal times, due to increased demand of their good. The reason for their utility not increasing as much as income is that the income is being spent on a normally sub-optimal proportion of social/regular goods. In the WFH-case, we note that all agents are worse off than in normal times, also revealing an inequality between flexible and rigid occupations.

Gini coefficient Figure 6 plots the Gini coefficients in terms of income and utility by t. Due to the efficiency losses associated with the WFH-case, the relative inequalities are diluted. Thus, the SIR-macro model proposes that letting people work fully on-site and letting all infection mitigation happen through consumption shifting leads to the largest overall inequalities, while letting people WFH leads to inequalities among more dimensions as seen in Figures 5. Most importantly, inequality increases substantially during the pandemic, regardless of measure.

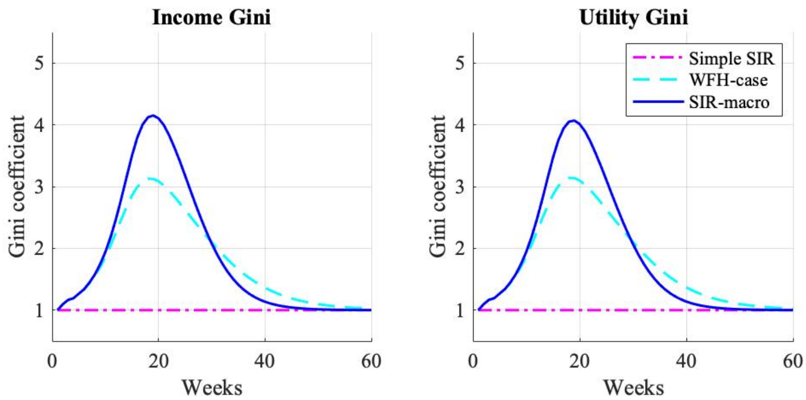

Figure 6: Gini: Simple SIR model vs. SIR-macro model. vs. WFH-case

Aggregated inequality effects Table 4 compiles the total income and utility effects across the entire pandemic, expressed in terms of the monthly pre-pandemic values of the respective occupation, as well as the final mortality rates of all occupations across the simple SIR model, the baseline SIR-macro model, and the WFH-case. The key takeaways are that consumption shifting creates large inequalities between the regular and social sector, while WFH creates further inequality within sectors in the flexibility dimension. Perhaps most importantly, it is clear that the pandemic strikes hardest at those who are already worse off in normal times. Going back to the calibrated pre-pandemic levels of the four occupations, we notice that those occupations with already lower income in normal times are the ones who experience a relatively higher loss during the pandemic, implying severe implications for inequality.

Table 4: Total income effect, total utility effect, and mortality rate, by occupation

	SIR	**SIR-macro**	**SIR-macro ext.**
Total income effect reg-flex	-0.0564	1.2318	0.3949
Total income effect reg-rig	-0.0564	1.2320	0.2332
Total income effect soc-flex	-0.0564	-1.3924	-1.5927
Total income effect soc-rig	-0.0564	-1.3924	-1.7137
Total utility effect reg-flex	-0.0564	0.0533	-0.0091
Total utility effect reg-rig	-0.0564	0.0599	-0.0235
Total utility effect soc-flex	-0.0564	-0.2409	-0.2562
Total utility effect soc-rig	-0.0564	-0.2410	-0.2757
Mortality rate reg-flex	0.0030	0.0027	0.0023
Mortality rate reg-rig	0.0030	0.0027	0.0023
Mortality rate soc-flex	0.0030	0.0026	0.0022
Mortality rate soc-rig	0.0030	0.0026	0.0022

Note: Total income effect is calculated as the difference between total income during the entire pandemic and what total income would have been in normal times during the same time period, expressed in terms of the pre-pandemic monthly income of the respective occupation. Total utility effect is, similarly, the difference between total utility during the pandemic and its non-pandemic counterpart, in terms of the pre-pandemic monthly utility of the respective occupation.

5.4 Lockdown experiment

In this section, the implications of the baseline lockdown scenario will be commented on through three perspectives, epidemiological implications, economic consequences, and inequality.

SIR In Figure 7 we note that as a lockdown is introduced, the infection rate is instantly suppressed. Once the lockdown is lifted, infection accelerates and forms a second wave. The lockdown forwards the peak of the pandemic and the overall length of the pandemic. Overall, it decreases the total deaths, in Swedish proportions, by around 2000.

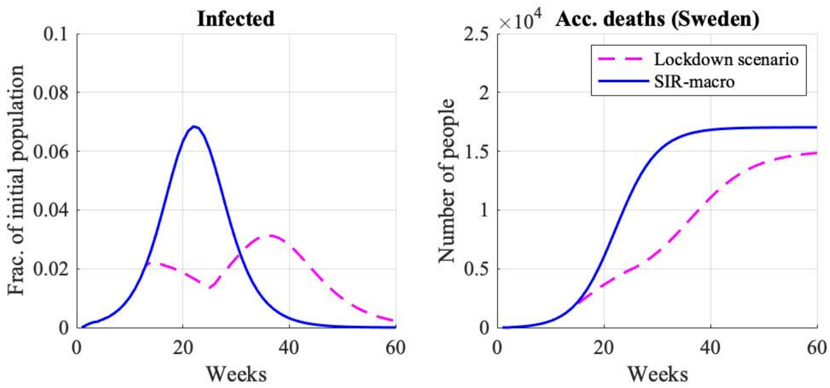

Figure 7: Epidemiology trajectory: SIR-macro vs. SIR-macro with a 3-month lockdown

Economic In Figure 8, the lockdown implies a substantial decrease in production due to the constraints on employment in the social sector, and on on-site work for all agents. While employment in the social sector is fixed to 0.5 during the lockdown, the price of the social good is now allowed to move freely, disconnected from the employment rate. Since the employment constraint decreases output of the social good more than people themselves want to shift away from social consumption, the price of the social good temporarily spikes during the pandemic. In the regular sector, price and employment are still connected and experience large decreases due to the overall recession.

Inequality Figure 9 indicates that the lockdown manages to curb the infection rate to a similar extent for all occupations. However, as the lockdown is lifted, agents again work fully on-site, social sector workers regain employment, and consumption can increase. Together, these effect's create the second wave of infection.

In terms of utility, in non-lockdown pandemic times, regular sector workers are clearly better off than social sector workers. During the lockdown however, the inequality occurs in the flexibility dimension where rigid occupations experience a more severe impact due to their low WFH productivity. The fact that the regular to social inequality is somewhat eradicated during the lockdown indicates that the temporarily increased price of the social good succeeds in compensating social sector workers for the decreased employment, so that they receive income in proportion to the actual demand of social goods in society.

Table 5 compiles income and utility effects aggregated over the total time of the pandemic, expressed in terms of their monthly pre-pandemic values, and the final mortality rates, of all occupations, in the baseline

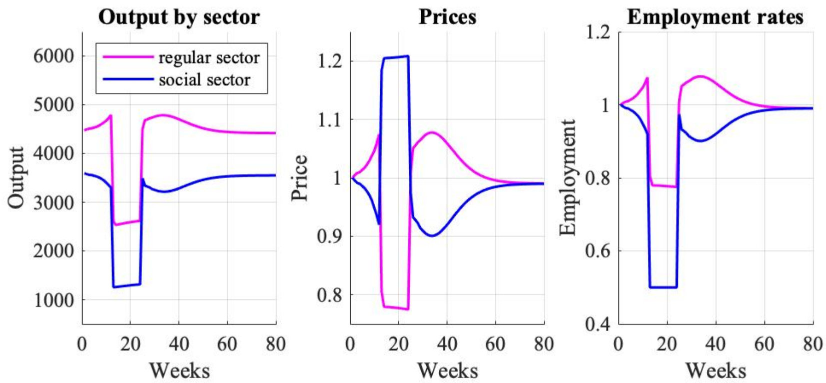

Figure 8: Macroeconomic outcomes: SIR-macro model vs. SIR-macro model with a 3-month lockdown

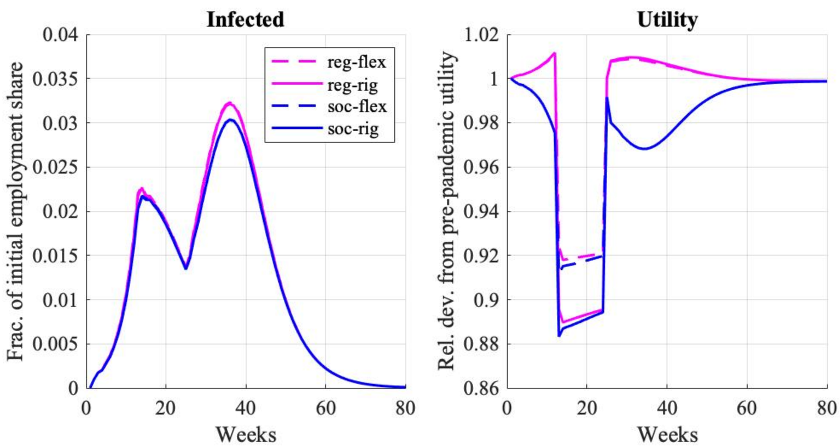

Figure 9: Inequality outcomes: SIR-macro model vs. SIR-macro model with a 3-month lockdown

lockdown scenario. As before, already worse off occupations experience larger relative losses during the pandemic, amplifying already existing inequalities.

Table 5: Inequality outcomes by occupation as a result of the lockdown scenario

	Lockdown scenario
Total income effect reg-flex	-0.7116
Total income effect reg-rig	-0.9747
Total income effect soc-flex	-2.6643
Total income effect soc-rig	-2.9256
Total utility effect reg-flex	-0.1798
Total utility effect reg-rig	-0.2514
Total utility effect soc-flex	-0.4159
Total utility effect soc-rig	-0.4914
Mortality rate reg-flex	0.0024
Mortality rate reg-rig	0.0024
Mortality rate soc-flex	0.0023
Mortality rate soc-rig	0.0023

Note: Total income effect is calculated as the difference between total income during the entire pandemic and what total income would have been in normal times during the same time period, expressed in terms of the pre-pandemic monthly income of the respective occupation. Total utility effect is, similarly, the difference between total utility during the pandemic and its non-pandemic counterpart, in terms of the pre-pandemic monthly utility of the respective occupation.

5.5 Pandemic possibility frontier

In the pandemic possibility frontier (PPF) section we illustrate the trade-off in curbing the mortality at the expense of economic welfare, by comparing lockdowns of different lengths.

Pandemic possibility frontier without vaccines The PPF of the SIR-macro model in Figure 10 produce intuitive results. As the number of deaths are targeted at the lower end of the x-axis, the economic welfare costs are increasing in size. The trade-off is also more influential on the economic conditions of workers within the social section. Also, the longer the lockdown, the more worse off are rigid occupations compared to flexible ones. Finally, the slopes get steeper as lockdown length increases, meaning that it gets increasingly expensive to save additional lives over a certain level.

Pandemic possibility frontier with vaccines As we a introduce the possibility of vaccination, herd immunity, or any other concept that eradicates the spread of the virus in Figure 11, the marginal cost of reducing the mortality rate is diminishing when the lockdown is extended, as opposed to the non-vaccine PPF. It suggests that longer lockdowns are better justified if a vaccine is on the horizon, as it narrows the window between the lifting of the lockdown, and the arrival of the vaccine, saving many lives at a relatively low economic cost.

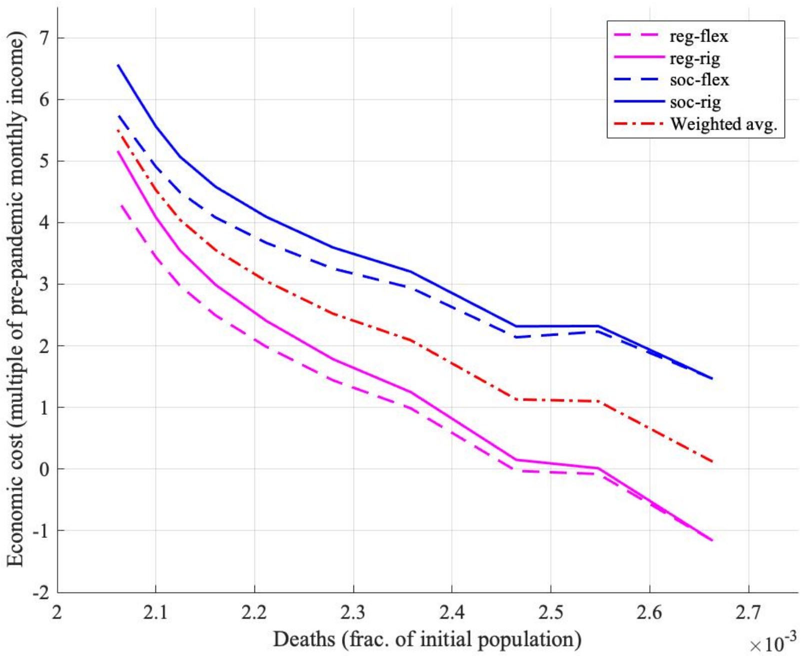

Figure 10: Pandemic Possibility Frontier: SIR-macro model

*The graph shows the outcome (in terms of economic cost per occupation, and total death rate in society) of lockdowns ranging from 0 to 10 months. Economic cost is calculated as the difference between the total income of an alive agent during the pandemic and what they would have earned during the same time period given the pre-pandemic steady state, expressed as a multiple of a pre-pandemic monthly income. Deaths is expressed as a fraction of the initial population. The weighted average of the economic costs is based on the initial sizes of occupation groups.

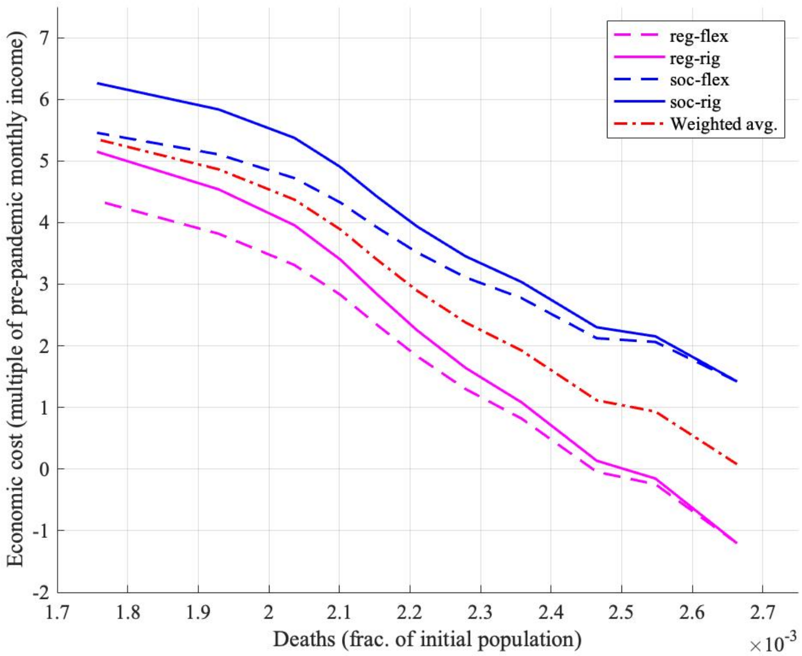

Figure 11: Pandemic Possibility Frontier: SIR-macro model by lockdown length

*The graph shows the outcome (in terms of economic cost per occupation, and total death rate in society) of lockdowns ranging from 0 to 10 months. Economic cost is calculated as the difference between the total income of an alive agent during the pandemic and what they would have earned during the same time period given the pre-pandemic steady state, expressed as a multiple of a pre-pandemic monthly income. Deaths is expressed as a fraction of the initial population. The weighted average of the economic costs is based on the initial sizes of occupation groups.

5.6 Robustness checks

In this subsection we address and report the performance and results of the model using different parameter values than in the baseline case, to get a grasp of the robustness of our results. Mainly, the sensitivity analysis will be applied to the baseline SIR-macro model. Later, the parameter values defining the WFH-case and the baseline lockdown scenario will be tweaked.

SIR-macro model Table 6 reports a number of statistics summarizing the overall results of the model given used parameter values. To begin with, by tweaking the weight assigned to each channel of infection, we note that the higher weight on the consumption channel through which agents can endogenously decrease infection risk, the more agents shift consumption to avoid infection risk, leading to larger sector effects, and fewer deaths.

Next, by increasing agent's beliefs about the pandemic horizon, the more weeks as recovered in pandemic times are expected to be associated with surviving infection, during which agents are relatively better off than when susceptible during the pandemic. This leads to a weaker reluctance to becoming infected, leading to weaker sector effects, more infection, and more deaths.

By changing the case fatality rate, we observe that a higher risk of death (which is associated with an expected utility of 0 forever) given infection leads to more aggressive consumption shifting in fear of infection, and thus fewer infections. However, total deceased increases, intuitively.

Further, by imposing a more aggressive present bias agents do not care as much about the future, i.e. whether they get infected or not, leading to less consumption shifting, milder sector effects, more infections and more deaths.

In the baseline, agents expect 0 utility during the weeks as infected. Here, we test assuming agents expect 80% of the average pre-pandemic utility in the economy, illustrating an expectation based on the knowledge about 80% of infected agents being asymptomatic. For symmetry, we also test the negative counterpart of this value. We find that the more afraid an agent is of two eventual weeks as infected, the harder consumption shifting, larger sector effects, and lower infection/death rates.

Next, the higher fraction of infected agents that are asymptomatic, the more infected individuals are participating in market activities, the more infected and more deaths. The higher infection rates leads to both sectors being worse off as the fraction of asymptomatic infected gets higher.

Lastly, setting productivity parameters equal to the income in SEK in each occupation, and pre-pandemic prices to 1, we imply the size of a good to equal a value of 1 SEK. Reducing productivity parameters to a tenth of their baseline values implies goods are valued at 10 SEK initially, leading to the quantity consumed being one tenth of baseline. This leads to the utility curve being steeper at the consumption level in question, leading to consumption shifting being relatively more expensive in terms of utility, leading to higher infection and death rates. On the opposite, using ten times larger productivity parameters leads to cheaper and more consumption shifting, reducing infections and deaths.

Table 7 compiles alternatives to the initially targeted final fraction of recovered agents of 60%. Now, the associated basic reproduction number is reported. Regarding health outcomes, the results are straightforward: a higher fraction of people going through infection at some point is associated with a higher basic reproduction number, a higher and earlier infection peak, and a higher final mortality rate. On the economic side however, we find that a medium aggressive pandemic creates the biggest divergence between the sector effects. A more aggressive pandemic does not create as strong consumption shifting overall since the pandemic is much shorter in time, while a less aggressive pandemic decreases consumption shifting throughout, but for a longer period.

WFH-case Table 8 relaxes the assumption of how much agents in rigid occupations work from home as a function of the current infection levels. Remember, agents in flexible occupations choose WFH as a function of the decision of rigid agents to be better off both in terms of productivity and avoiding workplace infection risk. We find that the more WFH, the fewer deaths overall, the larger utility loss for all occupations, and the larger divergence between flexible and rigid occupations within sectors due to differing WFH productivity.

Lockdown scenario The baseline lockdown scenario in Table 9 is adjusted in two dimensions. First, having the lockdown getting activated at a lower infection rate, the further away the society is from herd immunity as the lockdown gets lifted, leading to a larger second wave and more total deaths. Instead, activating the lockdown at a later stage better suppresses the possibility of a second wave, decreasing total deaths. The later lockdown also maximizes utility outcomes for all but one occupation.

Second, we find that a 4 month lockdown would make all occupations worse off in terms of utility, while saving lives compared to a 3 month lockdown. On the contrary, a 2 month lockdown create milder utility losses at the expense of more deaths.

Across all cases and scenarios, the model behaves as expected when tweaking parameters, arguing for the results being robust at least in their relative nature. The absolute levels of effects are somewhat sensitive to parameterization, but are also not part of the main scope of the paper.

6 Discussion

In the discussion section we comment on the implication of the results and to what extent the results can be applied in a broader context.

Interpretation of the results The results of the SIR-macro model imply that compared to a simple SIR model, agents can substantially contribute in curbing the spread of the virus through reallocating consumption away from social goods. Adding WFH into the model, infection can be avoided even further. Regarding inequalities in infection, our model predicts relatively homogeneous infection effects due to the fact that all economic benefits experienced by agents in the regular sector, or in flexible occupations, directly imply higher consumption rates since all income is consumed, in turn increasing infection. In terms of economic outcomes, the economy is to a small extent affected by absentees due to sickness, but responds strongly to the changes in relative demand, creating diverging faiths depending on sector. Again, WFH creates further inequalities between flexible and rigid occupations, as well as deepening the recession on aggregate.

The numerical experiment of a lockdown suggests that constraining interaction intensive market activities can substantially decrease the infection rate in society, but it is only effective as long as it is upheld and would extend the length of the pandemic. The lockdown will decrease the utility for living agents in all occupations by creating a major recession, although decreasing the relative inequality in income and utility, and saving many lives.

From a government perspective we note that in the PPF, it gets increasingly more costly to target a low mortality rate in the absence of a vaccine. Targeting a low mortality rate by implementing a long lockdown is relatively more justifiable from an economic perspective in a world where a vaccine or cure is eventually discovered.

Implications Similar to the model of Krueger et al. (2020), we reach the conclusion that by including heterogeneous goods, and letting agents endogenously shift away from contagious consumption, many of the negative impacts of a pandemic are mitigated. As opposed to in Eichenbaum et al. (2021) where there is only one good of which consumption is decreased by fear of infection, our model as well as the models of Krueger et al. (2020) and Kaplan et al. (2020) show how consumption does not necessarily need to be decreased, only reallocated. Further, this leads to lower infection rates in society.

However, we deviate from Krueger et al. (2020) in assumed occupational mobility. While they assume that agents can split their labor freely in any sector of choice and thus eradicate the possibility of any unequal labor market effects, we assume agents to be unable to switch occupation. We argue the occupational immobility assumption to be realistic considering the short time frame of a pandemic, and the large costs and frictions associated with switching occupation. Crucially, this assumption creates widely unequal economic effects of the pandemic, depending on occupation. In addition, our model supports the results that those already more financially vulnerable are those relatively most affected economically by the pandemic.

Acknowledging labor market frictions, occupational heterogeneity, and the resulting uneven impacts caused by the special nature of a pandemic shock is vital for policymakers to implement fair policies targeting those who need it the most.

Limitations and shortcomings The results of the model is limited by the set of calibrations and simplified assumption that abstract from many of the intangible forces and aspects that, in the light of a epidemiological scenario, constitute the real world. In ambition to bridge this gap we have included a robustness section covering the resilience of the structural framework, and the consistency in the variance analysis suggest robust results of the baseline SIR-macro model. However, as the results indicate that workers within regular occupation would prefer the occurrence of an epidemic shock (disregarding those who end up deceased), one should be careful in making any broader conclusion in that regard. Instead, the results are more representative in the interrelationship of occupations in the model framework.

Within the mentioned gap, there are two dimensions in particular, the inconsistency in the correlation between economic inequality and health inequality, and, the amplitude of the price pendulum. A plausible interpretation of the inconsistency is the lack of savings dynamics in the model. In the SIR-macro model, agents exhaust their income to the extent they find most fitting (consumption) which makes them more susceptible to contract the virus. This correlates positively with the severity of the pandemic due to the increasing demand of regular goods. By adding assets, the agents within the regular sector might choose to accumulate wealth instead, or refrain from working and exhaust their savings, which could lead to more realistic real world behaviours, and perhaps even more severe inequalities depending on wealth.

The second consideration refer to the frictionless price and employment dynamics of the SIR-macro model that contribute in making regular agents better off in absolute numbers during the pandemic. The implications of modelling prices and employment as more sticky would lead to demand effects to not fully translate into income effects for workers in the sector in question. Likewise, during a lockdown where the social production is constrained, workers would not be as compensated by a sharp increase in price as predicted by our model, further increasing inequality during the pandemic. Hence, in future research we recommend adding savings to the model as it would imply key dynamics of self-mitigation , and factors of price and employment stickiness.

The model calibration resembles Swedish data, but as the dimensions are restricted in a basic 2x2 matrix, the calibration inputs are broadly generalizable independent of the data of the subject of analysis. In a potential country comparison, it is possible to match the pre-pandemic steady state calibration on e.g., the size of the shares of occupation, the relative productivity of agents and the proxy for the fraction of jobs that can be performed at home.

7 Conclusion

In this paper, we expand on the dynamics of the SIR-macro framework of Eichenbaum et al. (2021) by adding layers of heterogeneity in goods and occupations. The model proposes that endogenous consumption reallocations in response to fear of infection risk leads to social sector workers being relatively better off than regular sectors workers. In addition, when on-site work is avoided or constrained, heterogeneity in productivity in working from home creates another dimension of disparity.

Importantly, our calibration confirms the empirical observation that those already more economically vulnerable in normal times are also those suffering the most from the unique effects of a pandemic, implying large distributional concerns.

As an additional numerical exercise, we test the implications of a lockdown scenario within the SIR-macro model framework. The resulting pandemic possibility frontier suggests that as we presume the existence of a cure two years ahead of time, there is a stronger case for extending the lockdown period to reduce mortality. Note, a lockdown implies a significant reduction in utility across all occupations, but succeeds in saving lives.

Overall, the results of our SIR-macro model provide possible insights for policymakers on what groups are specially vulnerable in pandemic times, and adds to the existing literature on the distributional aspects of pandemics.

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Appendices

Appendix A Computing the competitive equilibrium

In this section we direct some of the mathematical properties of the variables used through the study.

U^s and U^i

Comments: At each time t, agents update the set of beliefs with regards to the lifetime utilities of remaining susceptible or infected. Agents are assumed to have lagging expectations and believe that being susceptible during future pandemic periods will be identical to being susceptible last period $u^S(c_{t-1}^{reg}, c_{t-1}^{soc})$. Further, agents expect to receive 0 units of exogenous utility per week as infected, and expect future weeks as recovered during the pandemic to be identical to being recovered last period $u^R(c_{t-1}^{reg}, c_{t-1}^{soc})$. The T stipulates the horizon of the beliefs, i.e., how long an arbitrary agent believe that the epidemiological process will proceed. T is assumed to be constant throughout the pandemic: an agent has a constant belief of amount the remaining weeks of pandemic. The $u^*(c^{reg}, c^{soc})$ is the pre pandemic steady state period utility where $p_s^* = p_r^* = w^* = 1$ and $h^{WFH} = 0$. Note, since the agent knows infection levels of today, they do not need to use last period's τ straight off as an expectation of future τ-values, but can instead adjust it for the infection levels of today. Lastly, all expectations are, for obvious reasons, occupation specific.

$$\begin{aligned}
U_{t+1}^s = &\sum_{q=1}^{T} \beta^i * (1-\tau)^{q-1} * \left(u^S(c_{t-1}^{reg}, c_{t-1}^{soc})\right) \\
&+ \sum_{l=2}^{T-2} (1-\tau)^{l-2} * \tau * \left(\beta^l \Xi + \beta^{l+1}\Xi + \pi_r * \sum_{k=l+2}^{T} *\beta^k * u^R(c^{reg}, c^{soc})\right) \\
&+ (1-\tau)^{T-3} * \tau * (\beta^{T-1}\Xi + \beta^T \Xi) \\
&+ (1-\tau)^{T-2} * \tau * (\beta^T \Xi) \\
&+ \frac{\beta^{T+1}}{1-\beta} * \left((1-\tau_t)^{T-1} + (1-\tau)^{T-2} * \tau + \sum_{x=2}^{T-1} (1-\tau)^{x-2} * \tau * \pi^r\right) u^*(c^{reg}, c^{soc})
\end{aligned}$$

$$U_{t+1}^i = \beta\Xi + \beta^2\Xi + \pi^r \sum_{m=3}^{T} \beta^m \left(u^R(c^{reg}, c^{soc})\right) + \pi^r * \frac{\beta^{T+1}}{1-\beta}\left(u^*(c^{reg}, c^{soc})\right)$$

Appendix B Robustness checks

Table 6: Sensitivity analysis of the SIR-macro model

	Reg. output[a]	Soc. output[b]	Inf. rate %[c]	Mort. rate %[d]	SWE deaths[e]
Share of virus transmission from social consumption, work on-site, general contact					
1/12, 1/12, 5/6	0.2230	-0.4803	8.39	0.29	18555
1/6, 1/6, 2/3 (baseline)	0.5542	-0.7612	6.84	0.27	17026
1/3, 1/3, 1/3	1.1601	-1.2286	3.85	0.21	13692
Agent's beliefs about the pandemic horizon, T					
8 (baseline)	0.5542	-0.7612	6.84	0.27	17026
26	0.4154	-0.3643	7.87	0.28	18067
52	0.0887	-0.2896	8.59	0.29	18772
Case fatality rate, π_d					
0.004	0.4533	-0.6839	7.08	0.22	13794
0.005 (baseline)	0.5542	-0.7612	6.84	0.27	17026
0.011	0.8826	-1.3000	5.82	0.55	35097
Present bias in consumption, β					
$0.96^{\frac{1}{52}}$ (baseline)	0.5542	-0.7612	6.84	0.27	17026
$0.94^{\frac{1}{52}}$	0.5214	-0.4981	7.31	0.27	17496
Expected utility as infected, Ξ					
-11.9814	0.6710	-0.8494	6.59	0.26	16781
0 (baseline)	0.5542	-0.7612	6.84	0.27	17026
11.9814	0.4206	-0.6705	7.10	0.27	17271
Fraction of infected that are asymptomatic					
0.7	0.6272	-0.5181	3.46	0.20	12809
0.8 (baseline)	0.5542	-0.7612	6.84	0.27	17026
0.9	0.5124	-0.8086	10.81	0.32	20357
Productivity parameters, $z^{\nu,\xi}$					
$z^{\nu,\xi}/10$	0.5870	-0.4184	7.35	0.27	17560
$z^{\nu,\xi}$ (baseline)	0.5542	-0.7612	6.84	0.27	17026
$z^{\nu,\xi} * 10$	0.7264	-0.8841	6.49	0.26	16670

[a] Reg. output is defined as the aggregated deviation in regular output, between the pandemic period and its non-pandemic counterpart, in terms of one pre-pandemic month's worth of regular output.
[b] Reg. output is defined as the aggregated deviation in regular output, between the pandemic period and its non-pandemic counterpart, in terms of one pre-pandemic month's worth of regular output.
[c] The infection rate is defined as the peak infection rate, relative to the initial population.
[d] The mortality rate is defined as the fraction of deceased agents compared to the initial population size.
[e] SWE deaths is the corresponding rate of deceased relative the mortality rate. The population size is assumed to be approximately 6.4 million.

Table 7: Sensitivity analysis of the SIR-macro model w.r.t. $\mathcal{R}_0$

Pop. inf. %[a]	$\mathcal{R}_0$	Reg. output[b]	Soc. output[c]	Inf. rate %[d]	Peak week[e]	Mort. rate %[f]
50	1.3654	0.5461	-0.6818	4.51	25	0.22
60 (baseline)	1.4910	0.5542	-0.7612	6.84	21	0.27
70	1.6541	0.6012	-0.7268	10.32	18	0.31
80	1.8822	0.5271	-0.7087	15.81	16	0.37

[a] Pop. inf. is the assumed fraction of the population that will contract the virus, given zero measures to mitigate the spread. The baseline value corresponds to the Angela Merkel scenario.
[b] Reg. output is defined as the aggregated deviation in regular output, between the pandemic period and its non-pandemic counterpart, in terms of one pre-pandemic month's worth of regular output.
[c] Soc. output is defined as the aggregated deviation in social output, between the pandemic period and its non-pandemic counterpart, in terms of one pre-pandemic month's worth of regular output.
[d] The infection rate is defined as the peak infection rate, relative to the initial population.
[e] Peak infection week is defined as the week the infection rate reaches its peak.
[f] The mortality rate is defined as the fraction of deceased agents compared to the initial population size.

Table 8: Sensitivity analysis of the WFH-case w.r.t. utility and mortality

	Reg-flex	Reg-rig	Soc-flex	Soc-rig	SWE deaths
Rigid's WFH as a multiple of current infection rate					
2	0.0346	0.0330	-0.2392	-0.2470	15851
5 (baseline)	-0.0091	-0.0235	-0.2562	-0.2757	14625
8	-0.0370	-0.0638	-0.2651	-0.2963	13851

Note: The utility effect is the total utility effect of the pandemic compared to its non-pandemic counterpart (adjusted for health states), expressed in terms of pre-pandemic monthly utility of each occupation. The loss is based on a length of 80 weeks.SWE deaths is the corresponding rate of deceased relative the mortality rate. The population size that the mortality is based on is approximately 6.4 million.

Table 9: Sensitivity analysis of the baseline lockdown case w.r.t. total utility and mortality

	Reg-flex	Reg-rig	Soc-flex	Soc-rig	SWE deaths
Lockdown turn-on infection rate %					
1	-0.1800	-0.2542	-0.4376	-0.5167	15972
2 (baseline)	-0.1798	-0.2514	-0.4159	-0.4914	15073
4	-0.1846	-0.2488	-0.3809	-0.4484	13413
Lockdown length, weeks					
8	-0.0947	-0.1412	-0.3494	-0.4007	15756
12 (baseline)	-0.1798	-0.2514	-0.4159	-0.4914	15073
16	-0.2504	-0.3460	-0.4716	-0.5703	14570

Note: The utility effect is the total utility effect of the pandemic compared to its non-pandemic counterpart (adjusted for health states), expressed in terms of pre-pandemic monthly utility of each occupation. The utility loss is based on a horizon of 80 weeks. SWE deaths is the corresponding rate of deceased relative the mortality rate. The population size that the mortality is based on is approximately 6.4 million.

Appendix C Descriptive data on SNI 2007-industries

Table 10: The set of parameters of the heterogeneous agents [extended]

Industries					Sector		Occ.			Salary	
SNI 2007		Definition	Empl.[a]	Empl. (%)	Reg.	Soc.	Rig.	Flex.	Ω^b	Basic[c]	Month[d]
A	01-03	Agriculture, forestry, fishing, and hunting	34.7	1	✓		✓		0.08	27500	28200
B-E	05-33+35-39	Mining and quarrying; Manufacturing; Electricity, gas, steam and air conditioning supply; Water supply and sanitation	541.9	12	✓		✓		0.29	36175	38225
F	41-43	Construction	274	6	✓		✓		0.19	34500	35500
G	45-47	Wholesale trade and reparation	509.8	11	✓	✓	✓	✓	0.33	31400	34100
H	49-53	Transportation and storage	223.5	5	✓	✓	✓		0.19	29800	31300
I	55-56	Accommodation and food service activities	148.9	3		✓	✓		0.04	24900	26100
J	58-63	Information and communication	205.9	5	✓			✓	0.72	44200	45100
K-N	64-82	Financial and insurance activities; Real estate activities; Professional, scientific and technical activities; Administrative and support service activities	729.9	16	✓			✓	0.54	38680	39760
O+U	84+99	Public administration	365.8	8	✓	✓	✓	✓	0.41	36400	37000
P	85	Education	570.3	13		✓		✓	0.83	31700	31800
Q	86-88	Human health and social work activities	740.8	16		✓	✓		0.25	29700	31800
R-T	90-98	Arts, entertainment and recreation; Other service activities; Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	215	5		✓	✓		0.31	30400	31000

[a] Employment is the as the sum of full-time (FTE) workers and part-time worker (PTE) in Sweden year 2018. FTE workers are defined as individuals with a permanent employment. PTE worker are defined as individuals with temporary employment, employment support, seasonal work, probationary employment, object employment, project employment or any other form of fixed-term employment.

[b] The omega parameter proxies as the share of jobs within an industry that can be performed working from home (see the unweighted column in Table 3: Share of jobs that can be done at home, by industry (Dingel and Neiman (2020a), p.8).

[c] The basic salary is defined as the average earnings in SEK paid on a regular basis prior to additions and/or deductions year 2018. The estimates are retrieved from Statistics Sweden: Swedish National Mediation Office.

[d] The monthly salary is defined in SEK and is based on reports from 2018.The estimates are retrieved from Statistics Sweden: Swedish National Mediation Office.

Appendix D WFH scenarios

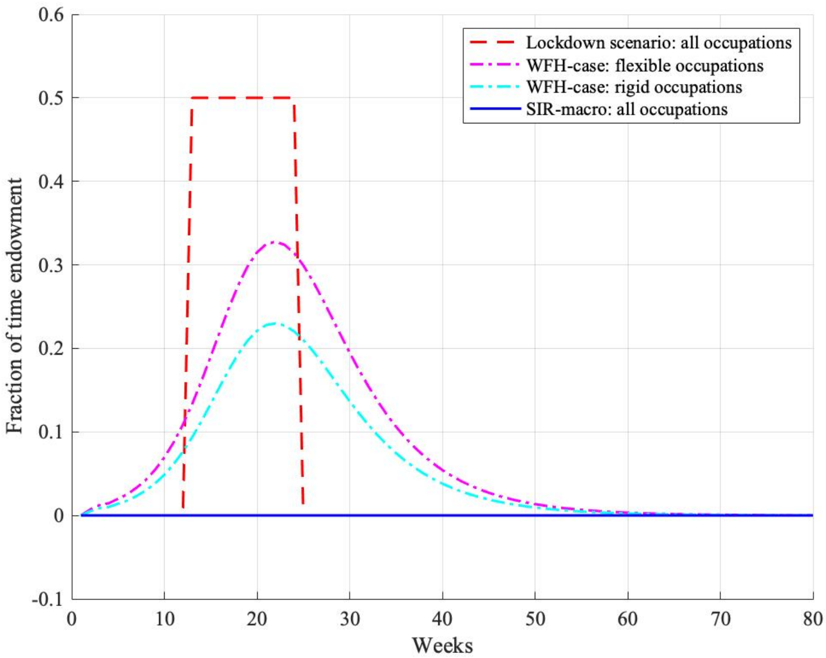

Figure 12: WFH sequence as specified by WFH-case, lockdown scenario, and SIR-macro model