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Labor Market and Fiscal Policy During and After the Coronavirus

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1 Introduction

What are the likely effects of coronavirus-related restrictions on the labor market and the macroeconomy? What are the likely effects of government policies on the unemployment rate and output? To answer these questions, I start by adapting a model I used in Auray, Eyquem, and Gomme (2019). Labor markets are characterized by search frictions summarized by a matching function (Diamond-Mortensen-Pissarides). Specifically, unemployed workers searching for a job, and firm vacancies come together in a matching function that determines the number of new firm-worker pairing. The remainder of the macroeconomy in the model is based on neoclassical foundation.

Next, I feed in 'educated guesses' for the impact effects of four exogenous shocks; the shocks then dissipate over the 18 months that the coronavirus is likely to directly affect the economy. First, relative to the pre-coronavirus U.S. economy, the job separation probability initially quadruple. While this is a rather large increase, on impact the job separation probability is not much higher than it was during the Great Recession. These separations are intended to reflect the outcome of lost revenues and the inability of workers to get to work

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in light of widespread lockdowns. To match the U.S. experience – a immediate and large increase in unemployment – the model simply needs such a large increase in separations. Second, match efficiency falls by 40%, capturing the difficulties workers and firms have in meeting when many firms are closed, and workers are restricted to their homes. Third, vacancy posting costs double. These costs capture a combination of the aforementioned difficulties firms have in recruiting when they are closed, and the inability of firms to obtain financing, some of which is used to pay for the up-front costs of recruiting. Finally, total factor productivity falls by 10%, capturing the loss in productivity of working from home, as well as disruptions to supply chains. By way of comparison, over the Great Recession, total factor productivity fell by 6.5%. When all four shocks are in play, absent a policy response, the outlook is dire: The model predicts that unemployment will peak at over 22.5% and output will fall by over 20%.

I consider four labor market policies. As with the shocks, these policies fade out over the 18 months of the coronavirus, reflecting the likelihood that these programs will be wound down, and that over time fewer firms and workers will quality for these programs. The first policy is a straight wage subsidy of 50%. While this policy reduces unemployment (by less than two percent) and cushions the fall in output (by 1.3 percentage points), it is not nearly as good as the second policy: a wage subsidy along with an employment guarantee (modeled as a return of the job separation probability to its pre-coronavirus value). This second policy is designed to get at policies in several countries, including Denmark and Canada, that tie the receipt of government help with firms' wage bills to those firms limiting job losses. Under this second policy, the unemployment rate initially rises to just over 10%, before falling gradually to its original value of 3.5%. Despite the improved unemployment performance, the model predicts a 14% decline in output. The third policy is more generous unemployment insurance. This policy is not particularly efficacious in terms of labor market outcomes: the model predicts a small increase in unemployment, and a slightly larger dip in output. To be sure, there are other reasons to increase the generosity of transfer programs like unemployment insurance; lowering the unemployment rate is simply not one of them. The final policy is a 50% subsidy to vacancy posting costs. This is a reduced-form way of incorporating a variety of programs aimed directly at firms, including various loan programs. Such a reduction in the cost of a vacancy lowers the peak unemployment rate by as much as six percentage points.

What if it takes a few months to actually implement these labor market policies? The model predicts that unemployment will be higher, and output lower, and for longer. A delay of one month implies a peak to the unemployment rate of 15.1% compared to just over 10.3% if there is no delay.

What happens when the coronavirus is no longer a pressing problem? According to the model, the government debt-output ratio will rise by around 30 percentage points. This is likely a conservative estimate of the rise in government debt since only labor market policy responses are considered. I evaluate the implications of restoring the debt-output ratio to its pre-coronavirus value through one of: the labor income tax, the capital income tax, or the sales tax (in Europe, the VAT). Since these taxes distort the economy in different ways, in principle the tax used to restore government debt levels should matter both during and after the coronavirus. Yet, visually, there is little difference in the model's predictions for most labor market and macroeconomic variables. The model indicates that substantial tax increases will be necessary. It may be tempting to simply leave the level of government debt permanently higher, but doing so will necessitate some sort of tax response – particularly if the economy exits this period of extraordinarily low real returns on government debt.

2 Economic Environment

2.1 The Family

The economy is populated by a large number of identical families. Each family consists of a large number of individuals A fraction e_t of family members are employed while the remaining fraction u_t is unemployed (and so seeking a job). The problems of employed and unemployed family members is discussed shortly. Here, I describe how the family allocates its resources given employment and unemployment.

The family cares about the discounted stream of utility received from consumption, c_t:

$$\sum_{t=0}^{\infty} \beta^t \mathcal{U}(c_t) \tag{1}$$

where $0 < \beta < 1$ is the discounting of next period utility. The family maximizes (1) subject to the sequence of budget constraints,

$$(1+\tau_{ct})c_t + k_{t+1} + d_{t+1} + T_t = (1-\tau_{wt})w_t e_t + b_t u_t + R_t^k k_t + R_{t-1}^d d_t + \pi_t. \tag{2}$$

Each employed family member receives after-tax earning $(1-\tau_{wt})w_t$ while each unemployed brings home an unemployment insurance benefit, b_t. The family brings into the period capital, k_t, from which it earns the return $R_t^k = 1 + (1-\tau_{kt})(r_t - \delta)$ where τ_{kt} is the tax rate on capital income net of depreciation (capital consumption). The family also brings into the period maturing government debt, d_t; this debt pays a real gross return, R_{t-1}^d. The final source of family income is distributed profit income, π_t. The family divides these resources between consumption (upon which it pays a sales tax, τ_{ct}), next period capital, purchases of government debt, and payment of a lump-sum tax, T_t.

The equations governing capital and bond equations (the Euler equations) are:

$$1 = \Delta_{t,t+1} R_{t+1}^k \tag{3}$$

$$1 = \Delta_{t,t+1} R_t^d \tag{4}$$

where

$$\Delta_{t,t+1} \equiv \frac{\beta \frac{\mathcal{U}'(c_{t+1})}{1+\tau_{c,t=1}}}{\frac{\mathcal{U}'(c_t)}{1+\tau_{ct}}}. \tag{5}$$

is the intertemporal marginal rate of substitution. This last term proves useful in describing the problems of firms and workers.

2.2 The Labor Market

Both firms and workers find the matching process costly and time consuming. Total matches, m_t, are determined by a Diamond-Mortensen-Pissarides-style matching function,

$$m_t = M(v_t, u_t; \mu_t). \tag{6}$$

The matching function, M, is constant returns to scale in unemployment, u_t, and vacancies, v_t. μ_t reflects match efficiency. Matches formed at time t do not start producing until the following period. Consequently, employment evolves over time according to

$$e_{t+1} = (1 - s_t)e_t + m_t \tag{7}$$

where s_t is the (exogenous) separation rate.

From the specification of matches above, it follows that the probability that a worker finds a job is

$$f_t = \frac{m_t}{u_t} = M\left(\frac{v_t}{u_t}, 1; \mu_t\right) \tag{8}$$

while the probability that a vacancy is filled is

$$a_t = \frac{m_t}{v_t} = M\left(1, \frac{u_t}{v_t}; \mu_t\right). \tag{9}$$

In (8) and (9), the second equality uses the constant-returns-to-scale property of the matching function, M. The ratio of vacancies to unemployed, v_t/u_t, or *labor market tightness* is a key variable in much of the search-and-matching literature.

The next task is to determine both the number of vacancies as well as the number of searchers (unemployed). To do so, I need to establish the incentives for firms to post vacancies, and for individuals to spend time unemployed. In turn, these incentives depend on values of various activities.

Start with the supply side of the labor market. As discussed earlier, at each date an individual is either employed or unemployed. Denote the capital value of each of these by

W_t and U_t, respectively. The capitalized value of looking for a job is

$$U_t = b_t + \Delta_{t,t+1}\left[f_t W_{t+1} + (1 - f_t)U_{t+1}\right]. \tag{10}$$

b_t, the unemployment benefit, is the current payoff to being unemployed. Next period, the individual finds a job with probability f_t which has value W_t. Alternatively, with probability $1 - f_t$ the individual remains unemployed. These future returns are discounted back to the present via the marginal rate of substitution, $\Delta_{t,t+1}$.

The value of working is

$$W_t = (1 - \tau_{wt})w_t + \Delta_{t,t+1}\left[(1 - s_t)W_{t+1} + s_t U_{t+1}\right]. \tag{11}$$

The first term on the right-hand side is current after-tax labor income. Next period, the employment relationship terminates with probability s_t, the likelihood of a separation, in which case the individual is unemployed. Alternatively, with probability $(1 - s_t)$, the worker remains matches and continues as employed. Again, these future returns are discounted by the intertemporal marginal rate of substitution.

Each firm consists of a large number of (potential) jobs. The firm produces output

$$y_t = F(k_t, e_t; z_t) \tag{12}$$

where k_t is capital, e_t employment, and z_t is total factor productivity. The production function, F, is constant returns to scale in capital and labor.

Let J_t denote the capital value of the last (marginal) worker hired, and V_t the capital value of posting a vacancy. The value of a vacancy is

$$V_t = -(1 - \tau_{vt})\kappa_t + \Delta_{t,t+1}\left[a_t J_{t+1} + (1 - a_t)V_{t+1}\right]. \tag{13}$$

At time t, it costs κ_t to post a vacancy, with the government providing a subsidy at the rate τ_{vt}. This vacancy results in a job match with probability a_t, where this match has the value J_{t+1}. Alternatively, no match occurs with probability $(1 - a_t)$. Notice that the firm discounts the future using the same marginal rate of substitution, $\Delta_{t,t+1}$, as its representative owner, the family. Since the firm has plenty of potential positions, it should post vacancies to the point that the last vacancy has a value of zero: $V_t = 0$.[1]

The value to the firm of the marginal worker is

$$J_t = F_2(k_t, e_t; z_t) - (1 - \tau_{st})w_t + \Delta_{t,t+1}\left[(1 - s_t)J_{t+1} + s_t V_{t+1}\right] \tag{14}$$

where τ_{st} is a wage subsidy. In the current period, the firm receives the marginal product of labor, $F_2(k_t, e_t; z_t)$, less the wage payment. Next period, the match dissolves with probability s_t in which case the position is vacant; or, the match continues with probability $(1-s_t)$ which has value J_{t+1}.

The firm also chooses how much capital to rent from the family. Given the rental rate, r_t, its capital decision is governed by

$$F_1(k_t, e_t; z_t) = r_t \tag{15}$$

which is a no-arbitrage condition equating the marginal return to hiring an additional unit of capital (the marginal product of capital, $F_1(k_t, e_t; z_t)$) with the cost of hiring that unit.

Finally, firm profits are

$$\pi_t = F(k_t, e_t; z_t) - (1 - \tau_{st})w_t e_t - r_t k_t - (1 - \tau_{vt})v_t \kappa_t. \tag{16}$$

That is, profits are output less factor payments, and less vacancy posting costs.

2.3 Wage Determination

As is typical of the search-and-matching literature, wages are determined through generalized Nash bargaining:

$$w_t = \text{argmax}\,(W_t - U_t)^{\theta}(J_t - V_t)^{1-\theta} \tag{17}$$

[1] The literature assumes that a firm is a job and motivates $V_t = 0$ via a free entry condition.

where θ is the workers' bargain strength. In (17), $W_t - U_t$ is the worker's surplus of being matched: the value of being matched, W_t, less the worker's outside option, U_t (remain unemployed). Similarly, $J_t - V_t$ is the firm's surplus: the value of being matched, J_t, less the value of being vacant, V_t. Since $V_t = 0$, the wage satisfies

$$(1-\theta)(W_t - U_t) = \theta \frac{1-\tau_{wt}}{1-\tau_{st}} J_t. \tag{18}$$

(18) implies that workers receive a constant fraction of match surplus, with this fraction determined by the worker's bargaining strength, θ.

2.4 Government

The government's primary deficit is

$$\text{DEF}_t = g_t + b_t u_t + \tau_{vt} v_t \kappa_t + \tau_{st} w_t n_t - \tau_{ct} c_t - \tau_{wt} w_t e_t - \tau_{kt}(r_t - \delta) k_t - T_t. \tag{19}$$

where g_t, denoting government spending; all other variables have previously been defined. After the coronavirus crisis, the government chooses one of its fiscal policy instruments to satisfy a fiscal policy feedback rule which ensures stationary of government debt. The specific rule is as in Auray, Eyquem, and Gomme (2019):

$$\frac{\text{DEF}_t}{y_t} - \frac{\text{DEF}}{y} = -\omega \left[\frac{d_t}{y_{t-1}} - \frac{d}{y} \right] \tag{20}$$

where d/y is the long run target for the government debt-output ratio, and DEF/y is the corresponding target for the deficit-output ratio. This rule says that the government runs smaller primary deficits when its debt is above target. The parameter ω governs the speed at which the government returns the debt-output ratio to target.

3 Calibration

The utility, production and matching functions are:

$$U(c, n) = \ln(c) \tag{21}$$

$$F(k, e; z) = zk^{\alpha}e^{1-\alpha} \tag{22}$$

$$M(v, u; \mu) = \mu v^{\phi}u^{1-\phi}. \tag{23}$$

A model period is a month which is short enough to capture rapidly moving events during the coronavirus period, as well as to be consistent with key U.S. labor market facts like the average durations of unemployment and of a job.

The capital share parameter, α, is set to 0.3. The depreciation rate, δ, to 0.5851% which is consistent with an annual rate of 6.8%. The values of α and δ are consistent with measurements for the U.S. economy reported in Gomme and Rupert (2007). Steady state total factor productivity, z, is set to one, an innocuous normalization (choice of units). ϕ, the elasticity of matches with respect to vacancies, is set to 0.544, the value estimated by Mortensen and Nagypál (2007). Efficiency dictates setting the worker's bargaining parameter, θ, to $1 - \phi$. Given the current low real interest rate environment, the steady state annual real interest rate is set to 1%; this value of most relevant for fiscal policy, although not for capital.

To compute model solutions, I need an initial condition that reflects conditions in the U.S. just prior to the coronavirus. Given that this paper focuses on the labor market, it is particularly important to make sure that the initial conditions reflect the favorable labor market conditions prevailing at that time. Consequently, I use facts from late 2019 for both the U.S. labor market as well as fiscal policy. As of late 2019, the monthly job-finding probability was 48.23% while the job-separation probability was 1.76%; these values imply a steady state unemployment rate of 3.5% which also corresponds to the observed value into early 2020. The vacancy cost, κ, and constant in the matching function, μ, are chosen so that in steady state the model matches the unemployment rate implied by the job-finding and job-filling probabilities, as well $u_t = v_t$ (the units for vacancies is not well-specified, and this last condition amounts to a choice of units for vacancies).

For fiscal policy, government's share of output in late 2019 was 17.55%, the debt-output ratio was 107% (expressed at an annual rate), the tax on consumption 3.55%, the capital income tax rate 21.68% and the labor income tax rate 29%. The unemployment insurance benefit, b, is set to 25% of the steady state after-tax wage. The value of the replacement rate reflects not only the policy rate, but also the low take-up rate for unemployment insurance benefits, as well as the upper bound on benefits. Initially, there is no subsidy to vacancies. The lump-sum tax, T, is then chosen to satisfy the steady state version of the government budget constraint. The policy feedback parameter, ω, is set to 0.015. While this value is considerably smaller than used by Auray, Eyquem, and Gomme (2019), in their paper a model period was a quarter while here is is a month.

The model is solved as a two point boundary problem (Fair and Taylor, 1983); see Auray, Eyquem, and Gomme (2016) for details. The coronavirus is an unanticipated shock at the start of the problem, but thereafter the model is solved assuming perfect foresight.

4 The 'Coronavirus' Shocks

I assume that the immediate effects of the coronavirus are: a quadrupling of the separation probability, s; a doubling of the vacancy cost, κ; a 40% fall in match efficiency; and a 10% fall in total factor productivity. In the results below, this initial period is March 2020. Thereafter, these shocks return linearly to their steady state values over the following 18 months. At this early date, these effects are, at best, educated guesses.

As of this writing, the unemployment rate has risen sharply, and is expected to continue to rise. An increase in the probability of a separation will deliver such an increase, and arguably reflects the effects of businesses firing and laying off workers due to lost revenues. While this increase in the separation probability is quite large, the separation rate prior to the coronavirus was was lower than it was prior to the Great Recession. It seems plausible that the labor market effects of the coronavirus will be more extreme.

The increase in the vacancy cost and decrease in match efficiency both reflect difficulties of worker and firms finding each other when many businesses are closed and many workers at restricted to staying at home. The higher vacancy cost also captures difficulties encountered by firms in paying for recruiting in the face of lost revenues, and an inability to borrow on conventional terms. To put the increase in the vacancy cost into perspective, Auray, Eyquem, and Gomme (2019) found that a tripling of the vacancy cost was necessary to fit labor market facts over the Great Recession. Separately, they also found that a 40% decline in match efficiency could match some labor market facts over the Great Recession.

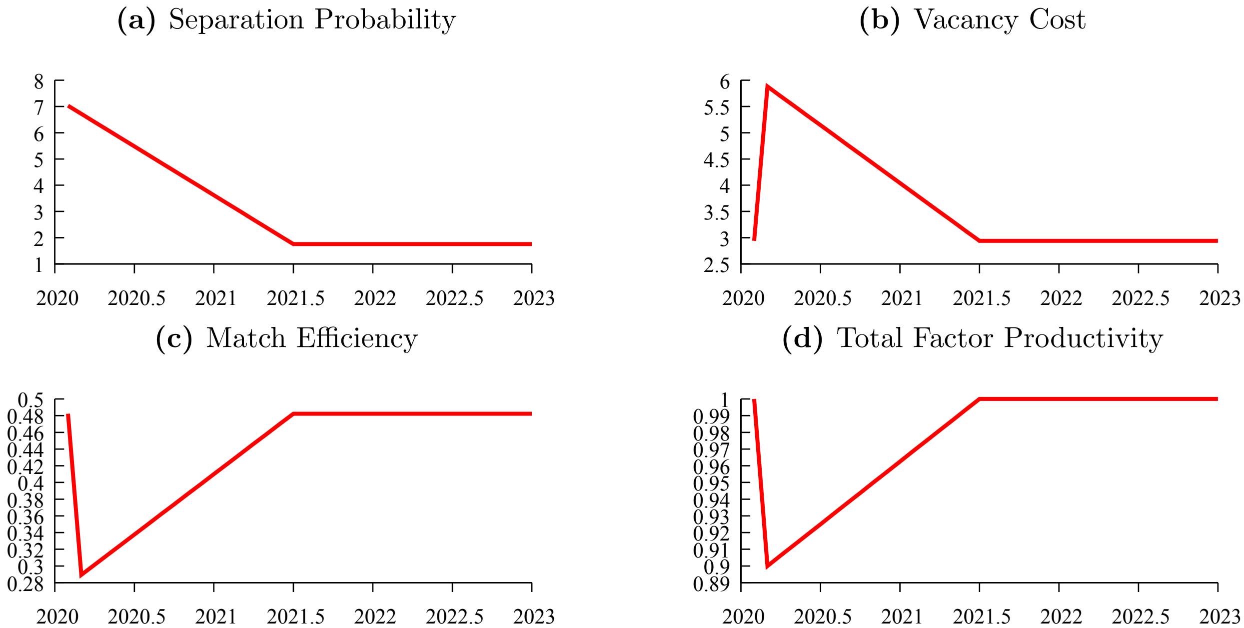
Finally, a reduction in total factor productivity plausibly reflects lost productivity associated with working at home. A 10% decline in total factor productivity is also quite large – from just prior to the Great Recession to its depths, measured total factor productivity fell by around 6.5%. The fall in productivity captures losses due to businesses being shut down, as well as lower efficiency of working from home (for those workers able to do so). The time paths of the four shocks are depicted in Figure 1.

So as not to take a stand on which distortionary tax the government might use to reduce its post-coronavirus debt, I assume that the government has access to non-distorting lump-sum taxes. Section 4.3 looks at the implications os restoring the level of government debt through distortionary taxation.

4.1 The Effects of the Shocks

To understand the results of the model with *all* shocks, it helps to first consider each shock in isolation. The most immediate effect of an increase in the separation probability is to shift workers from jobs into unemployment. As shown in Figure 2(c), the unemployment rate immediately rises to 10.3% (from 3.5%). An increase in the likelihood of a separation has two effects. First, by reducing the average duration of a match (the average length of

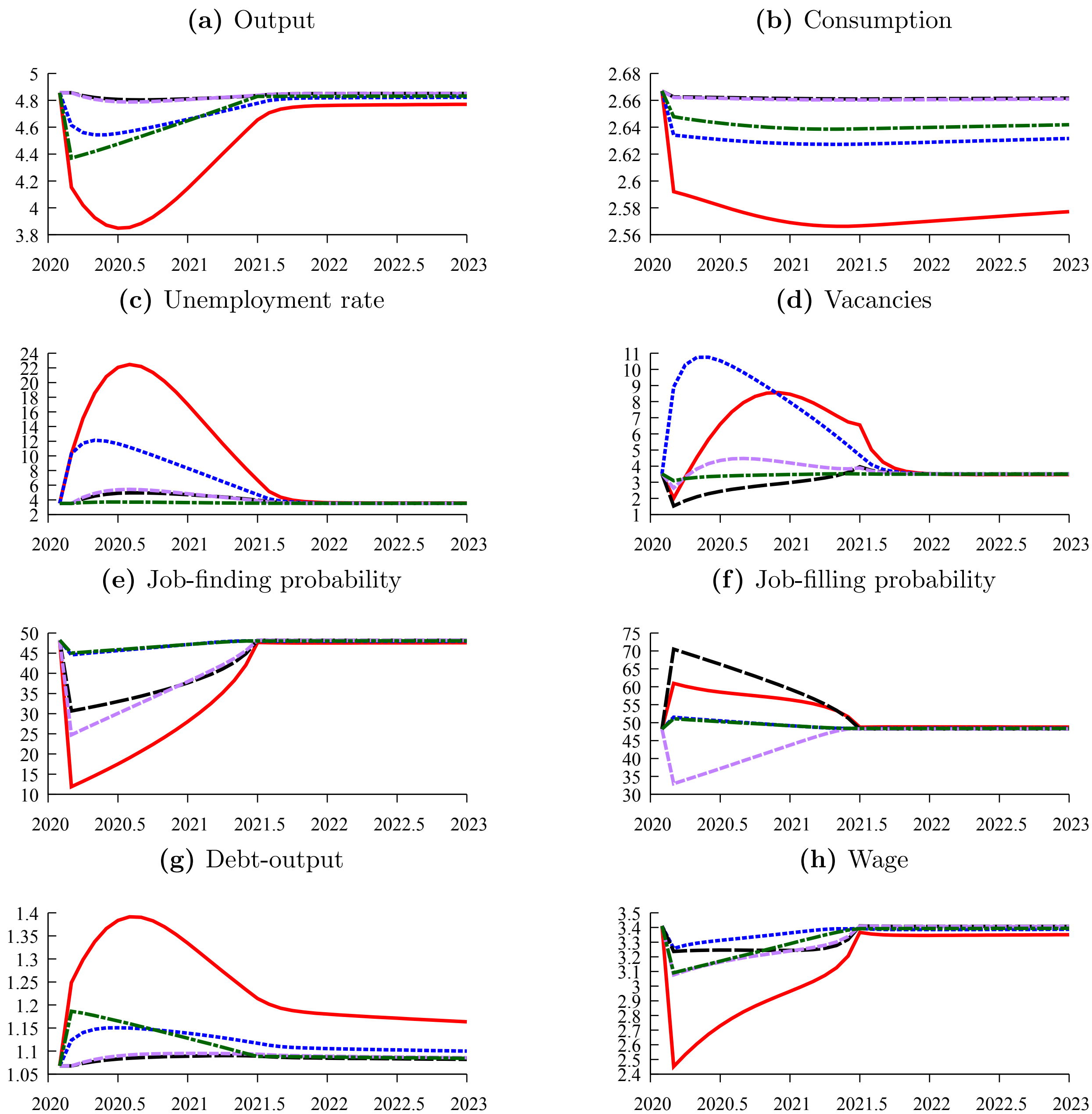
Figure 1: The Coronavirus Shocks



time of a firm-worker match), an increase in the separation probability reduces the value of a match which tends to reduce the number of vacancies firms post. However, since the increase in the job separation probability dissipates over the following 18 months, the drop in match surplus is modest: The value of being in a match is the discounted value of producing (with proper accounting for the possibility of a separation), and since the effects of the shocks disappear after 18 months, this present value simply does not change very much. Second, by increasing the flow of workers from employment to unemployment, a higher separation probability leads to an increase in vacancies to re-fill those jobs. As shown in Figure 2(d), this second effect dominates.

The higher job-posting cost, κ, directly discourages firms from posting vacancies; see Figure 2(d). The effect of this decline in vacancies is to reduce the number of matches, an effect that is reflected in the lower job-finding probability in Figure 2(e). At the same time, the job-filling probability increases as shown in Figure 2(f). The effect of the increase in the vacancy cost is to push the unemployment rate up to nearly 5% six months after the onset of the coronavirus.

Figure 2: Implications of Individual Shocks



Key: Blue dotted line: higher separations. Black long-dashed line: high vacancy cost. Purple dashed line: lower match efficiency. Green dash-dot line: lower total factor productivity. Red solid line: all shocks.

Holding fixed both vacancies and unemployment, a decline in match efficiency would result in a decrease in matches and so an increase in unemployment. Since such a fall in match efficiency reduces the probability of filling a job, as shown in Figure 2(f), firms reduce their vacancies (Figure 2(d)) since the payoff is lower. This shock results in a rise in the unemployment rate to 5.4% six months after the onset of the coronavirus crisis.

Finally, the principal effects of a reduction in total factor productivity are to reduce output and the wage; see Figures 2(a) and 2(h). The fall in the wage is an outcome of Nash bargaining which implies that firms and workers share the losses associated with lower productivity. Lower match surplus leads to fewer vacancies, but this effect is quite modest. So too are the implications for unemployment which rises, at most, 0.2 percentage points.

In a year or two, actual data will be available to give a fairly direct read on what happened to the job-separation probability during the coronavirus time. In addition, measured Solow residuals will give a pretty good picture of what happened to total factor productivity. However, it will be difficult to come up with direct evidence concerning what happened to either match efficiency or job-posting costs. Notice, however, that these two variables have much different implications for the job-filling probability: lower match efficiency says that this probability goes down while higher vacancy costs says the probability goes up. In the data, the job-filling probability is best reflected in the average duration of a vacancy (how long it takes firms to fill a job). As pointed out in Auray, Eyquem, and Gomme (2019), an increase in vacancy posting costs is consistent with the lower duration of a vacancy during the Great Recession while lower match efficiency is not.

Figure 2 also gives the effects of all four shocks at once. Of particular interest is the fact that these effects are more than additive. In particular, the increase in the separation probability raised the unemployment rate by at most 8.5 percentage points; the vacancy cost, 1.4 percentage points; match efficiency, 1.9 percentage points; and productivity, 0.2 percentage points. Adding these effects together gives a total of 12 percentage points, roughly 2/3 of the predicted 18.5 percentage point increase when all shocks are present. The implications for output are a severe contraction of over 20%. The implications for consumption (a more modest decline of 3.8%) are cushioned by an near collapse in investment (a fall of 95%, not depicted).

Clearly, I may have overstated the size of the changes in the underlying shocks. Figure 3 provides some idea of the sensitivity of the model's predictions by excluding one shock at a time (and so keeping the other three). Figure 3(c) shows that the increase in the unemployment is lowest if there is no change in separations. In this case, the unemployment rate 'only' rises to 7.5%. However, even at this early date, it is clear that unemployment – and by implication separations – have risen sharply. Even if the separation probability only doubled, with the other shocks in play, the unemployment rate is predicted to rise to 13%.

Absent the increase in vacancy costs, or the decrease in match efficiency, the unemployment rate still peaks above 16%. Removing the decline in total factor productivity has a very modest effect on the unemployment rate.

Admittedly, these are rough guesses for the magnitudes of the shocks being experienced by the U.S. economy. Nonetheless, these guesses would have to be far off the mark for the model to predict that the coronavirus will resemble anything less than a Great Depression-like episode

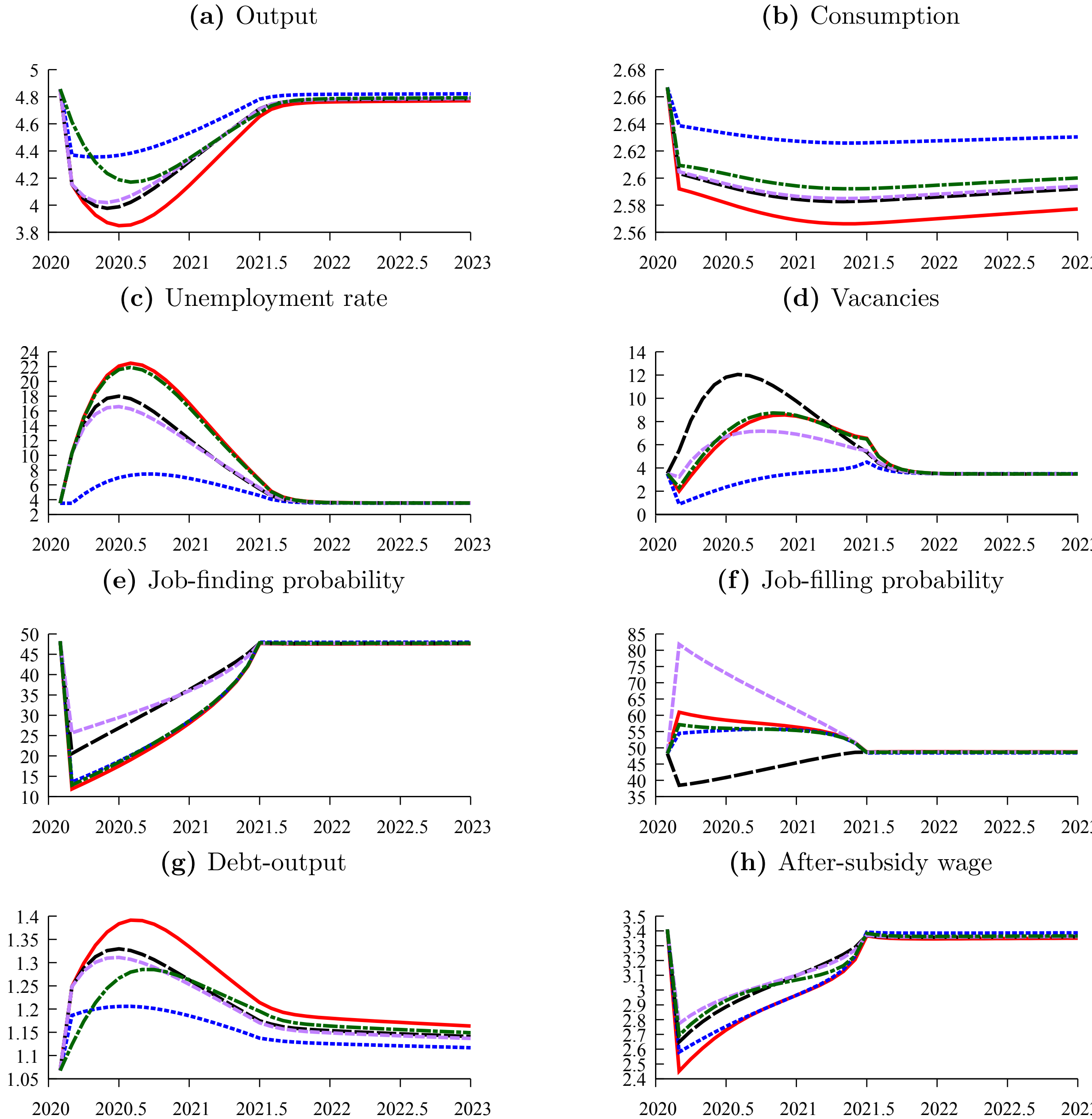
4.2 Policy Interventions

Given the baseline coronavirus scenario (the rise in separations and vacancy cost, the fall in match efficiency and productivity), I evaluate three policy interventions: a wage subsidy (with or without an employment guarantee), more generous unemployment insurance benefits, and a subsidy to vacancies (hiring).

4.2.1 A Wage Subsidy

A number of countries, including Canada and Denmark, are subsidizing wages during the coronavirus crisis. The fraction of wages covered as well as the number of firms and industries

Figure 3: Implications of Excluding One Shock at a Time



Key: Red solid line: Baseline with all shocks. Blue dotted line: no change in separations. Black long-dashed line: no change in the vacancy cost. Purple dashed line: no change in match efficiency. Green dash-dot line: no change total factor productivity.

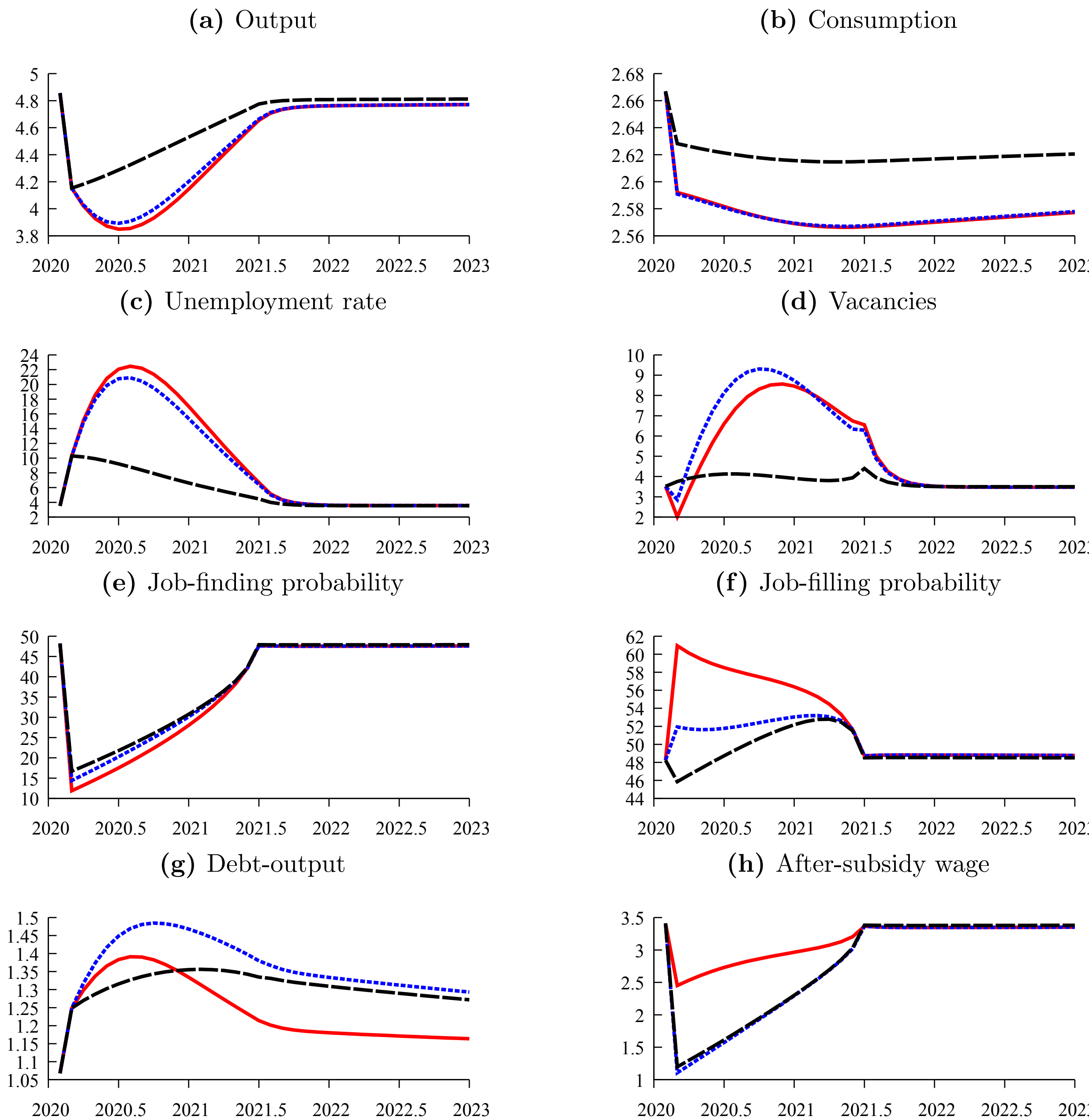
varies. The experiment considered here is an immediate 50% wage subsidy ($\tau_s = 0.5$), tapering off to zero over 18 months. The reason for reducing the wage subsidy over time is that it seems likely that governments will indeed reduce the subsidies as economies re-open, and that even without explicit reductions in subsidy rates, over time fewer firms will qualify. A straight wage subsidy has very little effect as shown in Figure 4. However, legislation to date has tied the receipt of wage subsidies to employment guarantees. To account for such employment guarantees, consider a policy of subsidizing wages along with a return of the separation rate to its pre-coronavirus value. To capture the fact that, at least in the U.S., a number of separations occurred shortly after the coronavirus lockdown, I assume that the initial wave of separations still occurs. Even so, as seen in Figure 4(c), such a policy holds the unemployment rate to 10.3%, with this rate returning to its original 3.5% level by the end of the coronavirus period. Figure 4(a) suggests that on impact, output drops 14.5%, and that this output loss is protracted.

4.2.2 More Generous Unemployment Insurance

U.S. legislation calls for extending unemployment insurance benefits by 13 weeks. Other countries have similarly extended the maximum benefit period, as well as allowing individuals who would not otherwise quality for these benefits to receive them. While the model does not have a fixed benefit period to extend, unemployment insurance generosity can be captured by simply increasing the unemployment insurance benefit, b. To this end, assume that benefits rise immediately by 50%, then decline linearly over the subsequent 18 months of the coronavirus.

If the goal is to bring down the unemployment rate, Figure 5(c) suggests that such a policy is a bust. More generous unemployment insurance increases the worker's outside option in the wage negotiation process, resulting in a higher wage as shown in Figure 5(h). Since firms' surplus falls, they post fewer vacancies (Figure 5(d)) and workers find it more difficult to find a job (Figure 5(e)). That said, these effects are modest, and there are reasons

Figure 4: Implications of a Wage Subsidy



Key: Red solid line: Baseline with all shocks. Blue dotted line: wage subsidy. Black dashed line: wage subsidy with employment guarantees.

outside the model for wanting to increase unemployment insurance benefits.

4.2.3 Subsidizing Vacancies

Earlier, I motivated the increase in the vacancy cost as reflecting difficulties firms face in obtaining loans on term prevailing prior to the coronavirus. Since U.S. legislation puts in place loans programs for firms, one way to capture the labor market implications of such programs is as a subsidy to firms' vacancy costs. I assume that the subsidy starts at a 50% rate, declining linearly over the next 18 months. As with the wage subsidy, the declining vacancy subsidy captures the idea that the effects of these loans programs will be strongest early in the coronavirus time, and diminish over time.

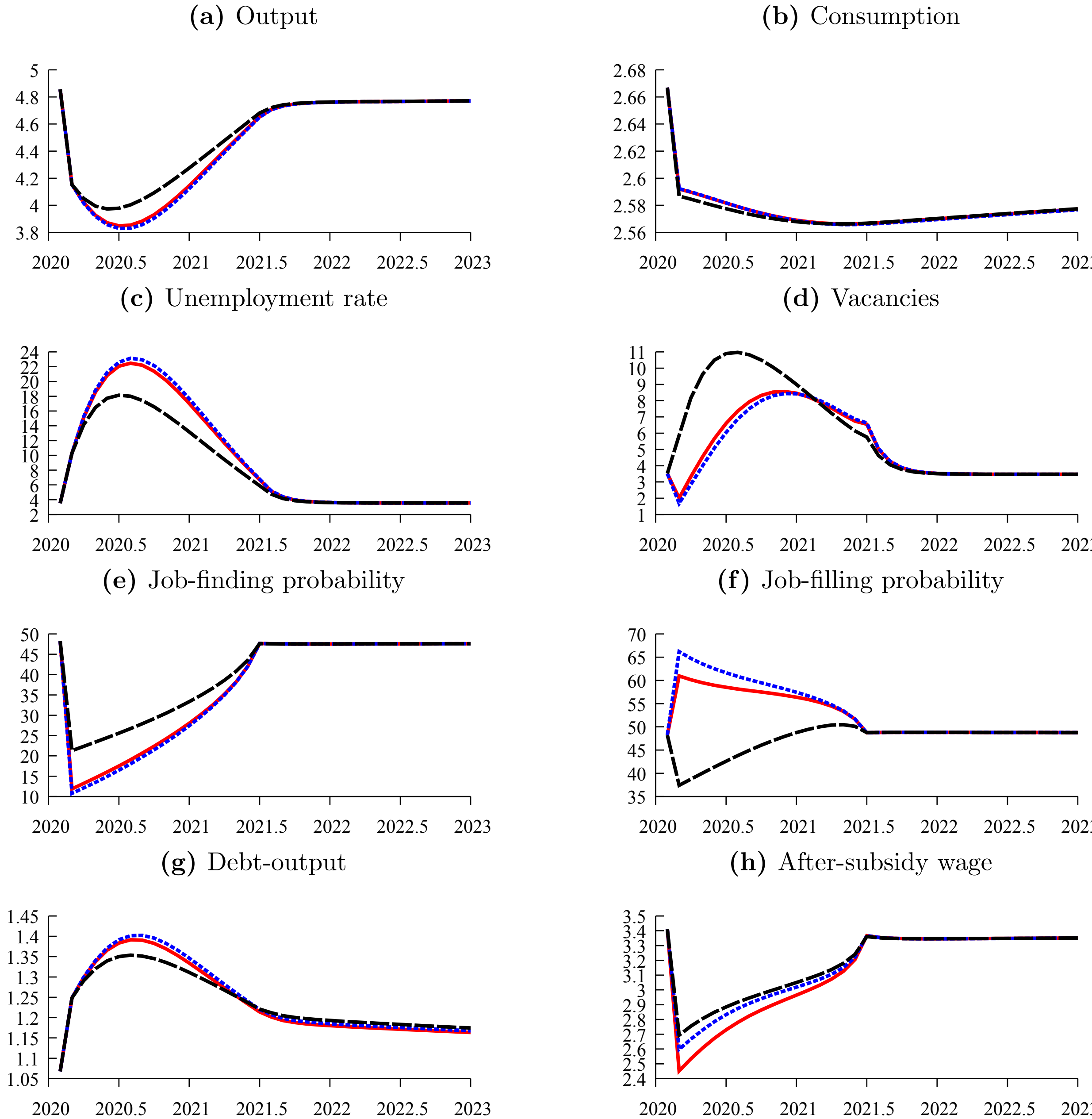
Naturally, a policy of subsidizing vacancies leads to more vacancies. Given that the subsidy rate (initially, 50%) exactly offsets the increased vacancy cost (initially, doubled), it should not be surprising that the model predicts that the economy evolves over time much like in Figure 3 when the increase in the vacancy cost was removed from the model. Higher vacancies lead to more job matches, and so lower unemployment. Nonetheless, the unemployment rate peaks at 18.1%, and output is predicted to fall by as much as 18.2% relative to its pre-coronavirus value.

4.2.4 All the Policies

Figure 6 presents the model's predictions when the wage subsidy, increased unemployment insurance generosity, and subsidized vacancies are all in place. To emphasize the importance of tying a wage subsidy to some sort of employment guarantee, I separately report results when there is only a wage subsidy, and when the wage subsidy is accompanied by an unchanging separation probability (apart from the initial period).

Absent the employment guarantee, the unemployment rate peaks at 17.3% compared to 10.3% with the guarantee. Furthermore, with the employment guarantee, the unemployment rate starts to decline after the first month. While the no-employment guarantee set of policies

Figure 5: Implications of Increased Unemployment Insurance and Subsidized Vacancies



Key: Red solid line: Baseline with all shocks. Blue dotted line: increased unemployment insurance. Black dashed line: vacancy subsidy.

leads to higher vacancies, they are not sufficiently higher to offset the deleterious effects of the higher likelihood of job separations.

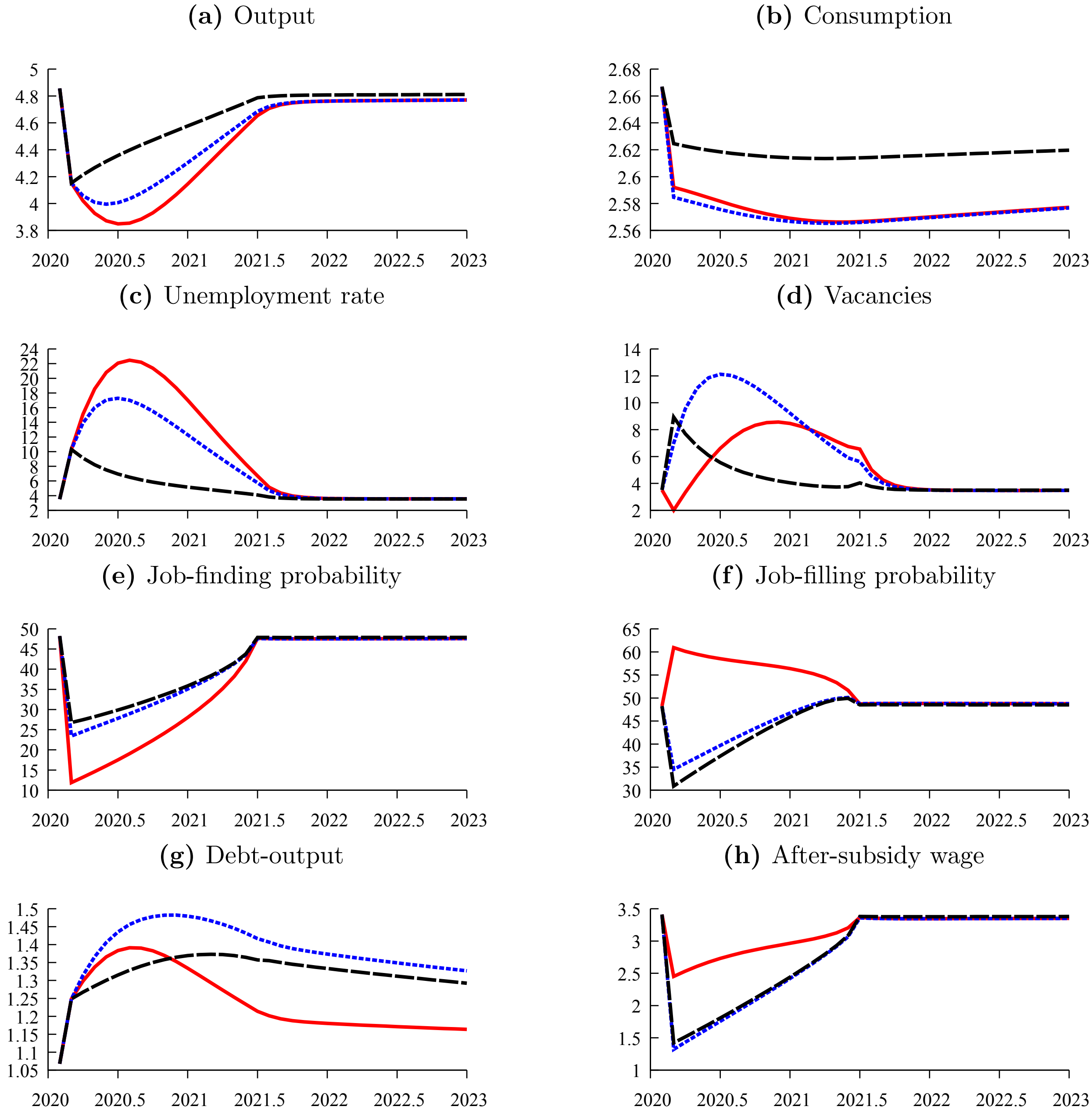
Output plummets 14.5% with the employment guarantee with a gradual, 18 month return to steady state. Absent the employment guarantee, the model predicts that output declines by as much as 17.5% relative to trend, five months into the coronavirus crisis; at the same five month horizon, the employment guarantee is associated with 'only' a 10.3% loss of output relative.

4.2.5 The Cost of Delay

The analysis thus far has proceeded as if the government recognizes the labor market problems presented by the coronavirus and immediately puts in place the wage subsidy with an employment guarantee, increased unemployment insurance generosity, and subsidy to vacancies. What if the government cannot act so quickly? Figure 7 compares the immediate policy response with a delay of one, three, six and nine months. The delayed policies are those that would have prevailed if the policy intervention occurred immediately. While the implementation of the policy is delayed, it is assumed that model agents *know* that the policy will be enacted right from the start of the coronavirus period.

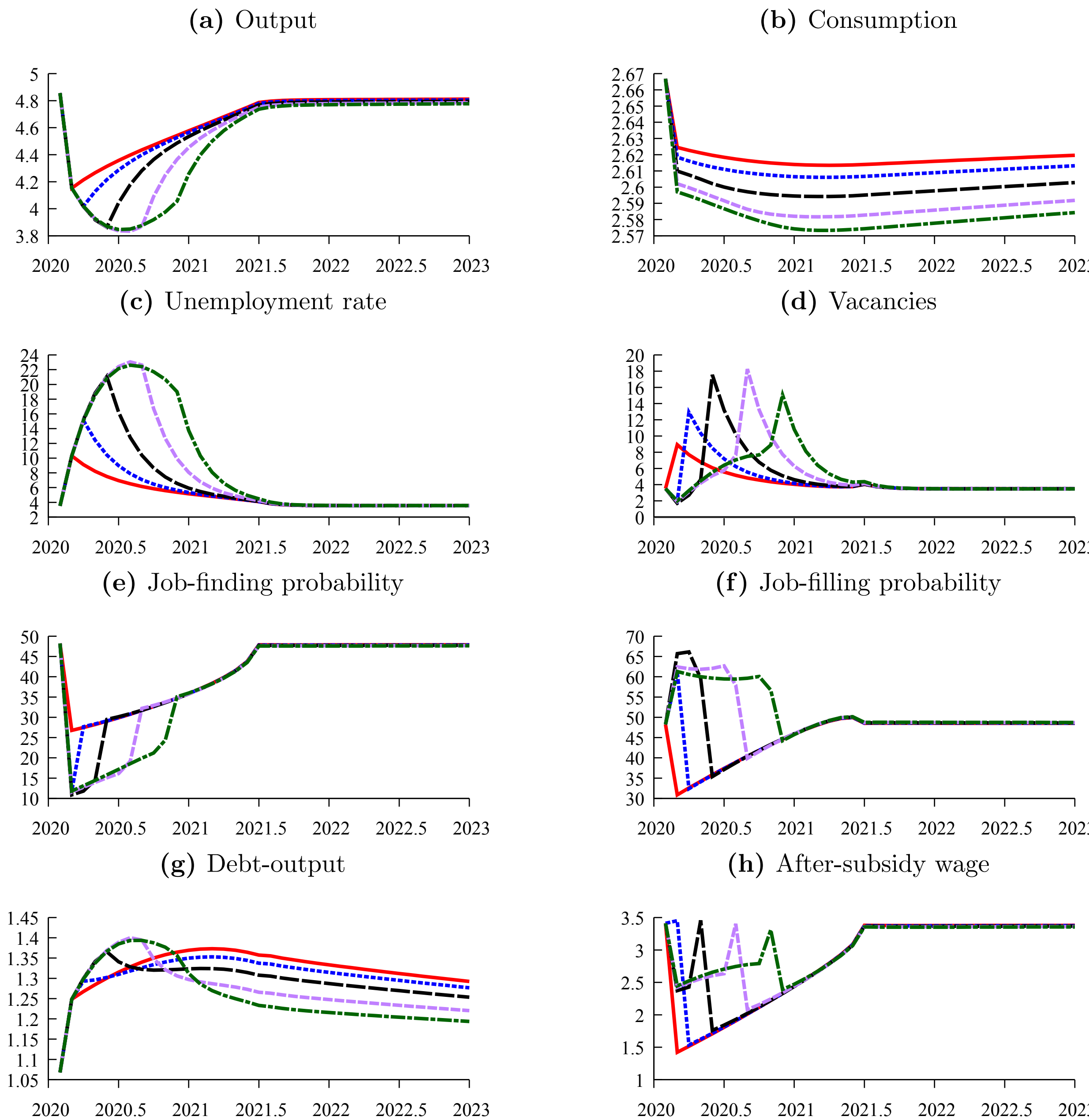
Delay pushes the peak response of vacancies out by the same number of months. As a consequence, unemployment stays higher for a longer period of time as the government delays. A delay as short as a month results in a peak unemployment rate of 15.1% – five percentage points higher than if policy is immediately implemented. While there is little difference in the unemployment rate peak when comparing a delay of six and nine months, the nine month delay needlessly keeps the unemployment rate considerably higher for many months. The model predicts that output losses are similarly larger as policy implementation is delayed.

Figure 6: Implications of All Policies



Key: Red solid line: baseline with all shocks, no policy intervention. Blue dotted line: wage subsidy, increased unemployment insurance, subsidized vacancies. Black dahsed line: in addition, employment guarantees.

Figure 7: Implications of A Delayed Policy Response



Key: Red solid line: No delay. Blue dotted line: 1 month delay. Black long-dashed line: 3 month delay. Purple dashed line: 6 month delay. Green dash-dot line: 9 month delay.

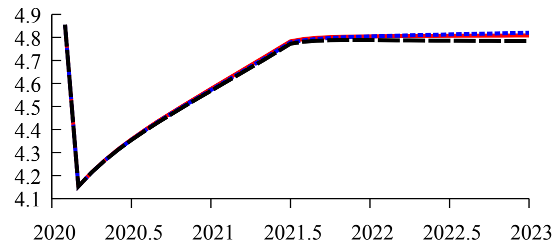
4.3 After

Thus far, I have presented model results under the favorable assumption that the government pays for its coronavirus policies through lump-sum taxes starting immediately after the coronavirus period. In truth, governments do not really have access to such non-distortionary taxes, and must rely on some combination of labor income, capital income, and sales taxes. Figure 8 presents results for using *one* of these tax rates to return the government debt-output ratio to its pre-coronavirus value gradually over time as specified by the fiscal policy rule, (20). Using the labor income tax rate requires an initial increase in this rate from 29% to 37.1%; it then falls monotonically back to 29% over many years. Restoring the debt-output ratio through the capital income tax rate calls for an increase from 21.68% to 123.2%. While a capital income tax rate in excess of 100% may seem ridiculous, keep in mind that in the short term, capital is inelastically supplied, and there is little that the owners of capital can do apart from reducing their investment prior to the application of such a tax rate. While such a high capital income tax rate reduces investment – and so the capital stock – these effects are modest. Were they not, the paths for output across the three tax rates would differ markedly, yet they do not as shown in Figure 8(a). Increasing the sales tax rate from 3.55% to (initially) 14.6% also eventually restores the government debt-output ratio to its pre-coronavirus value. This level of consumption taxation would not be shocking to either Europeans or Canadians.

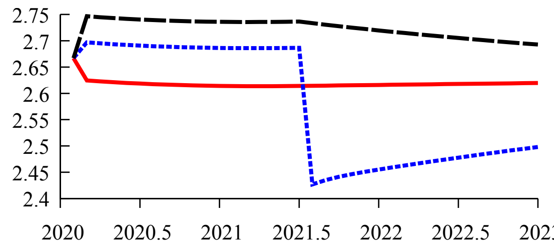
There are two particularly interesting results in Figure 8. First, labor market variables and output look quite similar across the three tax rates. Second, the paths for consumption do differ. When agents know that the government will pay for its coronavirus policies through the sales tax, they increase their consumption when the tax rate is still low (during coronavirus), then reduce consumption sharply when its tax rate goes up. The response of consumption associated with using the labor income tax rate suggests a conventional wealth effect: the coronavirus has temporarily reduced the productive capacity of the economy, and due to the lower earnings, households reduce their consumption. The path for consump-

Figure 8: Implications of Alternative Fiscal Policies After the Coronavirus

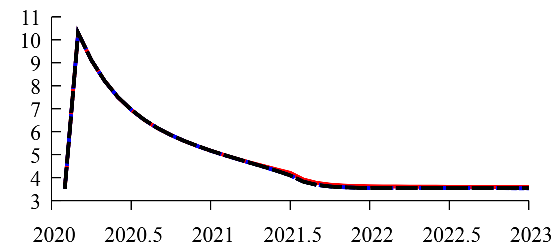
(a) Output



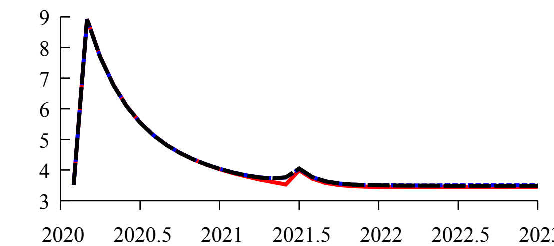
(b) Consumption



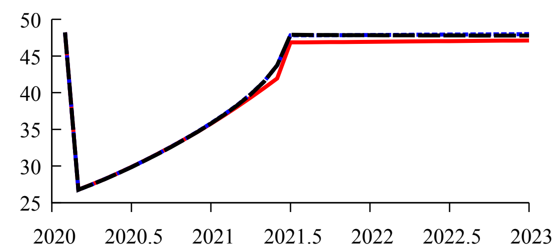
(c) Unemployment rate



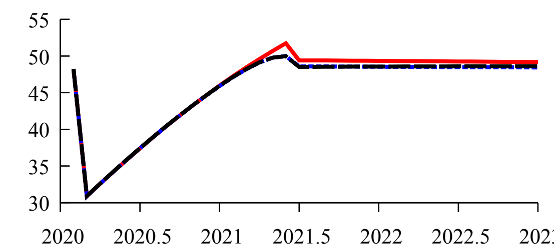
(d) Vacancies



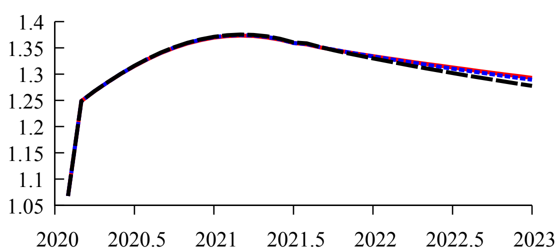
(e) Job-finding probability



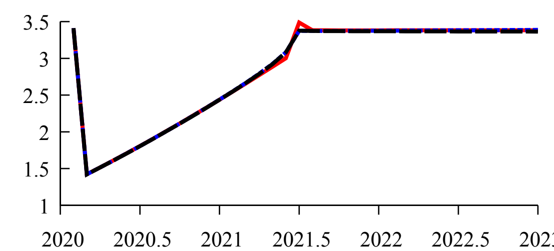
(f) Job-filling probability



(g) Debt-output



(h) After-subsidy wage



Key: Red line: Labor income tax. Blue line: consumption tax. Black line: Capital income tax.

tion associated with restoring fiscal balance through the capital income tax rate may seem anomalous: consumption rises even more than under the sale tax. The reason is that households – the owners of capital in this model – are forward looking, and knowing that their capital income will be taxed very heavily in the near future, reduce their investment and as a consequence can consume more. Over horizons much longer than depicted in these figures, consumption eventually falls below its pre-coronavirus steady state value as households re-build their capital stocks when the capital income tax rate declines to more 'reasonable' values.

5 Conclusion

This paper traced out the likely labor market implications of the coronavirus on U.S. labor markets. The model is a variant on the Diamond-Mortensen-Pissarides search-and-matching framework which captures frictions in the worker-firm meetings through a matching function. The driving mechanisms were: an increase in job separations, reflecting the fact that firms have shed workers in the face of lost business and revenue; a decrease in match efficiency due to difficulties faced by firms and workers in meeting owing to many firms being shutdown and workers restricted to staying at home; an increase in the costs of posting vacancies, reflecting not only the difficulties firms and workers face in meeting, but also the problems faced by firms in obtaining financing; and a decrease in total factor productivity due not only to a loss in efficiency among those suddenly working at home, but also disruptions to supply chains, and production lost due to firms temporarily eing ordered to close. The magnitudes of these shocks are, hopefully, not implausibly large.

Increased job separations were found to be the single most important shock driving the unemployment rate. In this case, the model predicts a peak unemployment rate of over 12%. Total factor productivity is the largest contributor to the predicted fall in output. More important: The model predicts that the shocks collectively have effects that exceed the sum of their individual contributions. With all of the shocks in play, unemployment peaks at over 22% and output experiences a decline of over 20%. To the extent that there is good news, it is that these effects largely dissipate after the coronavirus.

Four policy responses were considered: a wage subsidy; a wage subsidy along with an employment guarantee; increased unemployment insurance generosity; and a subsidy to firms' vacancies. The single most efficacious policy intervention is a wage subsidy tied to maintaining a certain level of employment. In this case, unemployment peaks at just over 10%, and the drop in output limited to 14.5%. Subsidizing vacancies limits the increase in the unemployment rate to around 18%, and the output decline to 18%. While there may be good reasons to increase generosity of the unemployment insurance program, improved labor market and output performance are not among those reasons. The model finds that such a policy increases unemployment as well as the fall in output, although these effects are fairly small.

Delaying the policy response is costly in terms of both unemployment and output. A delay as short as a month in implementing the full range of policies increases unemployment by nearly five percentage points. Delaying three months leads to a peak unemployment rate almost as high as no policy response, although output and unemployment return to trend more quickly after government policies are implemented.

The model predicts an increase in government debt, from 107% of output, to around 136%. I consider the effects of using one tax rate – labor income, capital income, or consumption – to eventually return the government debt-output ratio to its pre-coronavirus level. For the most part, the model's predictions for macroeconomic variables are fairly insensitive to which tax instrument is used. This last finding suggests that the effects of the coronavirus are so extreme that the tax rate effects are too small to discern.

One could reasonably argue tht feeding exogenous shocks into a model gives short shrift to the underlying economic mechanisms in play. To this, I have two responses. First, these shocks give guidance as to where to look for the effects of the coronavirus restrictions. Second, the policy prescriptions likewise point policymakers in directions that are more likely achieve better labor market outcomes.

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