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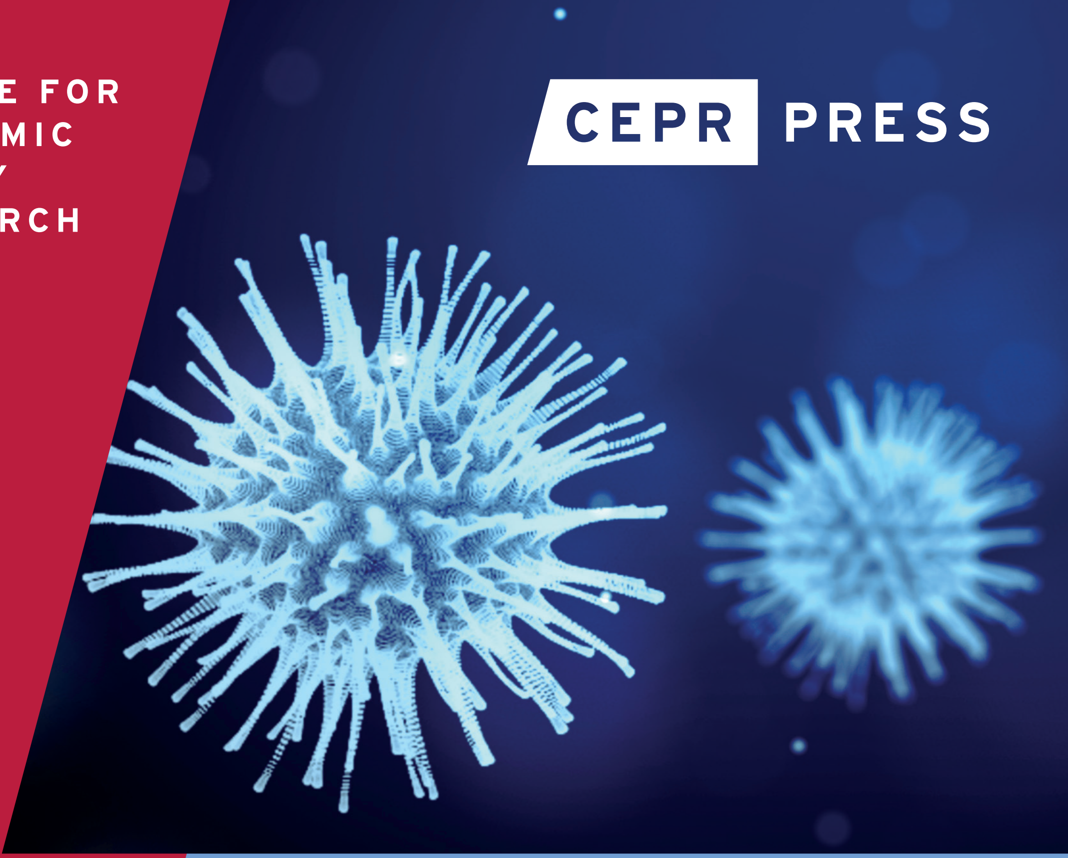

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VETTED AND REAL-TIME PAPERS

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Bringing back the jobs lost to Covid-19: The role of fiscal policy

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Covid-19 induced job losses occurred predominantly in industries with intensive worker-client interaction as well as in pink-collar and blue-collar occupations. We study the ability of fiscal policy to stabilize employment by occupation and industry during the Covid-19 crisis. We use a multi-sector, multi-occupation macroeconomic model and investigate different fiscal policy instruments that help the economy recover faster. We show that fiscal stimuli foster job growth for hard-hit pink-collar workers, whereas stimulating blue-collar job creation is more challenging. A cut in labor taxes performs best in stabilizing total employment and the employment composition.

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1 Introduction

Job losses in the Covid-19 recession stand out in comparison to those in other recessions in two ways. First, the Covid-19 downturn is enormous and is unfolding at unprecedented speed. From February to April 2020, the monthly average of total private employment fell by more than 20 million jobs, and the unemployment rate skyrocketed from 3.5% to 14.7%.[1] Second, it is an unusual mix of workers who are struck by job losses. In a typical recession, job losses are concentrated in construction and manufacturing industries and in blue-collar occupations (Hoynes, Miller, and Schaller 2012). This time, job losses have occurred to a great extent in sectors with a high intensity of worker-client interaction. Between February and April 2020, over 10 million jobs have been lost in "retail trade" and "leisure and hospitality" industries alone. The most affected major occupation group is service occupations with an employment drop of one third from February to April 2020. In general, so-called pink-collar workers (workers in sales and service occupations) have suffered most, followed by blue-collar workers.[2] The latter suffered from heavy job losses, too, as in any downturn. In contrast, white-collar workers were affected relatively mildly.[3]

While there is no role for aggregate demand management as long as public-health measures bring down the economy's potential output, aggregate demand management is relevant when restrictions are relaxed such that potential output can return toward its pre-crisis level. Then, a fiscal stimulus can be a tool to accelerate the recovery of actual output and employment. When this time has come, economic policy should not only concentrate on pushing up the total number of jobs but should also be concerned with the industry mix and –in particular– the occupation mix of employment to avoid excessive losses of industry-specific and occupation-specific human capital. Kambourov and Manovskii (2009) show that displaced workers' future earnings losses are three times larger when they are unable to find a job in their initial occupation. The costs of switching occupations are estimated to be as high as several annual earnings for switches between major

[1] Due to pandemic-related classification problems in the CPS, the released BLS employment statistics are likely even to understate the severity of the downturn, and the April unemployment rate could be closer to 20%, see `https://www.bls.gov/news.release/archives/empsit_05082020.htm`. Preliminary data for May 2020 show first indications of a beginning rebound on the labor market.

[2] Some commentators referred to the Covid-19 recession as a "pink-collar recession" (Celina Ribeiro in The Guardian, May 23, 2020; Nancy Wang on Forbes, May 24, 2020). Due to the high share of women in pink-collar occupations and sectors with a high intensity of worker-client interaction, Covid-induced job losses for women have been much higher than during typical recessions (Alon, Doepke, Olmstead-Rumsey, and Tertilt 2020).

[3] See Adams-Prassl, Boneva, Golin, and Rauh (2020) for real-time data on Covid-19 related job losses by worker characteristics including industry and occupation.

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occupation groups (see Artuç and McLaren, 2015, and Cortes and Gallipoli, 2018). Moreover, the returns to occupational tenure are found to be almost as large as the total returns to labor-market experience and to exceed the returns to firm or industry tenure, see, e.g., Shaw (1984), Kambourov and Manovskii (2009), and Sullivan (2010). This evidence suggests that stabilization policy can reduce the economic costs of the Covid-19 pandemic if, during the recovery, fiscal policy promotes job creation in the occupation groups hit hardest by the crisis. In this paper, we conduct a model-based analysis of the effectiveness of different fiscal-policy measures in pursuing this goal.

To clarify the scope of our analysis, it is helpful to apply Olivier Blanchard's taxonomy of the roles of fiscal policy in the Covid-19 crisis.[4] According to Blanchard, the first role of fiscal policy is infection-fighting, i.e., to spend much on testing and create incentives for firms to produce necessary medical equipment. The second role is disaster relief, i.e., to provide transfers and loans to liquidity-constrained households and firms in order to avoid excessive hardship and bankruptcies. The third role is aggregate demand management when infections are under control, and restrictions can be relaxed. We focus on the third role (aggregate demand management) and, to isolate this role, we assume that policy is or has been successful in the first two roles. Our model has no interaction between infections and economic activity (i.e., infections are under control in the model) and abstracts from consumption heterogeneity or bankruptcies (i.e., disaster relief is successful in the model).[5]

To study the effects of fiscal-policy stimulus in the Covid-19 recovery, we use a multi-sector, multi-occupation New Keynesian business-cycle model. We distinguish between two large sectors of the economy and three broad occupation groups. Following Kaplan, Moll, and Violante (2020), we differentiate between a "social" sector that comprises industries with high physical proximity between clients and workers, such as retail trade and hospitality, and a "distant" sector where less face-to-face contact is required. Our broad occupation groups are, first, white-collar occupations such as management, professional, and office occupations, second, blue-collar occupations such as production or construction occupations, and, third, service and sales ("pink-collar") occupations.

[4] See, for example, Olivier Blanchard: Designing the fiscal response to the Covid-19 pandemic. `https://www.piie.com/blogs/realtime-economic-issues-watch/designing-fiscal-response-covid-19-pandemic`

[5] For model-based analyses of the interaction between infections and economic activity, see, for example, Acemoglu, Chernozhukov, Werning, and Whinston (2020), Eichenbaum, Rebelo, and Trabandt (2020), and Krueger, Uhlig, and Xie (2020).

Our model generates heterogeneity in occupational employment dynamics as a consequence of i) a composition effect due to heterogeneous employment changes across sectors with different average occupation mixes and ii) changes in the occupation mix within sectors due to differences in the substitutability with capital services across occupations (similar to Autor and Dorn 2013 and Bredemeier, Juessen, and Winkler 2020). In particular, labor provided by blue-collar occupations is, on average, more easily substitutable with capital than labor provided by white-collar and pink-collar occupations.

We calibrate the model to the U.S. economy and expose it to a "Covid-19 shock" that generates employment losses by industry and occupation, as seen in spring 2020. Hence, employment falls particularly sharply in the social sector as well as in blue-collar and pink-collar occupations. We then perform the following policy experiments: Nine months after the Covid-19 shock hits the economy, expansionary fiscal policy supports its recovery. We consider a variety of fiscal stimuli, both spending-based and tax-based. We further differentiate between spending packages that differ in how strongly they are directed toward a specific sector as well as between capital and labor income tax cuts.

Our results show that, in general, expansionary fiscal-policy measures promote employment growth disproportionately in the social sector and in pink-collar occupations, which counteracts the substantial losses these groups experience due to the Covid-19 crisis. By contrast, most fiscal stimulus measures exert only a low push on blue-collar employment and are hence ineffective in promoting the recovery for this group of workers. Comparing the different fiscal stimulus measures, our results show that directing spending strongly toward one of the sectors does not impact too strongly on the composition of the created jobs due to counteracting changes in the sectoral composition of private demand and the occupation mix within sectors. Even a spending expansion directed strongly toward the distant sector fosters blue-collar employment the least. The measure that quickens the recovery in blue-collar work most strongly and, in general, achieves the most significant stabilization of the occupation composition after the imminent Covid-19 crisis is a cut in tax rates on labor income.

Our paper contributes to the literature on fiscal policy during the Covid-19 crisis. Bayer, Born, Luetticke, and Müller (2020) quantify the effectiveness of disaster relief in limiting the economic

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fallout from the Covid-19 pandemic by computing multipliers for the transfer component of the CARES Act in an estimated heterogenous-agents New Keynesian model. Likewise, Faria-e-Castro (2020) uses a two-agent New Keynesian model to compute the effectiveness of different types of fiscal policy instruments in cushioning the immediate effects of the Covid-19 shock, including a quantification of the impact of the CARES Act. Our paper complements these works in that it analyzes the impact of different fiscal instruments that support aggregate demand once potential output returns toward its pre-crisis level. Moreover, our focus is on how fiscal policy affects employment possibilities of workers, which are, in no small degree, determined by the labor-market situation in the worker's industry and occupation. Bredemeier, Juessen, and Winkler (2020) provide evidence of differences in the impact of government spending shocks on pink-collar relative to blue-collar employment and develop a business-cycle model that can explain these heterogeneous occupational employment dynamics. This paper extends our previous work in two important dimensions. First, we investigate the effects of a variety of fiscal policy instruments – different spending-based programs as well as cuts in labor and capital taxes. Second, we conduct a model-based analysis of potential fiscal policy measures in the recovery after a Covid-19 shock, which we calibrate to mimic the labor market during the Covid-19 crisis.[6]

The remainder of this paper is organized as follows. In Section 2, we present the model, its calibration, and how we model the Covid-19 crisis. In Section 3, we present results on the impacts of a variety of fiscal stimulus measures, which are aimed at helping the economy recover, on employment by occupation and sector. Section 4 concludes.

2 Model

We consider a two-sector economy consisting of firms, households, and the government. We will calibrate the model such that there is a "social" sector and a "distant" sector, following the classification by Kaplan, Moll, and Violante (2020). Firms in each sector produce differentiated goods under monopolistic competition and face costs of price adjustment. Production inputs are capital services and three types of occupational labor – pink-collar, blue-collar, and white-collar

[6] In general, our paper is related to the literature on the distributional consequences of fiscal policy, see, amongst others, Anderson, Inoue, and Rossi (2016), Giavazzi and McMahon (2012), Johnson, Parker, and Souleles (2006), Misra and Surico (2014), Brinca, Holter, Krusell, and Malafry (2016), Kaplan and Violante (2014), and McKay and Reis (2016).

labor. The output of each sector is used for investment, consumption, and government spending. Households are families whose members differ by occupation and can work in either sector. The government consists of a monetary and a fiscal authority. The monetary authority sets the short-term nominal interest rate. The fiscal authority collects income taxes, issues short-term government bonds, pays transfers, and purchases goods from both sectors for government consumption.

Before we describe the model in detail, we highlight the decisive factors through which the model can generate heterogeneity in the responses of employment to economic shocks. First, sectors can be affected differently by economic shocks leading to different employment responses across sectors. This leads to heterogeneity in the responses of occupational employment through a *composition effect* as long as the occupation mix of employment differs across sectors. Consider, for example, a demand shock that boosts economic activity mainly in the social sector, which employs a disproportionate share of pink-collar workers (think about a fiscal stimulus targeted directly toward the social sector). For a given occupation mix within sectors, the associated employment boom brings about predominantly pink-collar jobs since pink-collar jobs are concentrated in the social sector. Of course, the strength of this channel depends on how differently sectoral employment responds to the shock. If, in our example, changes in private demand weaken the demand stimulus targeted toward the social sector considerably, employment in the social sector may not increase significantly more strongly than in other sectors.

A second channel that can generate heterogeneity in the employment responses to economic shocks relates to *capital-labor substitution*. In our model, there is a change in the occupation mix of employment within sectors when we allow for differences across occupations in the short-run substitutability between labor and capital services, that is, the stock of physical capital times the intensity with which it is used. In particular, we build on the notion that labor provided by blue-collar occupations is, on average, more easily substitutable with capital services than labor provided by pink-collar and white-collar occupations (similar to Autor and Dorn 2013). To understand how this can lead to changes in the occupation mix of employment, consider a positive shock to aggregate demand again, now affecting both sectors equally. In response to the shock, firms in both sectors demand more factor inputs to meet increased product demand, which puts upward pressure on factor costs. Given the fact that the short-run supply of capital services is

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relatively more elastic compared to the supply of labor, factor costs change in favor of capital use compared to labor. Therefore, firms raise their demand for capital services more than their demand for labor. The disproportionate surge in capital usage lowers the marginal productivity of its closer substitute, blue-collar employment, relative to pink-collar or white-collar employment. Thus, firms change their occupation mix in favor of pink-collar and white-collar work, employing now a higher share of pink-collar workers than before (see Bredemeier, Juessen, and Winkler 2020). Of course, a shock that directly affects the relative costs of labor in a way such that labor becomes cheaper relative to capital (for example, a cut in labor income taxes), will lead to the opposite result. In this case, blue-collar workers will benefit disproportionately as firms substitute away from capital services toward labor.

The occupation mix within a sector has implications for the overall employment effects of fiscal policy within a sector. The less easily labor can be substituted by capital within an industry, the higher will be the job multiplier in the industry. This is the case in the social sector, which employs a disproportionate share of pink-collar workers. By contrast, in industries that employ relatively many blue-collar workers, additional government purchases lead to comparatively moderate employment boosts as firms in such sectors meet the increased demand by raising their use of capital services predominantly.

We expose our model economy to a Covid-19 shock. Following Eichenbaum, Rebelo, and Trabandt (2020), we use stochastic wedges to construct a Covid-19 scenario that matches empirical job losses by sector and occupation group in spring 2020. The wedges combine aspects of both supply and demand disturbances, in line with the evidence by Brinca, Duarte, and Faria-e-Castro (2020). In particular, we incorporate stochastic wedges between producer prices and the total consumer cost of a good as well as between firms' labor costs and workers' effective net labor income. The price wedge in the social sector can be interpreted as the additional cost associated with trading this sector's output in times of social distancing. The labor market wedges can be interpreted as the extra cost required to provide labor services during the pandemic. These costs are plausibly heterogeneous across occupations since occupations differ considerably in terms of work-from-home possibilities (see, e.g., Dingel and Neiman 2020).

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2.1 Model description

Households. There is a continuum of infinitely-lived households, with mass normalized to one. Each household supplies pink-collar, blue-collar, and white-collar labor to both sectors. Household members are not allowed to switch their occupation, in line with empirical evidence that occupation switches are associated with substantial costs (see, e.g., Kambourov and Manovskii, 2009, Artuç and McLaren, 2015, Cortes and Gallipoli, 2018) and occur rarely (see, e.g., Moscarini and Thomsson, 2007, Fujita and Moscarini, 2013, Foote and Ryan, 2014). We assume a unitary household that cares about its total consumption level of a composite good (consisting of goods of both sectors) and receives disutility from all types of labor – pink-collar labor, n_t^p, blue-collar labor, n_t^b, and white-collar labor, n_t^w. With this modeling assumption, our analysis should be understood as a positive analysis. At the same time, our model is not supposed to allow a normative analysis of the distributional effects of stabilization policy.

Each household maximizes lifetime utility

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t, n_t^p, n_t^b, n_t^w), \tag{1}$$

where $\beta \in (0,1)$ is the households' discount factor and c_t is consumption of a composite good, defined as an aggregate of consumption of the sector-1 good, $c_{1,t}$, and consumption of the sector-2 good, $c_{2,t}$, with substitution elasticity $\mu > 0$,

$$c_t = \left(\zeta^{\frac{1}{\mu}} \cdot (c_{1,t})^{\frac{\mu-1}{\mu}} + (1-\zeta)^{\frac{1}{\mu}} \cdot (c_{2,t})^{\frac{\mu-1}{\mu}} \right)^{\frac{\mu}{\mu-1}} . \tag{2}$$

Given a decision on the composite consumption good c_t, the household allocates optimally the expenditure on consumption of good 1 and good 2 by minimizing total expenditures $(1+\wedge_{1,t})p_{1,t}c_{1,t} + (1+\wedge_{2,t})p_{2,t}c_{2,t}$, subject to (2), where $p_{1,t}$ and $p_{2,t}$ are the prices of the sectoral goods and $\wedge_{1,t}$ and $\wedge_{2,t}$ are good-specific wedges that follow exogenous stochastic processes with mean zero. These wedges, among other wedges discussed below, allow us to capture the Covid-19 downturn in our model. In particular, the Covid-induced sector-specific collapses in demand will be triggered by sector-specific increases in the price wedges.

Following Horvath (2000), we assume that members of each household supply labor to firms in

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both sectors according to

$$n_t^o = \left((\aleph^o)^{-\frac{1}{\omega}} \cdot \left(n_{1,t}^o\right)^{\frac{1+\omega}{\omega}} + (1-\aleph^o)^{-\frac{1}{\omega}} \cdot \left(n_{2,t}^o\right)^{\frac{1+\omega}{\omega}} \right)^{\frac{\omega}{1+\omega}}, \quad \text{for} \quad o = p, b, w. \tag{3}$$

The parameter $\omega > 0$ controls the degree of labor mobility across sectors. For $\omega \to \infty$, labor can be freely reallocated and all sectors pay the same hourly wage at the margin. For $\omega < \infty$ there is a limited degree of sectoral labor mobility and sectoral wages are not equalized. Given a decision on n_t^p, n_t^b, and n_t^w the household allocates optimally the supply of labor to sectors 1 and 2 by maximizing, for $o = p, b, w$, real wage income $(1 - \wedge_t^o)\left(w_{1,t}^o n_{1,t}^o + w_{2,t}^o n_{2,t}^o\right)$, subject to (3), where $w_{1,t}^o$ and $w_{2,t}^o$ are sector-specific real wages for white-collar, blue-collar, and pink-collar labor. The term $\wedge_t^o$ is an occupation-specific wedge that follows an exogenous stochastic process with mean zero. In our model, the Covid-induced occupation-specific employment losses will be matched by changes in occupation-specific labor wedges.

Following Jaimovich and Rebelo (2009), the period utility function $u(c_t, n_t^p, n_t^b, n_t^w)$ takes a form that allows to parameterize the wealth effect on labor supply:

$$\frac{\left(c_t - \left(\frac{\Omega^p}{1+1/\eta}(n_t^p)^{1+1/\eta} + \frac{\Omega^b}{1+1/\eta}(n_t^b)^{1+1/\eta} + \frac{\Omega^w}{1+1/\eta}(n_t^w)^{1+1/\eta}\right) x_t\right)^{1-1/\sigma} - 1}{1 - 1/\sigma}, \tag{4}$$

where $\sigma > 0$ is the intertemporal elasticity of substitution in consumption, $\Omega^p > 0$, $\Omega^b > 0$, and $\Omega^w > 0$ are scale parameters, x_t is a weighted average of current and past consumption evolving over time according to

$$x_t = c_t^{\chi} x_{t-1}^{1-\chi}, \tag{5}$$

$\chi \in (0, 1]$ governs the wealth elasticity of labor supply, and $\eta > 0$ is the Frisch elasticity of labor supply in the limiting case $\chi \to 0$. In this case, there is no wealth effect on labor supply and preferences are of the type considered by Greenwood, Hercowitz, and Huffman (1988).

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The household's period-by-period budget constraint (in real terms) is given by

$$\begin{aligned} c_t + \frac{(1+\wedge_{1,t})p_{1,t}}{p_t} i_{1,t} + \frac{(1+\wedge_{2,t})p_{2,t}}{p_t} i_{2,t} + b_t = \\ (1+r_{t-1})\frac{b_{t-1}}{\pi_t} + (1-\tau_t^k)\left(r_{1,t}^k \tilde{k}_{1,t} + r_{2,t}^k \tilde{k}_{2,t}\right) + T_t + d_t \\ + (1-\tau_t^n)\left[w_t^p n_t^p + w_t^b n_t^b + w_t^w n_t^w\right] \\ - \frac{(1+\wedge_{1,t})p_{1,t}}{p_t} e(u_{1,t}) k_{1,t-1} - \frac{(1+\wedge_{2,t})p_{2,t}}{p_t} e(u_{2,t}) k_{2,t-1}\,, \end{aligned} \tag{6}$$

where $p_t = \left(\zeta \cdot [(1+\wedge_{1,t})p_{1,t}]^{1-\mu} + (1-\zeta)\cdot[(1+\wedge_{2,t})p_{2,t}]^{1-\mu}\right)^{1/(1-\mu)}$ is the price of the composite good c_t, $i_{s,t}$ is investment into physical capital in sector s (where $s = 1, 2$), b_{t-1} is the beginning-of-period stock of real government bonds, τ_t^n is the labor tax rate, τ_t^k is the capital tax rate, $\tilde{k}_{s,t}$ are capital services in sector s, $r_{s,t}^k$ is the sector-specific rental rate of capital services, $k_{s,t-1}$ denotes the beginning-of-period capital stock in sector s, $u_{s,t}$ is capital utilization in sector s, $e(u_{s,t})$ are the costs of capital utilization in sector s, T_t are government transfers, $d_t = d_{1,t}+d_{2,t}$ are dividends from the ownership of firms in both sectors, r_t is the nominal interest rate, $\pi_t = p_t/p_{t-1}$ is consumer price inflation, and $w_t^o = \left(\aleph^o \cdot ((1-\wedge_t^o)w_{1,t}^o)^{1+\omega} + (1-\aleph^o)\cdot((1-\wedge_t^o)w_{2,t}^o)^{1+\omega}\right)^{1/(1+\omega)}$ is the aggregate real wage for occupation $o = p, b, w$.

Following Ramey and Shapiro (1998), we assume that capital goods for a particular sector must be produced within that sector. Thus, the capital stock in each sector evolves according to

$$k_{s,t} = (1-\delta)k_{s,t-1} + \left(1 - \frac{\kappa_i}{2}\left(\frac{i_{s,t}}{i_{s,t-1}} - 1\right)^2\right) i_{s,t}\,, \quad s = 1, 2\,, \tag{7}$$

where $\delta \in (0,1)$ is the capital depreciation rate and $\frac{\kappa_i}{2}\left(i_{s,t}/i_{s,t-1} - 1\right)^2$ represents investment adjustment costs with $\kappa_i \geq 0$.

Households choose capital utilization rates $u_{s,t}$, which transform physical capital in sector s into capital services $\tilde{k}_{s,t}$ according to $\tilde{k}_{s,t} = u_{s,t}k_{s,t-1}$. Costs of capital utilization are given by

$$e(u_{s,t}) = \delta_1(u_{s,t}-1) + \frac{\delta_2}{2}(u_{s,t}-1)^2\,, \quad s = 1, 2\,,$$

which implies the absence of capital utilization costs at the deterministic steady state in which capital utilization is normalized to $u_s = 1$. The elasticity of capital utilization with respect to the rental rate of capital, evaluated at the steady state, is given by $\Delta = \delta_1/\delta_2 > 0$. As capital is

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predetermined, Δ corresponds to the short-run elasticity of the supply of capital services.

Households choose quantities (c_t, x_t, b_t, $k_{s,t}$, $i_{s,t}$, $u_{s,t}$, n_t^b, n_t^p, and n_t^w), taking as given the set of prices (w_t^p, w_t^b, w_t^w, p_t, $p_{s,t}$, $r_{s,t}^k$, and r_t), dividends (d_t), transfers (T_t), taxes (τ_t^n, τ_t^k), and wedges ($\wedge_{s,t}$, $\wedge_t^b$, $\wedge_t^p$, $\wedge_t^w$) to maximize (1) subject to (5), (6) and (7). First-order conditions can be found in the Appendix.

Firms. Each sector $s = 1, 2$ produces a final good and a continuum of intermediate goods indexed by j, where j is distributed over the unit interval. Each intermediate good is produced by a single firm. There is monopolistic competition in the markets for intermediate goods. Final goods firms in each sector use intermediate goods $y_{j,s,t}$, taking as given their price $p_{j,s,t}$, and sell the output $y_{s,t}$, at the competitive price $p_{s,t}$. The production function of the sector-s final good is $y_{s,t} = \left(\int_0^1 y_{j,s,t}^{(\epsilon-1)/\epsilon} di\right)^{\epsilon/(\epsilon-1)}$, where $\epsilon > 1$ is the elasticity of substitution between different varieties.

Firm j in sector s produces its output $y_{j,s,t}$ using capital services $\tilde{k}_{j,s,t}$, three types of labor, blue-collar labor $n_{j,s,t}^b$, pink-collar labor $n_{j,s,t}^p$, and white-collar labor $n_{j,s,t}^w$, and the following nested normalized CES production technology:

$$y_{j,s,t} = y_{j,s} \cdot \left(\upsilon_s \cdot \left(\frac{\upsilon_{j,s,t}^p}{\upsilon_{j,s}^p} \right)^{\frac{\iota-1}{\iota}} + (1-\upsilon_s) \cdot \left(\frac{n_{j,s,t}^w}{n_{j,s}^w} \right)^{\frac{\iota-1}{\iota}} \right)^{\frac{\iota}{\iota-1}}, \tag{8}$$

where $\upsilon_{j,s,t}^p$ is a normalized CES bundle of $\upsilon_{j,s,t}^b$ and pink-collar labor, given by

$$\upsilon_{j,s,t}^p = \upsilon_{j,s}^p \cdot \left(\alpha_s \cdot \left(\frac{\upsilon_{j,s,t}^b}{\upsilon_{j,s}^b} \right)^{\frac{\theta-1}{\theta}} + (1-\alpha_s) \cdot \left(\frac{n_{j,s,t}^p}{n_{j,s}^p} \right)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}},$$

where $\upsilon_{j,s,t}^b$ is, in turn, a normalized CES bundle of capital services and blue-collar labor:

$$\upsilon_{j,s,t}^b = \upsilon_{j,s}^b \cdot \left(\gamma_s \cdot \left(\frac{\tilde{k}_{j,s,t}}{\tilde{k}_{j,s}} \right)^{\frac{\phi-1}{\phi}} + (1-\gamma_s) \cdot \left(\frac{n_{j,s,t}^b}{n_{j,s}^b} \right)^{\frac{\phi-1}{\phi}} \right)^{\frac{\phi}{\phi-1}}.$$

The parameter $\phi > 0$ captures the elasticity of substitution between capital services and labor in the representative blue-collar occupation, the parameter $\theta > 0$ captures the elasticity of substitution between capital services and labor in the representative pink-collar occupation, and the parameter ι captures the elasticity of substitution between capital services and labor in the representative white-collar occupation. The parameters $\upsilon_s \in (0, 1)$, $\alpha_s \in (0, 1)$, and $\gamma_s \in (0, 1)$ reflect factor intensities in

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production. The normalization of the CES production technology allows to disentangle the factor intensities υ_s, α_s, and γ_s from the elasticities of substitution ι, ϕ, and θ (see, e.g., León-Ledesma, McAdam, and Willman 2010).

The firm chooses $\tilde{k}_{j,s,t}$, $n^w_{j,s,t}$, $n^b_{j,s,t}$, and $n^p_{j,s,t}$ to minimize its costs (deflated by the consumer price index p_t)

$$\begin{aligned} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \{ \; & w^b_{s,t} n^b_{j,s,t} + w^p_{s,t} n^p_{j,s,t} + w^w_{s,t} n^w_{j,s,t} + r^k_{s,t} \tilde{k}_{j,s,t} \\ & + \frac{\kappa_{n,s}}{2} \left[\left(\frac{n^w_{j,s,t}}{n^w_{j,s,t-1}} - 1 \right)^2 + \left(\frac{n^b_{j,s,t}}{n^b_{j,s,t-1}} - 1 \right)^2 + \left(\frac{n^p_{j,s,t}}{n^p_{j,s,t-1}} - 1 \right)^2 \right] \frac{(1+\wedge_{s,t}) p_{s,t}}{p_t} y_{s,t} \Bigg\} , \end{aligned} \tag{9}$$

subject to (8), where $\frac{\kappa_{n,s}}{2} \left(n^o_{j,s,t} / n^o_{j,s,t-1} - 1 \right)^2$ are quadratic labor adjustment costs for occupation $o = w, p, b$, expressed in units of the final consumption good, where the sector-specific parameter $\kappa_{n,s} \geq 0$ measures the extent of labor adjustment costs in the respective sector. The firm takes factor prices as given. The term $\beta^t \lambda_t / \lambda_0$ denotes the stochastic discount factor for real payoffs, where λ_t is the marginal utility of real income of the representative household that owns the firm.

The firm faces a quadratic cost of price adjustment. It chooses its price $p_{j,s,t}$ to maximize the discounted stream of profits, expressed in units of the final consumption good,

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left(\frac{p_{j,s,t}}{p_t} \cdot y_{j,s,t} - mc_{j,s,t} \cdot y_{j,s,t} - \frac{\psi}{2} \left(\frac{p_{j,s,t}}{p_{j,s,t-1}} - 1 \right)^2 \frac{(1+\wedge_{s,t}) p_{s,t}}{p_t} y_{s,t} \right), \tag{10}$$

subject to the demand function for variety j, $y_{j,s,t} = \left(p_{j,s,t} / p_{s,t} \right)^{-\epsilon} y_{s,t}$, where $y_{s,t}$ is aggregate demand for the good of sector s, $p_{j,s,t}/p_{s,t}$ is the relative price of variety j within the sector, and $p_{s,t} = \left(\int_0^1 p^{1-\epsilon}_{j,s,t} di \right)^{1/(1-\epsilon)}$ is the price index of sector s. $mc_{j,s,t}$ denotes real marginal costs. The final term in (10) represents the costs of price adjustment, where $\psi \geq 0$ measures the degree of nominal price rigidity. Firms' first-order conditions can be found in the Appendix.

Market clearing, monetary and fiscal policy. The fiscal authority finances transfers and an exogenous stream of government spending g_t by labor and capital taxes. The government consumption bundle comprises goods 1 and 2 in a similar way than that of households,

$$g_t = \left(\zeta_g^{\frac{1}{\mu}} \cdot (g_{1,t})^{\frac{\mu-1}{\mu}} + (1-\zeta_g)^{\frac{1}{\mu}} \cdot (g_{2,t})^{\frac{\mu-1}{\mu}} \right)^{\frac{\mu}{\mu-1}} , \tag{11}$$

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where ζ_g determines the steady-state share of good 1 in total government spending while, for simplicity, the elasticity of substitution between the two goods, μ is the same as for households. The government budget constraint (in real terms) reads

$$\frac{p_{g,t}}{p_t}g_t + T_t + (1+r_{t-1})\frac{b_{t-1}}{\pi_t} = b_t + \tau_t^n\left(w_t^b n_t^b + w_t^p n_t^p + w_t^w n_t^w\right) + \tau_t^k\left(r_{1,t}^k \tilde{k}_{1,t} + r_{2,t}^k \tilde{k}_{2,t}\right), \tag{12}$$

where $p_{g,t} = \left(\zeta_g \cdot [(1+\wedge_{1,t})p_{1,t}]^{1-\mu} + (1-\zeta_g)\cdot[(1+\wedge_{2,t})p_{2,t}]^{1-\mu}\right)^{1/(1-\mu)}$ is the price index of government spending and g_t follows an exogenous stochastic process with mean g. For a given g_t, the government determines its purchases of goods 1 and 2 such as to minimize purchasing costs. Tax rates, τ_t^k and τ_t^n, follow exogenous stochastic processes with means τ^k and τ^n. Government spending and tax shocks are contemporaneously financed by adjustments in government debt. In order to guarantee the stability of government debt, transfers follow the rule $\log(T_t) = (1-\rho_T)\log(T) + \rho_T \log(T_{t-1}) - \gamma_b \cdot (b_{t-1} - b)/y$, where the parameter γ_b is positive and sufficiently large.

Monetary policy is described by the augmented Taylor rule

$$\log((1+r_t)/(1+r)) = \delta_\pi \log(\pi_t/\pi) + \delta_y \log(y_t/y) + \delta_g \log(g_t/g), \tag{13}$$

where the parameters $\delta_\pi > 1$ and $\delta_y \geq 0$ measure the responsiveness of the nominal interest rate to consumer price inflation and aggregate output, respectively, where aggregate output, y_t, is defined as $y_t = (p_{1,t}/p_t)y_{1,t} + (p_{2,t}/p_t)y_{2,t}$. Following Nakamura and Steinsson (2014), the nominal interest rate may also directly respond to government spending, with responsiveness measured by δ_g.

Goods market clearing requires aggregate production in sector s, $y_{s,t}$, to be equal to aggregate demand for the sector-s good which includes sector-specific resources needed for capital utilization, price adjustment, labor adjustment, and product and labor wedges:

$$y_{s,t} = (1+\wedge_{s,t})\Bigg(c_{s,t} + i_{s,t} + g_{s,t} + e(u_{s,t})k_{s,t-1} + \frac{\psi}{2}(\pi_{s,t}-1)^2 y_{s,t} + \frac{\kappa_{n,s}}{2}\left[\left(\frac{n_{s,t}^b}{n_{s,t-1}^b}-1\right)^2 + \left(\frac{n_{s,t}^p}{n_{s,t-1}^p}-1\right)^2 + \left(\frac{n_{s,t}^w}{n_{s,t-1}^w}-1\right)^2\right]y_{s,t}\Bigg) + \frac{p_t}{p_{s,t}}\left(\wedge_t^p w_{s,t}^p n_{s,t}^p + \wedge_t^b w_{s,t}^b n_{s,t}^b + \wedge_t^p w_{s,t}^w n_{s,t}^w\right), s = 1, 2. \tag{14}$$

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Data-consistent employment. As the goods-market clearing conditions (14) show, the model economy produces some goods which are then wasted due to the wedges on goods and labor markets ($\wedge_{s,t}$ for $= 1, 2$ and $\wedge_t^o$ for $o = p, b, w$). We define data-consistent employment measures which corrects for the production of goods used to "pay" for the inefficiencies modeled by the wedges. Specifically, data-consistent employment by sector, $l_{s,t}$ ($s = 1, 2$), by occupation, l_t^o ($o = p, b, w$), as well as data-consistent aggregate employment, l_t, are given by

$$l_{s,t} = \frac{1}{1+\wedge_{s,t}} \left(n_{s,t}^p (1 - \wedge_t^p) + n_{s,t}^b (1 - \wedge_t^b) + n_{s,t}^w (1 - \wedge_t^w) \right), \tag{15}$$

$$l_t^o = (1 - \wedge_t^o) \left(\frac{n_{1,t}^o}{1+\wedge_{1,t}} + \frac{n_{2,t}^o}{1+\wedge_{2,t}} \right), \tag{16}$$

and

$$l_t = l_t^w + l_t^b + l_t^p = l_{1,t} + l_{2,t}. \tag{17}$$

2.2 Data, calibration, and the Covid-19 shock

The parametrization is a combination of using empirical estimates for the U.S. from the literature for some parameters and calibrating others. Before we describe the calibration in detail, we first describe the data on industry and occupation used to calibrate the model.

We use Kaplan, Moll, and Violante (2020)'s classification of NAICS industries as either part of the social sector or the distant sector. Table A.1 in the Appendix shows this sectoral classification. The 23 major occupations groups from the 2018 Standard Occupational Classification System are aggregated into the white-collar, blue-collar, and pink-collar occupation groups as shown in Table A.2 in the Appendix.

We use the 2018 BLS industry-occupation matrix to determine the size of our three-occupation groups as well as their distribution over our two sectors. As can be seen in Table 1, the social sector uses pink-collar labor relatively intensively, whereas the distant sector is blue-collar intensive. White-collar employment, by contrast, is almost equally distributed across the two industry groups. We calculate average wages by occupation using the May 2018 National Occupational Employment and Wage Estimates from the Occupational Employment Statistics. Workers in white-collar occupations earn the highest hourly wage rates (approximately \$33), followed by blue-collar workers with an average hourly wage rate of roughly \$23. Workers in pink-collar occupations earn the

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Table 1: Share of aggregate employment in sector-occupation group cells.

	social sector	distant sector	$\sum$
white-collar occupations	23.4%	21.4%	44.7%
blue-collar occupations	6.0%	17.8%	23.8%
pink-collar occupations	26.3%	5.1%	31.4%
$\sum$	55.7%	44.3%	100%

Notes: Results aggregated from the 2018 BLS industry-occupation matrix.

least, having an average wage rate of about \$16 per hour.

We calibrate the model such that sector 1 is the social sector, and sector 2 is the distant sector. One period is one quarter. The intertemporal elasticity of substitution in consumption, σ, is set to 1. We use the estimates in Schmitt-Grohé and Uribe (2012) to quantify the wealth elasticity $\chi = 0.0001$, the elasticity of capital utilization $\Delta = \delta_1/\delta_2 = 3$, and the investment adjustment costs $\kappa_i = 9$. We set the Frisch elasticity of labor supply, which equals the parameter η when χ is close to zero, to 0.72, taken from Bredemeier, Gravert, and Juessen (2019).

We use the U.S. estimate for the degree of labor mobility across sectors by Horvath (2000) and set $\omega = 1$. We set the elasticity of substitution between goods within a sector to $\epsilon = 6$ implying a steady-state markup of prices over marginal costs equal to 20%. The elasticity of substitution in consumption between the goods of both sectors is set to $\mu = 1$. For some goods, this value tends to overestimate the substitutability between social-sector products and the average distant-sector good. For example, it is difficult to think about consumers substituting health services for the typical distant-sector good. However, there are arguably also goods for which the degree of substitutability is far higher. For example, consumers can easily switch from buying products at bricks and mortar retailers (social sector) to online shopping (distant sector). We, therefore, choose the standard Cobb-Douglas case of $\mu = 1$ as our baseline value.

The quarterly capital depreciation rate, δ, and the discount factor, β, are set to $\delta = 0.022$ and $\beta = 0.9927$. These values imply an aggregate capital to output ratio of 3.6 and an annualized real interest rate of around 3 percent. We parameterize the cost of price adjustment, ψ, to generate a slope of the Phillips curve consistent with a probability of adjusting prices in the Calvo model equal to 1/3, as estimated by Smets and Wouters (2007). This delivers $\psi \approx 30$. The steady-state

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tax rates and the annualized steady-state debt to GDP ratio are set to $\tau^n = 0.28$, $\tau^k = 0.36$, and $b/(4y) = 0.63$, as calculated by Trabandt and Uhlig (2011). The responsiveness of government transfers to changes in government debt is set to $\gamma_{sb} = 0.1$ to ensure debt sustainability. The coefficients of the Taylor rule measuring the responsiveness of the interest rate to inflation and output are set to $\delta_\pi = 1.5$ and $\delta_y = 0.5/4$, as proposed by Taylor (1993). We impose a zero net inflation steady state ($\pi = 1$).

The steady-state share of government spending in total output is set to the standard value of 0.2. We set the autocorrelation of government spending to $\rho_g = 0.9$. To calibrate the parameter ζ_g, which determines the distribution of government spending across sectors, we use the information on government spending for education and health services, the major components of public spending in the social sector. According to data from the World Bank Database and Congressional Budget Office, expenditures of federal, state, and local governments amount to 5% of GDP for education and 6% of GDP for health services, net of tax preferences. Hence, we consider government expenditure in the social sector to be 11% of GDP. With a total share of government spending in GDP of 20%, this gives a share of social-sector government expenditures in total government expenditures of $\zeta_g = 0.55$.

The weights on labor in the utility function, Ω^p, Ω^b, and Ω^w, are chosen to generate a steady-state occupation mix of employment consistent with the empirical counterpart displayed in Table 1. We set the share parameters $\aleph^p$, $\aleph^b$, $\aleph^w$, υ_1, υ_2, α_1, α_2, γ_1, γ_2, and ζ to match the composition of occupations across industries displayed in Table 1 as well as the relative occupational wages rates along with a labor income share of 67%. We achieve these calibration targets by setting $\zeta = 0.5$, $\aleph^p = 0.84$, $\aleph^b = 0.25$, $\aleph^w = 0.52$, $\alpha_1 = 0.45$, $\alpha_2 = 0.9$, $\gamma_1 = 0.64$, $\gamma_2 = 0.51$, $\upsilon_1 = 0.5$, and $\upsilon_2 = 0.54$.

The following parameters are taken from Bredemeier, Juessen, and Winkler (2020), where we parameterize a multi-sector, multi-occupation New Keynesian business cycle model to match the estimated effects of U.S. government spending shocks. The parameter δ_g, which captures the responsiveness of the nominal interest rate to government spending, is $\delta_g = -0.364$. In Bredemeier, Juessen, and Winkler (2020), we use this value to match the estimated government spending multiplier. Furthermore, we believe that monetary accommodation describes monetary policy

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during and in the aftermath of the Covid-19 crisis rather well.[7] The parameters governing the size of labor adjustment costs in both sectors are $\kappa_{n,1} = 1.03$ and $\kappa_{n,2} = 3.33$. These values match the empirical evidence on the response of relative sectoral employment to government spending shocks, together with a weighted average of labor adjustment costs of 1.85, as estimated by Dib (2003). The elasticities of substitution with capital services are $\phi = 2.7$ for blue-collar work, $\theta = 0.07$ for pink-collar work, and $\iota = 1$ for white-collar work, respectively. In Bredemeier, Juessen, and Winkler (2020), we show that these values rationalize the relative occupational employment dynamics in response to U.S. government spending shocks. At the same time, they imply an average elasticity of substitution between capital services and labor of one, as in the canonical Cobb-Douglas case.

Covid-19 shock. We expose the model economy to a "Covid-19" shock, which we calibrate to match the spring-2020 job losses and their distribution over sectors and occupation groups. The Covid-19 scenario we consider is not meant to explain the labor market outcomes in the Covid-19 crisis as we mostly use exogenous wedges to match empirical observations. The scope of our Covid-19 scenario is to set the scene for the policy analyses described in the next section, which we want to conduct in an environment mimicking the labor-market situation during the Covid-19 crisis as closely as possible. In particular, we want to analyze the ability of fiscal policy to create jobs where they were lost. While, in a model like ours, the isolated effects of a shock, e.g., a fiscal policy innovation, are barely affected by the state of the economy when the shock hits, it is worth mentioning that these isolated effects are not our primary focus. Instead, our aim is to study how well the distribution of jobs created by different fiscal policy impulses fits the needs in the Covid crisis, i.e., the distribution of job losses due the Covid shock.

For the aggregate employment drop and its expected future development, we use the May 2020 Interim Economic Projections by the Congressional Budget Office (CBO), `https://www.cbo.gov/publication/56368`. The CBO expects employment in the second quarter of 2020 to be 25.6 million lower than in the last quarter of 2019, which corresponds to a drop by about 17% relative to 2019 employment levels. While acknowledging the severe uncertainty about how the crisis continues to unfold, the CBO forecasts a gradual return starting immediately after the initial bust in spring 2020, and that job losses will have halved by the second quarter of 2021. These

[7] It does not appear reasonable to assume that, in the near term, monetary policy will lean against a fiscal expansion that aims to help the economy recover faster.

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Table 2: Shares of 2018 employment and Covid-related employment losses by worker group.

Worker group	Share of 2018 employment	Share of Covid-19 job losses
Sectors		
distant	44.3%	29.1%
social	55.7%	70.9%
Occupation groups		
white-collar	44.7%	33%
blue-collar	22.9%	27%
pink-collar	31.4%	39%

Notes: Own calculations based on Adams et al. (2020) and BLS industry-occupation matrix.

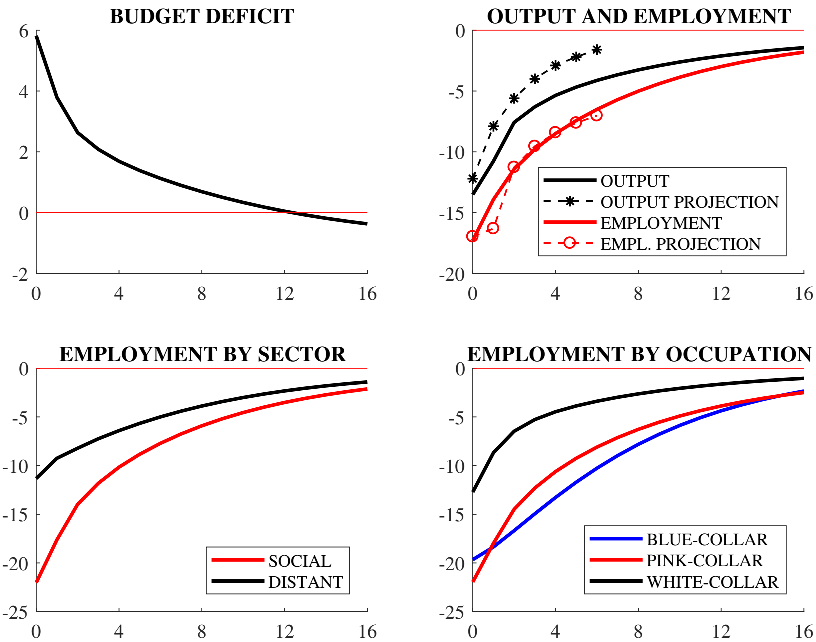
projections are in line with the preliminary BLS employment statistics for May which showed first signs of a beginning rebound. It is worth mentioning that the CBO projections incorporate the assumption that current laws generally remain unchanged and that no significant additional emergency funding is provided. The CBO projections thus constitute a useful baseline scenario against which we can analyze the effects of different fiscal policy measures in the crisis.

Regarding the distribution of job losses over sectors and occupations, we use the numbers reported by Adams-Prassl, Boneva, Golin, and Rauh (2020). They performed a real-time survey on Covid-19 related job losses and report percentage employment losses by occupation and industry. We multiply these numbers with the 2018 employment level to obtain absolute numbers, which we then add by sectors and occupation groups. We then calculate the distribution of total job losses over sectors and occupation groups.[8] Results are shown in Table 2. More than 7 out of 10 Covid-related job losses occurred in the social sector, and about 4 in 10 occurred in pink-collar occupations. The overall employment loss reported by Adams-Prassl, Boneva, Golin, and Rauh (2020) is 18% and hence similar to the number implied by the CBO projections.

Our analysis does not seek to explain these developments, which likely have to do with opportunities to work from home (relatively pronounced for white-collar occupations) and the sectoral

[8] Adams-Prassl, Boneva, Golin, and Rauh (2020) do not differentiate between retail and wholesale trade and do not report job losses for subcategories of transportation and warehousing industries. We use CES employment data for March to distribute the job losses reported by Adams-Prassl, Boneva, Golin, and Rauh (2020) for wholesale and retail trade as well as for transportation and warehousing to their respective subcategories. The CES numbers for March show that employment in wholesale trade increased from February. To remain conservative, we attribute all job losses reported by Adams-Prassl, Boneva, Golin, and Rauh (2020) for wholesale and retail trade to retail trade. Similarly, the CES numbers for March do not indicate employment losses in the truck, pipeline, and storage industries. Accordingly, we attribute all job losses reported by Adams-Prassl, Boneva, Golin, and Rauh (2020) for transportation and storage to the social sector.

Figure 1: Baseline Covid-19 scenario



Notes: Deviations from steady state. Budget deficit in percent of steady-state GDP. All other variables in percent of their own steady-state values.

composition of employment by occupation (pink-collar occupations make up a major share of employment in the social sector). These phenomena are outside the model, and we use the "wedges" to generate the observed phenomena. In particular, we calibrate the innovations to the wedges to generate a 17% drop in aggregate employment on impact (in quarter zero), which is distributed over the different sectors and occupations, as summarized in Table 2. Moreover, we model the stochastic wedge processes as an autoregressive process of order one and set the autocorrelation to 0.86 to match as closely as possible the employment path projected by the CBO.

Subject to these shocks, the model produces profiles for the main variables depicted in Figure 1. We assume that the economy was at its steady state before the crisis. All variables are expressed in percentage deviations from their pre-crisis (steady-state) levels, except for the budget deficit, which we measure in percent of steady-state GDP. The vertical axis displays quarters after the shock. We consider quarter "0" as the second quarter of 2020.

The model predicts the budget deficit to rise by 5.8% percent of steady-state GDP in response to the crisis. In our model, this is a consequence of the collapse in tax revenues only as we do not

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model the budgetary costs of infection-fighting and disaster relief. Therefore, the actual budgetary costs of the Covid-19 crisis are likely higher. In April 2020, the CBO projected the deficit for the year 2020 to increase by 7.7 percent of 2019 GDP.[9]

The upper-right panel of Figure 1 shows the path of output and employment in our scenario. As targeted, aggregate employment (solid red line) falls by 17% on impact and then recovers gradually. Over the course of two years, the employment recovery fits the CBO projections (dashed red lines with circles) rather well such that the AR(1) assumption for the wedges seems adequate. Also the response of output, which is non-targeted in our scenario, is relatively similar to the CBO projections. Our model predicts that output (solid black line) plummets by 13% in the second quarter of 2020, which is only slightly larger than in the CBO projection (dashed black line with asterisks). Output in the model recovers somewhat more slowly than projected by the CBO, but the overall shape is similar.

The lower panels of the figure show the responses of employment by occupation and sector. While the initial job losses by sector and occupation are targeted in our calibration of the Covid-19 shock, we do not target a sector-specific or occupation-specific speed of recovery. The model predicts blue-collar employment to recover more slowly than pink-collar employment, making it the occupation group with the most significant employment loss relative to pre-Covid levels from fall 2020 onward.

3 Policy scenarios

In this section, we study the effects of aggregate demand management in the Covid-19 recovery as projected by our model. We consider three different, discretionary, government spending expansions that differ by the distribution of purchases across sectors and three tax cut scenarios that differ by the treatment of capital and labor income. As discussed in the introduction, we focus on aggregate demand management when the infection rate is under control and most restrictions on economic activity are relaxed. While it remains uncertain when these conditions will be met, we choose the first quarter of 2021 as the starting point of aggregate demand management. We quantify the size of the expansionary impulse to achieve a full recovery of aggregate employment

[9] We calculate this number as the projected increase in the deficit-to-GDP ratio minus the projected percentage decline in GDP. The May outlook does not include a deficit forecast.

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by the third quarter of 2021. While this constitutes an ambitious goal, we want to compare policy measures that have the same effect on total employment, which allows us to concentrate on their differential effects on the employment composition.

3.1 Spending expansions

We first consider expansions in government spending. Our focus is on the disaggregated employment developments during the recovery. As discussed in Section 2, disaggregated employment dynamics in our model are driven by two channels, one that relates to differences in economic activity across sectors and their resulting composition effects and one that relates to capital-labor substitution within industries. In the recovery supported by spending expansions, these two channels work as follows.

The spending stimulus boosts aggregate demand, which leads to increased factor demand and, hence, tends to promote the recovery of employment. Mechanically, the more additional government purchases accrue in any given sector, the more strongly the recovery in this sector tends to be accelerated. Via *composition effects*, this can also help stimulate the employment recovery for those occupation groups strongly represented in this sector.

The increase in factor demand also promotes the recovery in factor prices. This is more pronounced for labor, which is in less elastic supply than capital services. Therefore, firms return production toward normal levels by predominantly raising their use of capital services, which remain cheap. The more intensive use of capital lowers the marginal productivity of its close substitute, blue-collar labor, weakening the recovery of blue-collar work. On the contrary, the more intensive use of capital raises the marginal productivity of its close complement, pink-collar labor, reinforcing the recovery of pink-collar employment. The increase in white-collar employment, for which the elasticity of substitution with capital services is equal to unity, lies in between the increase of pink-collar and blue-collar labor employment. At the sectoral level, the *capital-labor substitution* channel, in isolation, implies that a spending expansion tends to promote the employment recovery relatively strongly in sectors that employ many pink-collar workers and more weakly in industries employing relatively many blue-collar workers. Put differently, the job multiplier is higher in pink-collar intensive sectors.

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As we will discuss in detail below, the distribution of government spending across sectors shapes the recovery of employment by sector, but it does not affect considerably the strength and speed of the employment recovery by occupation. This indicates that composition effects due to sectors having a different occupation mix play only a limited role and that the capital-labor substitution channel is most important for the occupational employment effects of spending expansions.

Distributing additional purchases evenly across sectors. We start with a fiscal stimulus where the government increases its purchases in both sectors by the same amount. The upper-left panel of Figure 2 shows spending in both sectors as well as the primary fiscal deficit in percent of steady-state GDP. In this scenario, additional government purchases amount to 7.8% of quarterly steady-state GDP (corresponding to about \$1.7 trillion using 2019 GDP numbers) in the first quarter of 2021 (quarter 3 of our analysis). The stimulus is then slowly phased out with autocorrelation of 0.9. Over a four-year horizon, additional government spending amounts to 60% of quarterly steady-state GDP or about \$13 trillion. The government attributes half of the spending boost to each of the two sectors, so 3.9% of a quarterly GDP initially or about 30% of a quarterly GDP (about \$6.5 trillion) over four years. Recall that the size of the impulse is chosen to bring aggregate employment (displayed in the upper-right panel of Figure 2) back to its steady state by the third quarter of 2021 (quarter 5). For the time thereafter, the model predicts a moderate boom in aggregate employment. The boost to aggregate demand accelerates the recovery of output strongly. Output returns to its pre-crisis level relatively quickly, overshoots, and gradually returns to the steady state thereafter.

The lower-left panel of Figure 2 shows that the employment composition by sector is stabilized successfully by the spending boost. From early 2021 (quarter 4) on, the lines in the figures are close together, indicating that employment losses relative to steady state in both sectors are proportional to steady-state sector size. This appears surprising at first, given the substantial Covid-19 job losses in the social sector and the symmetry of the fiscal package. The reason is that the job multiplier in the social sector, which employs relatively many pink-collar workers, is larger than in the distant sector, which employs relatively many blue-collar workers.

Although the sectoral composition of employment is back to normal rather quickly in this scenario, its occupational composition is destabilized for over four years, see the lower-right panel

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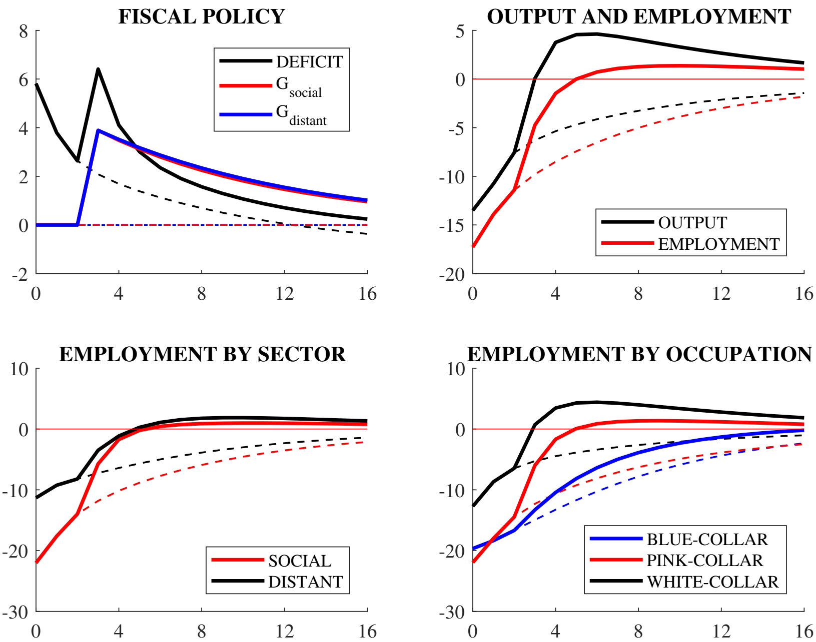
Figure 2: Covid-19 recovery with an equal spending expansion across sectors

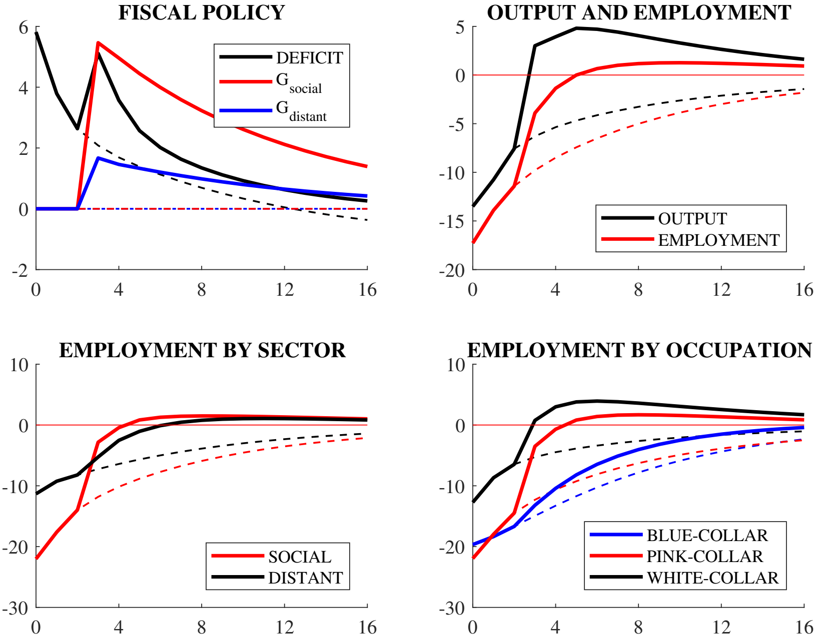


Notes: Deviations from steady state. Budget deficit and government spending by sector in percent of steady-state GDP. All other variables in percent of their own steady-state values. Dashed lines show Covid-19 scenario without fiscal policy intervention.

of Figure 2. Until 2024, employment is biased toward white-collar occupations and away from blue-collar occupations. White-collar employment is back to steady state already in the quarter of the fiscal stimulus and above steady state for the three consecutive years. By contrast, it takes almost four years for blue-collar employment to recover to its pre-Covid level. Pink-collar employment lies in between, with a return to steady state by fall 2021 (quarter 5) and a post-Covid boom that is less pronounced but of similar duration as the one for white-collar employment. As explained before, the reason why blue-collar employment benefits the least from the demand stimulus lies in its relatively high degree of substitutability with capital services, weakening its recovery relative to other occupation groups.

Spending expansion biased toward social sector. We now investigate a scenario where three-quarters of the government's additional expenditures accrue in the social sector. Such a stimulus package can be thought of as primarily expanding public education or health expenditures. The total stimulus now amounts to roughly 7.1% of steady-state GDP or \$1.5 trillion of which about \$1.15 trillion is spent in the social sector, see the upper-left panel of Figure 3. The responses of

Figure 3: Covid-19 recovery with a spending expansion strongly directed into the social sector



Notes: Deviations from steady state. Budget deficit and government spending by sector in percent of steady-state GDP. All other variables in percent of their own steady-state values. Dashed lines show Covid-19 scenario without fiscal policy intervention.

aggregate employment and output, shown in the upper-right panel of Figure 3, are similar to the scenario with an equal spending expansion across sectors as the sizes of the stimulus packages are chosen to achieve a full recovery of aggregate employment in quarter 5.

The lower-left panel shows the sector-specific employment recoveries. Not surprisingly, directing more spending toward the social sector induces this sector to recover more quickly. Social-sector employment, though hit harder by the Covid-19 shock, reaches its pre-crisis level in quarter 5 (roughly by summer 2021). By contrast, distant-sector employment takes until quarter 7 to recover completely. Given that the symmetric spending expansion stabilizes the economy's sectoral composition rather successfully (see Figure 2), it is not surprising that a package directed disproportionately into the social sector overshoots in this respect, destabilizing the sector mix toward the social sector.

The quantitative effect on sector-specific employment is relatively small compared to the strong directing of government spending toward the social sector. It is dampened by reactions of private demand, which shifts toward the distant sector as goods and services produced in the social sector

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become relatively more expensive due to the surge in the government's demand for them.

As can be seen in the lower-right panel, the fiscal stimulus package directed mostly into the social sector accelerates the recovery of pink-collar employment in particular since pink-collar employment is represented disproportionately in the social sector. However, this composition effect is relatively moderate. In quarter 3 (when the fiscal stimulus comes into force), the spending expansion boosts the recovery of pink-collar work by only about 2.5 percentage points more relative to the unbiased spending expansion (see Figure 2).

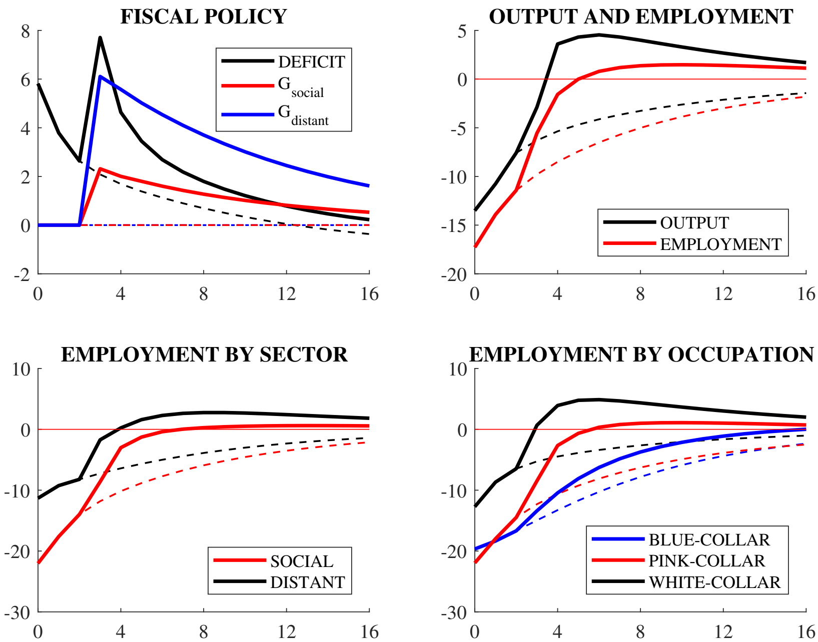
Blue-collar employment recovers somewhat more slowly in this scenario compared to the symmetric spending boost as it makes up only a small part of the workforce in the social sector where much of the direct effects of the stimulus takes effect. For this reason, directing government expenditures disproportionately into the social sector does not help to stabilize the economy's occupation mix. However, differences between the two scenarios with respect to the response of blue-collar employment are quantitatively negligible and amount to only about 0.1 percentage points around the end of 2021.

Overall, differences in occupation-specific employment dynamics to the unbiased spending expansion are small. There are two reasons for this result. First, employment by sector does not respond strongly to directing the stimulus to the hardest-hit sector since endogenous counteracting responses of private spending are strong. Second, within-sector effects, driven by differences in capital-labor substitutability across occupations, are powerful and dominating the impact on employment by occupation.

Spending expansion biased toward distant sector. In this scenario, we analyze how far a spending expansion directed toward the distant sector can foster job creation for blue-collar workers. In particular, we consider a fiscal stimulus package in which around three-quarters of the additional purchases accrue in the distant sector. Here, the total hike in government expenditures amounts to 8.4% of steady-state GDP (or about \$1.8 trillion) in quarter 3. Of these expenditures, the government channels \$1.35 trillion into the distant sector, see the upper-left panel of Figure 4. Again, the model-predicted acceleration of the recovery from the Covid-19 shock does not differ substantially from the other scenarios, see the upper-right panel of Figure 4.

As can be seen in the lower-left panel, employment in the distant sector recovers substantially

Figure 4: Covid-19 recovery with a spending expansion strongly directed into the distant sector



Notes: Deviations from steady state. Budget deficit and government spending by sector in percent of steady-state GDP. All other variables in percent of their own steady-state values. Dashed lines show Covid-19 scenario without fiscal policy intervention.

more quickly than employment in the social sector. This is due to the distant sector not being hit as hard by the Covid-19 shock and boosted disproportionately by fiscal stimulus. As a consequence of these two effects, the spending package directed mostly into the distant sector induces a destabilization of the economy's sectoral mix over the entire four years shown in the figure.

The sectoral destabilization may come at the benefit of a more substantial occupational stabilization, in particular an additional boost to the recovery of blue-collar employment. However, the lower-right panel of Figure 4 shows that the employment effects, by occupation, of directing the spending stimulus into the distant sector are small. Blue-collar employment recovers only slightly more strongly compared to the other packages. The responses of blue-collar employment differ barely across scenarios, amounting to only about 0.2 percentage points. Again, this can be explained by two countervailing influences. First, the biased spending expansion leads to an increase in the relative price of distant-sector goods, which induces households and firms to switch part of their expenditure to the social sector. Second, there are substantial changes in the occupation-mix within sectors favoring pink-collar and white-collar employment.

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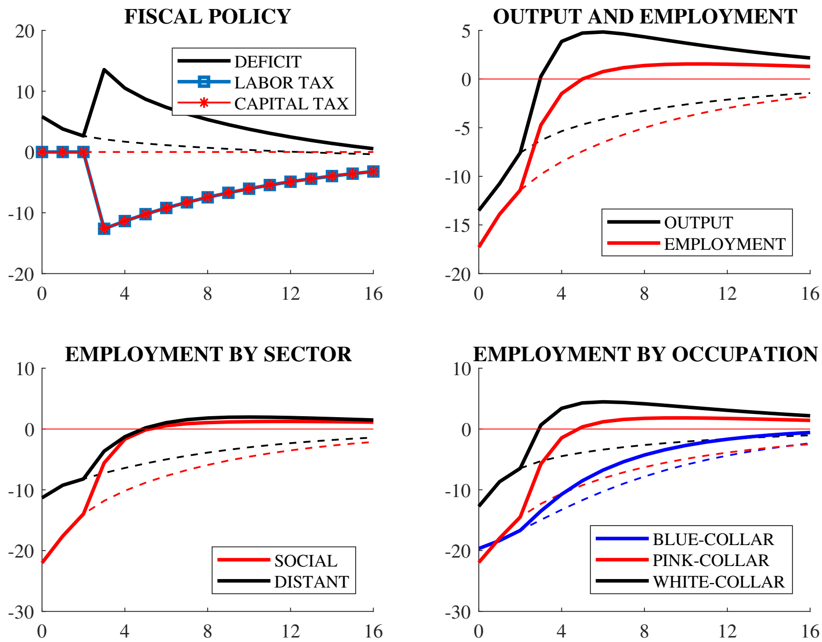
Figure 5: Covid-19 recovery with a symmetric reduction in capital and labor income tax rates



Notes: Deviations from steady state. Budget deficit in percent of steady-state GDP. Tax rates in percentage points. All other variables in percent of their own steady-state values. Dashed lines show Covid-19 scenario without fiscal policy intervention.

3.2 Tax cuts

We now turn to tax cuts as an alternative to expanding government purchases. First, we consider a scenario where the government cuts tax rates on both capital and labor income by the same absolute amount. We then turn to a scenario where only taxes on labor income are reduced and, finally, consider a cut only in taxes on capital income.

Cut in taxes on labor income and capital income. To start with, we consider a reduction in tax rates on both labor income and capital income by 13 percentage points in quarter 3 of our analysis, which achieves the target of a completed recovery of aggregate employment by quarter 5. When it takes effect, the tax cut leads to a surge in the primary fiscal deficit of about ten percent of steady-state GDP, or about $2.15 trillion, see the upper-left panel of Figure 5.

The tax cut makes the use of production factors cheaper for firms, which hence return production toward pre-crisis levels. The upper-right panel of Figure 5 shows that this takes place relatively quickly, and that output has fully recovered shortly after the tax stimulus. This and

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the subsequent post-Covid boom are similar to the spending expansions considered before. The duration of the employment recovery is, by construction, precisely the same across scenarios and reflects the target of a full aggregate employment recovery half a year after the stimulus. The relation between output and employment is not affected substantially by whether the fiscal stimulus is executed via a spending expansion or a symmetric tax cut.

Turning to the disaggregated effects of the stimulus, the mechanisms are similar to those at play in response to the spending expansions. As firms are incentivized to take back some of the reduction of factor demand, the recovery of factor prices is accelerated. As in the spending scenarios, this effect is more pronounced for labor, which is less elastically supplied than are capital services. As a consequence, firms act more quickly in bringing back their use of capital services toward pre-crisis levels while they are more reluctant toward calling back workers. This substitution toward capital services slows down most strongly the recovery of employment in blue-collar occupations where capital-labor substitution is easiest. Again, this also impacts on sectoral employment as relatively little jobs are created by the stimulus in industries with many blue-collar workers and hence a high average degree of capital-labor substitutability.

Hence, the employment effects of the tax stimulus are more substantial in the social sector, and the tax cuts predominantly help this sector accelerate its recovery. The lower-left panel of Figure 5 shows that the social sector catches up to the distant sector around summer 2021, and both sectors experience somewhat parallel smooth upturns afterward. These developments are similar to those in the unbiased spending scenario considered in Figure 2.

The occupational employment dynamics displayed in the lower-right panel of Figure 5 also resemble those from the spending expansions. The tax stimulus accelerates the pink-collar recovery but pink-collar employment remains persistently below white-collar employment in terms of deviation from steady state. Blue-collar employment reaches its pre-crisis level as late as four years after the Covid-19 shock and workers in these occupations do not enjoy a post-Covid boom.

Labor income tax cut. Here, we consider a scenario where tax rates on labor income are cut but not those on capital income. This is an interesting scenario because the policy stimulus directly affects relative factor prices, which play an essential role in the transmission from fiscal policy to disaggregated employment dynamics. The tax rate on labor income has to be cut by about 13

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percentage points to achieve the stabilization of aggregate employment. This tax cut would let the deficit surge by approximately 10% of a quarterly steady-state GDP, about $2.2 trillion, see the upper-left panel of Figure 6. The aggregate employment effects are again similar to the ones in the other scenarios, which is a consequence of targeting the speed of the employment recovery. As the upper-right panel of Figure 6 shows, the recovery of output is less strongly accelerated than in the other scenarios as the stimulus only makes labor but not capital services less expensive for firms.

The disaggregated effects of the labor income tax cut differ from those of the stimulus measures in the previous scenarios. Cutting taxes on labor but not on capital alters the relative price of the two factors directly. With labor becoming relatively cheaper, firms return production to normal levels mostly by hiring more workers, whereas the use of capital services is raised only modestly. This shift in the composition of factors away from capital services and toward labor tends to increase the marginal product of blue-collar work, which is a close substitute for capital services. In contrast, it tends to decrease the marginal product of pink-collar work, which is a complement to capital services. This counteracts the tendency for strong employment effects in pink-collar occupations and in industries that employ many pink-collar workers. By contrast, firms' demand for blue-collar labor recovers more strongly than under the other stimulus programs. Through composition effects, this also leads to an accelerated recovery in the distant sector where relatively many blue-collar workers are employed. At the same time, it slows down the recovery in the social sector, compared to the stimulus measures discussed before. As a consequence, the sectoral composition of the economy is not as strongly stabilized as it is by the symmetric tax cut or the unbiased spending boost. The lower-left panel of Figure 6 shows that the social sector lags behind the distant sector in terms of employment for the entire four years we consider.

As seen in the lower-right panel of Figure 6, the labor income tax cut achieves a substantially more pronounced stabilization of employment by occupation than the other stimulus measures. As the labor income tax stimulus promotes job growth in blue-collar occupations considerably, blue-collar workers are not left behind during the recovery under this policy scenario. Blue-collar employment recovers far more quickly than in any other scenario, achieving a full recovery to pre-crisis levels by mid-2022.

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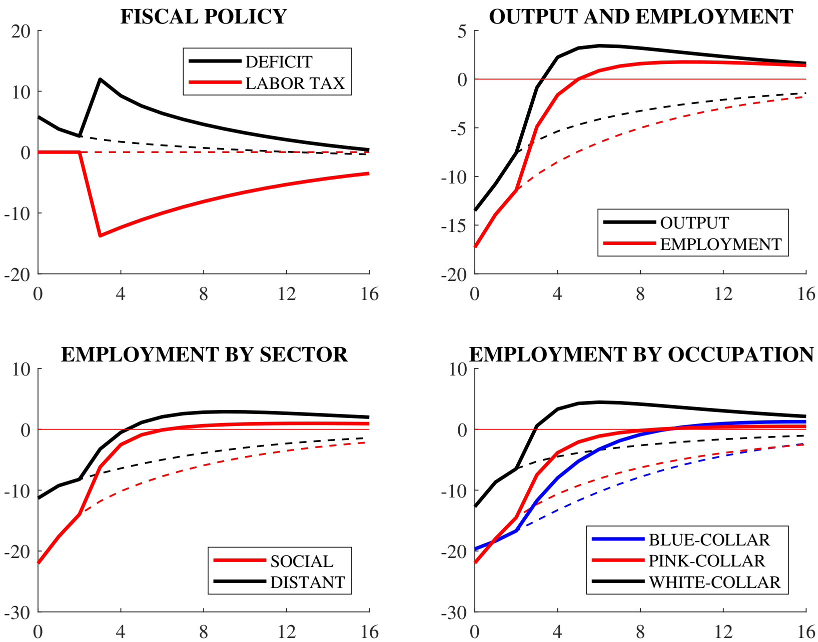
Figure 6: Covid-19 recovery with a reduction in the labor income tax rate

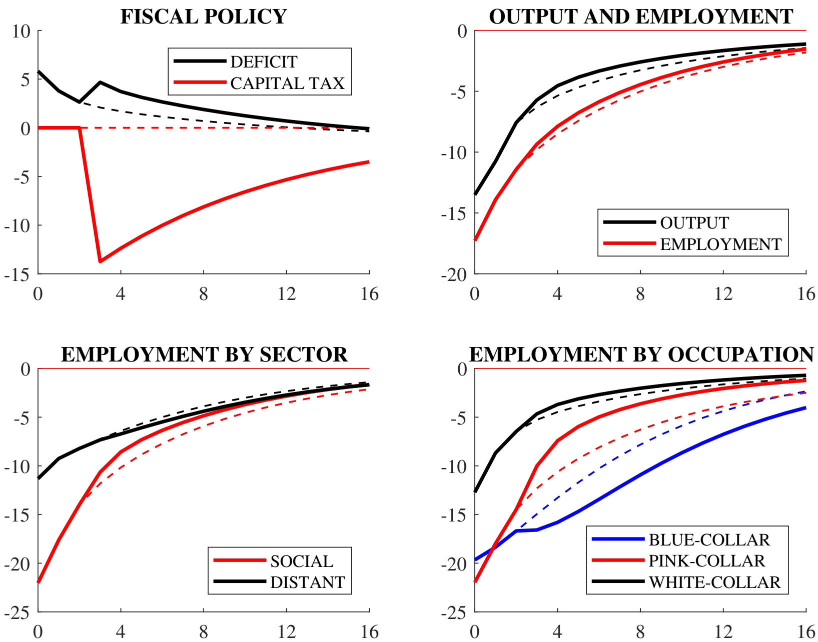


Notes: Deviations from steady state. Budget deficit in percent of steady-state GDP. Tax rates in percentage points. All other variables in percent of their own steady-state values. Dashed lines show Covid-19 scenario without fiscal policy intervention.

Capital income tax cut. Finally, we consider a scenario where only tax rates on capital income are cut but not those on labor income. This policy change only affects a small part of aggregate income and, hence, any given absolute change in the capital tax rate affects economic activity less strongly than the same change in, e.g., the labor income tax. In particular, the effects on employment are small since employment is affected only indirectly. For this reason, we refrain from the stabilization target for aggregate employment as an immense cut of capital income tax rates would be needed to achieve it. Instead, we consider a reduction in tax rates on capital income by the same amount as tax rates on labor income are reduced in the previous scenario. In particular, tax rates on capital are reduced by 13 percentage points which leads to a deficit surge of about 2.5% of pre-crisis GDP (or about \$500 billion), see upper-left panel of Figure 7.

This stimulus accelerates the aggregate recovery only slightly, see the upper-right panel of Figure 7. Given the relatively small stimulus considered in this scenario, this is not surprising. As a consequence of the change in relative factor prices, the capital-tax stimulus fosters the output recovery more strongly than the employment recovery.

Figure 7: Covid-19 recovery with a reduction in the capital income tax rate



Notes: Deviations from steady state. Budget deficit in percent of steady-state GDP. Tax rates in percentage points. All other variables in percent of their own steady-state values. Dashed lines show Covid-19 scenario without fiscal policy intervention.

At the disaggregated level, effects are the opposite of those of the labor-tax stimulus considered before. When the government directly reduces the costs of using capital services, the tendency of stimulus measures to promote job growth for pink-collar workers and leave out blue-collar workers are reinforced. Regarding sectors, this translates into a strong bias of the created jobs toward the social sector. Quantitatively, our results show that the recoveries of employment in the distant sector (lower-left panel of Figure 7) and blue-collar occupations (lower-right panel of Figure 7) are even slowed down by the stimulus. The latter is especially remarkable due to blue-collar workers' substantial exposure to crisis-related job losses.

4 Conclusion

The massive job losses in the Covid-19 crisis were disproportionately borne by workers in retail trade, hospitality, and other contact-intensive industries as well as by workers in blue-collar, sales, and service occupations. Given the high costs of switching industry or occupation, the total economic cost of the Covid-19 crisis can be reduced if policy achieves stabilization not only of

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aggregate employment but also of the composition of employment, i.e., manages to foster rapid job growth in particular in those industries and occupations that were hit hardest by the crisis.

In this paper, we analyze the ability of different fiscal stimulus measures to achieve this goal. To do so, we use a multi-sector, multi-occupation dynamic stochastic general equilibrium model to study the effects of different types of fiscal policy instruments on employment by occupation and industry. In the model, heterogeneity in employment responses to a fiscal stimulus results from two channels. First, government spending can be distributed unevenly across sectors leading to disproportionate job growth in industries where purchases are increased considerably and affecting occupational employment through composition effects. Second, differences in the substitutability with capital services across occupations induce fiscal policy to create job growth predominantly in those occupations where labor is a complement to capital services.

Our model predicts that the two groups of occupations hit hard by the Covid-19 recession, pink-collar and blue-collar workers, profit differentially from a fiscal stimulus. All types of fiscal stimulus promote job growth in pink-collar occupations considerably. In this sense, fiscal policy is successful in helping create jobs where they were lost during the Covid-19 crisis – labeled as a "pink-collar recession" by some commentators. But this recession has, as previous ones, also struck blue-collar workers hard. To create jobs for this group of workers, a fiscal stimulus has to be designed in specific ways to circumvent or at least weaken the mechanisms that dampen the employment gains for blue-collar workers. The fiscal-policy measure best suited to stabilize the economy's occupation composition after the imminent Covid-19 crisis is a cut in labor income taxes.

The white-collar occupation group, which is relatively mildly affected by the Covid-19 crisis, enjoys some employment growth in all stimulus scenarios. Independent of how the fiscal stimulus is set up in detail, the recovery of white-collar employment is accelerated considerably. This implies that fiscal policy during the Covid-19 recovery also helps create jobs where not so many were lost in the first place.

Regarding sectoral employment, the weak capital-labor substitutability in the social sector, i.e., in industries with intensive face-to-face contacts between workers and customers, brings about pronounced job growth induced by fiscal stimulus measures in this sector. In our model analysis,

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this mechanism leads to a relatively quick stabilization of the economys industry mix even when a fiscal policy does not target the social sector explicitly.

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Appendix

Equilibrium conditions

This appendix collects the equilibrium conditions of our model. In a symmetric equilibrium, $y_{s,t} = y_{j,s,t}$, $\widetilde{k}_{j,s,t} = \widetilde{k}_{s,t}$, $n^p_{j,s,t} = n^p_{s,t}$, $n^b_{j,s,t} = n^b_{s,t}$, $n^w_{j,s,t} = n^w_{s,t}$, $mc_{j,s,t} = mc_{s,t}$, and $p_{j,s,t} = p_{s,t}$. Let $\pi_{s,t} = p_{s,t}/p_{s,t-1}$ denote gross price growth in sector s. The first-order conditions of firms in sector $s = 1, 2$ are then given by

$$y_{s,t} = y_{j,s} \cdot \left(\upsilon_s \cdot \left(\frac{v^p_{j,s,t}}{v^p_{j,s}} \right)^{\frac{\iota-1}{\iota}} + (1-\upsilon_s) \cdot \left(\frac{n^w_{j,s,t}}{n^w_{j,s}} \right)^{\frac{\iota-1}{\iota}} \right)^{\frac{\iota}{\iota-1}} \tag{A.1}$$

$$v^p_{j,s,t} = v^p_{j,s} \cdot \left(\alpha_s \cdot \left(\frac{v^b_{j,s,t}}{v^b_{j,s}} \right)^{\frac{\theta-1}{\theta}} + (1-\alpha_s) \cdot \left(\frac{n^p_{j,s,t}}{n^p_{j,s}} \right)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{A.2}$$

$$v^b_{j,s,t} = v^b_{j,s} \cdot \left(\gamma_s \cdot \left(\frac{\tilde{k}_{j,s,t}}{\tilde{k}_{j,s}} \right)^{\frac{\phi-1}{\phi}} + (1-\gamma_s) \cdot \left(\frac{n^b_{j,s,t}}{n^b_{j,s}} \right)^{\frac{\phi-1}{\phi}} \right)^{\frac{\phi}{\phi-1}} \tag{A.3}$$

$$mc_{s,t} \cdot mpk_{s,t} = r^k_{s,t} \tag{A.4}$$

$$\begin{aligned} mc_{s,t} \cdot mpl^b_{s,t} &= w^b_{s,t} + \kappa_{n,s} \left(\frac{n^b_{s,t}}{n^b_{s,t-1}} - 1 \right) \frac{(1+\wedge_{s,t}) p_{s,t}}{p_t} \frac{y_{s,t}}{n^b_{s,t-1}} \\ &- \kappa_{n,s} \beta \, \mathrm{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{n^b_{s,t+1}}{n^b_{s,t}} - 1 \right) \frac{(1+\wedge_{s,t+1}) p_{s,t+1}}{p_{t+1}} y_{s,t+1} \left(\frac{n^b_{s,t+1}}{(n^b_{s,t})^2} \right) \right\} \end{aligned} \tag{A.5}$$

$$\begin{aligned} mc_{s,t} \cdot mpl^p_{s,t} &= w^p_t + \kappa_{n,s} \left(\frac{n^p_{s,t}}{n^p_{s,t-1}} - 1 \right) \frac{(1+\wedge_{s,t}) p_{s,t}}{p_t} \frac{y_{s,t}}{n^p_{s,t-1}} \\ &- \kappa_{n,s} \beta \, \mathrm{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{n^p_{s,t+1}}{n^p_{s,t}} - 1 \right) \frac{(1+\wedge_{s,t+1}) p_{s,t+1}}{p_{t+1}} y_{s,t+1} \left(\frac{n^p_{s,t+1}}{(n^p_{s,t})^2} \right) \right\} \end{aligned} \tag{A.6}$$

$$\begin{aligned} mc_{s,t} \cdot mpl^w_{s,t} &= w^w_t + \kappa_{n,s} \left(\frac{n^w_{s,t}}{n^w_{s,t-1}} - 1 \right) \frac{(1+\wedge_{s,t}) p_{s,t}}{p_t} \frac{y_{s,t}}{n^w_{s,t-1}} \\ &- \kappa_{n,s} \beta \, \mathrm{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{n^w_{s,t+1}}{n^w_{s,t}} - 1 \right) \frac{(1+\wedge_{s,t+1}) p_{s,t+1}}{p_{t+1}} y_{s,t+1} \left(\frac{n^w_{s,t+1}}{(n^w_{s,t})^2} \right) \right\} \end{aligned} \tag{A.7}$$

$$mpk_{s,t} = \upsilon_s \cdot \alpha_s \cdot \gamma_s \cdot \left(\frac{y_s}{\tilde{k}_s} \right) \left(\frac{y_{s,t}/y_s}{v^p_{s,t}/v^p_s} \right)^{1/\iota} \left(\frac{v^p_{s,t}/v^p_s}{v^b_{s,t}/v^b_s} \right)^{1/\theta} \left(\frac{v^b_{s,t}/v^b_s}{\tilde{k}_{s,t}/\tilde{k}_s} \right)^{1/\phi} \tag{A.8}$$

$$mpl^b_{s,t} = \upsilon_s \cdot \alpha_s \cdot (1-\gamma_s) \cdot \left(\frac{y_s}{n^b_s} \right) \left(\frac{y_{s,t}/y_s}{v^p_{s,t}/v^p_s} \right)^{1/\iota} \left(\frac{v^p_{s,t}/v^p_s}{v^b_{s,t}/v^b_s} \right)^{1/\theta} \left(\frac{v^b_{s,t}/v^b_s}{n^b_{s,t}/n^b_s} \right)^{1/\phi} \tag{A.9}$$

$$mpl^p_{s,t} = \upsilon_s \cdot (1-\alpha_s) \left(\frac{y_s}{n^p_s} \right) \left(\frac{y_{s,t}/y_s}{v^p_{s,t}/v^p_s} \right)^{1/\iota} \left(\frac{v^p_{s,t}/v^p_s}{n^p_{s,t}/n^p_s} \right)^{1/\theta} \tag{A.10}$$

$$mpl^w_{s,t} = (1-\upsilon_s) \cdot \left(\frac{y_s}{n^w_s} \right) \cdot \left(\frac{y_{s,t}/y_s}{n^w_{s,t}/n^w_s} \right)^{1/\iota} \tag{A.11}$$

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$$\psi(\pi_{s,t}-1)\pi_{s,t} = \psi\beta\,\mathrm{E}_t\left\{\frac{\lambda_{t+1}}{\lambda_t}\frac{y_{s,t+1}}{y_{s,t}}\frac{\wedge_{s,t+1}}{\wedge_{s,t}}\frac{\pi_{s,t+1}}{\pi_{t+1}}(\pi_{s,t+1}-1)\pi_{s,t+1}\right\} + \epsilon\left(mc_{s,t} - \frac{p_{s,t}}{p_t}\frac{(\epsilon-1)}{\epsilon}\right) \tag{A.12}$$

The first-order conditions of the household problem are given by

$$c_{1,t} = \zeta\left(\frac{(1+\wedge_{1,t})p_{1,t}}{p_t}\right)^{-\mu} c_t \tag{A.13}$$

$$c_{2,t} = (1-\zeta)\left(\frac{(1+\wedge_{2,t})p_{2,t}}{p_t}\right)^{-\mu} c_t \tag{A.14}$$

$$1 = \left(\zeta\cdot\left(\frac{(1+\wedge_{1,t})p_{1,t}}{p_t}\right)^{1-\mu} + (1-\zeta)\cdot\left(\frac{(1+\wedge_{2,t})p_{2,t}}{p_t}\right)^{1-\mu}\right)^{1/(1-\mu)} \tag{A.15}$$

$$n^p_{1,t} = \aleph^p\left(\frac{(1-\wedge^p_t)w^p_{1,t}}{w^p_t}\right)^{\omega} n^p_t \tag{A.16}$$

$$n^p_{2,t} = (1-\aleph^p)\left(\frac{(1-\wedge^p_t)w^p_{2,t}}{w^p_t}\right)^{\omega} n^p_t \tag{A.17}$$

$$n^b_{1,t} = \aleph^b\left(\frac{(1-\wedge^b_t)w^b_{1,t}}{w^b_t}\right)^{\omega} n^b_t \tag{A.18}$$

$$n^b_{2,t} = (1-\aleph^b)\left(\frac{(1-\wedge^b_t)w^b_{2,t}}{w^b_t}\right)^{\omega} n^b_t \tag{A.19}$$

$$n^w_{1,t} = \aleph^w\left(\frac{(1-\wedge^w_t)w^w_{1,t}}{w^w_t}\right)^{\omega} n^w_t \tag{A.20}$$

$$n^w_{2,t} = (1-\aleph^w)\left(\frac{(1-\wedge^w_t)w^w_{2,t}}{w^w_t}\right)^{\omega} n^w_t \tag{A.21}$$

$$w^p_t = \left(\aleph^p\cdot((1-\wedge^p_t)w^p_{1,t})^{1+\omega} + (1-\aleph^p)\cdot((1-\wedge^p_t)w^p_{2,t})^{1+\omega}\right)^{1/(1+\omega)} \tag{A.22}$$

$$w^b_t = \left(\aleph^b\cdot((1-\wedge^b_t)w^b_{1,t})^{1+\omega} + (1-\aleph^b)\cdot((1-\wedge^b_t)w^b_{2,t})^{1+\omega}\right)^{1/(1+\omega)} \tag{A.23}$$

$$w^w_t = \left(\aleph^w\cdot((1-\wedge^w_t)w^w_{1,t})^{1+\omega} + (1-\aleph^w)\cdot((1-\wedge^w_t)w^w_{2,t})^{1+\omega}\right)^{1/(1+\omega)} \tag{A.24}$$

$$\lambda_t = \xi_t + \chi\tilde{\iota}_t\frac{x_t}{c_t} \tag{A.25}$$

$$x_t = c_t^{\chi}x_{t-1}^{1-\chi} \tag{A.26}$$

$$\tilde{\iota}_t = -\xi_t\Omega_t + \beta(1-\chi)\,\mathrm{E}_t\left\{\tilde{\iota}_{t+1}\frac{x_{t+1}}{x_t}\right\} \tag{A.27}$$

$$\Omega_t = \frac{\Omega^p}{1+1/\eta}(n^p_t)^{1+1/\eta} + \frac{\Omega^b}{1+1/\eta}(n^b_t)^{1+1/\eta} + \frac{\Omega^w}{1+1/\eta}(n^w_t)^{1+1/\eta} \tag{A.28}$$

$$\lambda_t = \beta\,\mathrm{E}_t\left\{\lambda_{t+1}\frac{(1+r_t)}{\pi_{t+1}}\right\} \tag{A.29}$$

$$\lambda_t q_{s,t} = \beta\,\mathrm{E}_t\left\{\lambda_{t+1}\left((1-\tau^k_{t+1})r^k_{s,t+1}u_{s,t+1} - \frac{(1+\wedge_{s,t+1})p_{s,t+1}}{p_{t+1}}e(u_{s,t+1}) + q_{s,t+1}(1-\delta)\right)\right\} \tag{A.30}$$

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$$
\begin{aligned}
\frac{(1+\wedge_{s,t})p_{s,t}}{p_t} &= q_{s,t}\left(1-\frac{\kappa_i}{2}\left(\frac{i_{s,t}}{i_{s,t-1}}-1\right)^2-\kappa_i\left(\frac{i_{s,t}}{i_{s,t-1}}-1\right)\frac{i_{s,t}}{i_{s,t-1}}\right)\\
&\quad+\beta\,\mathrm{E}_t\left\{\frac{\lambda_{t+1}}{\lambda_t}q_{s,t+1}\kappa_i\left(\frac{i_{s,t+1}}{i_{s,t}}-1\right)\left(\frac{i_{s,t+1}}{i_{s,t}}\right)^2\right\} \qquad \text{(A.31)}
\end{aligned}
$$

$$(1-\tau_t^k)r_{s,t}^k = \frac{(1+\wedge_{s,t})p_{s,t}}{p_t}\left(\delta_1+\delta_2(u_{s,t}-1)\right) \qquad \text{(A.32)}$$

$$w_t^b(1-\tau_t^n)\lambda_t = \Omega^b\left(n_t^b\right)^{1/\eta}x_t\xi_t \qquad \text{(A.33)}$$

$$w_t^p(1-\tau_t^n)\lambda_t = \Omega^p\left(n_t^p\right)^{1/\eta}x_t\xi_t \qquad \text{(A.34)}$$

$$w_t^w(1-\tau_t^n)\lambda_t = \Omega^w\left(n_t^w\right)^{1/\eta}x_t\xi_t \qquad \text{(A.35)}$$

$$\xi_t = (c_t-\Omega_t x_t)^{-\frac{1}{\sigma}} \qquad \text{(A.36)}$$

$$k_{s,t} = (1-\delta)k_{s,t-1}+\left(1-\frac{\kappa_i}{2}\left(\frac{i_{s,t}}{i_{s,t-1}}-1\right)^2\right)i_{s,t} \qquad \text{(A.37)}$$

$$e(u_{s,t}) = \delta_1(u_{s,t}-1)+\frac{\delta_2}{2}(u_{s,t}-1)^2 \qquad \text{(A.38)}$$

where $s=1,2$, and λ_t, $q_{s,t}\lambda_t$, and $\tilde{\imath}_t$ denote Lagrange multipliers on the household's budget constraint, the capital accumulation equations, and the definition of x_t, respectively, where $q_{s,t}$ is the shadow value of installed capital in sector s.

Fiscal and monetary policy are described by

$$
\begin{aligned}
\frac{p_{g,t}}{p_t}g_t+T_t+(1+r_{t-1})\frac{b_{t-1}}{\pi_t} &= b_t+\tau_t^n\left(w_t^bn_t^b+w_t^pn_t^p+w_t^wn_t^w\right)\\
&\quad+\tau_t^k\left(r_{1,t}^k\tilde{k}_{1,t}+r_{2,t}^k\tilde{k}_{2,t}\right) \qquad \text{(A.39)}
\end{aligned}
$$

$$g_{1,t} = \zeta_g\left(\frac{(1+\wedge_{1,t})p_{1,t}}{p_{g,t}}\right)^{-\mu}g_t \qquad \text{(A.40)}$$

$$g_{2,t} = (1-\zeta_g)\left(\frac{(1+\wedge_{2,t})p_{2,t}}{p_{g,t}}\right)^{-\mu}g_t \qquad \text{(A.41)}$$

$$\frac{p_{g,t}}{p_t} = \left(\zeta_g\cdot\left(\frac{(1+\wedge_{1,t})p_{1,t}}{p_t}\right)^{1-\mu}+(1-\zeta_g)\cdot\left(\frac{1+\wedge_{2,t})p_{2,t}}{p_t}\right)^{1-\mu}\right)^{1/(1-\mu)} \qquad \text{(A.42)}$$

$$\log g_t = (1-\rho_g)\log g+\rho_g\log g_{t-1}+\varepsilon_t^g \qquad \text{(A.43)}$$

$$\log\left(T_t\right) = (1-\rho_T)\log(T)+\rho_T\log\left(T_{t-1}\right)-\gamma_b\cdot(b_{t-1}-b)/y \qquad \text{(A.44)}$$

$$\tau_t^n-\tau^n = \rho_\tau(\tau_{t-1}^n-\tau^n)+\varepsilon_t^{\tau^n} \qquad \text{(A.45)}$$

$$\tau_t^k-\tau^k = \rho_\tau(\tau_{t-1}^k-\tau^k)+\varepsilon_t^{\tau^k} \qquad \text{(A.46)}$$

$$\log\left((1+r_t)/(1+r)\right) = \delta_\pi\log\left(\pi_t/\pi\right)+\delta_y\log\left(y_t/y\right)+\delta_g\log\left(g_t/g\right) \qquad \text{(A.47)}$$

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The following conditions describe goods market clearing for good $s = 1, 2$, inflation in sector s, and aggregate output y_t:

$$\begin{aligned}
y_{s,t} = (1 + \wedge_{s,t}) \Bigg(& c_{s,t} + i_{s,t} + g_{s,t} + e(u_{s,t})k_{s,t-1} + \frac{\psi}{2}(\pi_{s,t} - 1)^2 y_{s,t} \\
& + \frac{\kappa_{n,s}}{2} \left[\left(\frac{n^b_{s,t}}{n^b_{s,t-1}} - 1 \right)^2 + \left(\frac{n^p_{s,t}}{n^p_{s,t-1}} - 1 \right)^2 + \left(\frac{n^w_{s,t}}{n^w_{s,t-1}} - 1 \right)^2 \right] y_{s,t} \Bigg) \\
& + \frac{p_t}{p_{s,t}} \left(\wedge^p_t w^p_{s,t} n^p_{s,t} + \wedge^b_t w^b_{s,t} n^b_{s,t} + \wedge^w_t w^w_{s,t} n^w_{s,t} \right) \qquad \text{(A.48)}
\end{aligned}$$

$$\pi_{s,t} = \frac{p_{s,t}/p_t}{p_{s,t-1}/p_{t-1}} \pi_t \,, \qquad s = 1, 2 \qquad \text{(A.49)}$$

$$y_t = (p_{1,t}/p_t) y_{1,t} + (p_{2,t}/p_t) y_{2,t} \qquad \text{(A.50)}$$

We define data-consistent employment by sector $s = 1, 2$, occupation $o = p, b, w$, as well as aggregate employment as follows:

$$l_{s,t} = \frac{1}{1 + \wedge_{s,t}} \left(n^p_{s,t}(1 - \wedge^p_t) + n^b_{s,t}(1 - \wedge^b_t) + n^w_{s,t}(1 - \wedge^w_t) \right) \,, \qquad \text{(A.51)}$$

$$l^o_t = (1 - \wedge^o_t) \left(\frac{n^o_{1,t}}{1 + \wedge_{1,t}} + \frac{n^o_{2,t}}{1 + \wedge_{2,t}} \right) \,, \qquad \text{(A.52)}$$

and

$$l_t = l^w_t + l^b_t + l^p_t = l_{1,t} + l_{2,t}. \qquad \text{(A.53)}$$

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Classifications of industries and occupations

Table A.1: Assignment of NAICS industries to social and distant sector.

Industry	Sector
Agriculture, forestry, fishing and hunting	distant
Mining, quarrying, and oil and gas extraction	distant
Utilities	distant
Construction	distant
Manufacturing	distant
Wholesale trade	distant
Retail trade	social
Transportation and warehousing	
Warehousing and storage	distant
Truck transportation	distant
Pipeline transportation	distant
All other	social
Information	distant
Finance and insurance	distant
Real estate and rental and leasing	social
Professional, scientific, and technical services	distant
Management of companies and enterprises	distant
Administrative and support and waste management and remediation services	distant
Educational services; state, local, and private	social
Healthcare and social assistance	social
Arts, entertainment, and recreation	social
Accommodation and food services	social
Other services (except public administration)	social
Government	n.a.

Source: Kaplan, Moll, and Violante (2020).

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Table A.2: Assignment of SOC occupations to white-collar, blue-collar, and pink-collar occupation groups

Occupation	Group
Management occupations	white-collar
Business and financial operations occupations	white-collar
Computer and mathematical occupations	white-collar
Architecture and engineering occupations	white-collar
Life, physical, and social science occupations	white-collar
Community and social service occupations	pink-collar
Legal occupations	white-collar
Education, training, and library occupations	white-collar
Arts, design, entertainment, sports, and media occupations	white-collar
Healthcare practitioners and technical occupations	white-collar
Healthcare support occupations	pink-collar
Protective service occupations	blue-collar
Food preparation and serving related occupations	pink-collar
Building and grounds cleaning and maintenance occupations	pink-collar
Personal care and service occupations	pink-collar
Sales and related occupations	pink-collar
Office and administrative support occupations	white-collar
Farming, fishing, and forestry occupations	blue-collar
Construction and extraction occupations	blue-collar
Installation, maintenance, and repair occupations	blue-collar
Production occupations	blue-collar
Transportation and material moving occupations	blue-collar

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