Covid-19 and the Economy: Theory

Economic downturns can result from adverse shocks to aggregate supply or (more commonly) from reductions in aggregate demand. The covid-19 recession clearly has elements of both. Businesses closing either through their own choice or through public health measures such as lockdowns are a reduction in AS. A less healthy workforce is another example. But consumers' reluctance to travel, dine out, etc. is a reduction to aggregate demand and it is not obvious which factors will dominate. Inflation data provide a first look.

Figure 1: Annualized Core-PCE Inflation

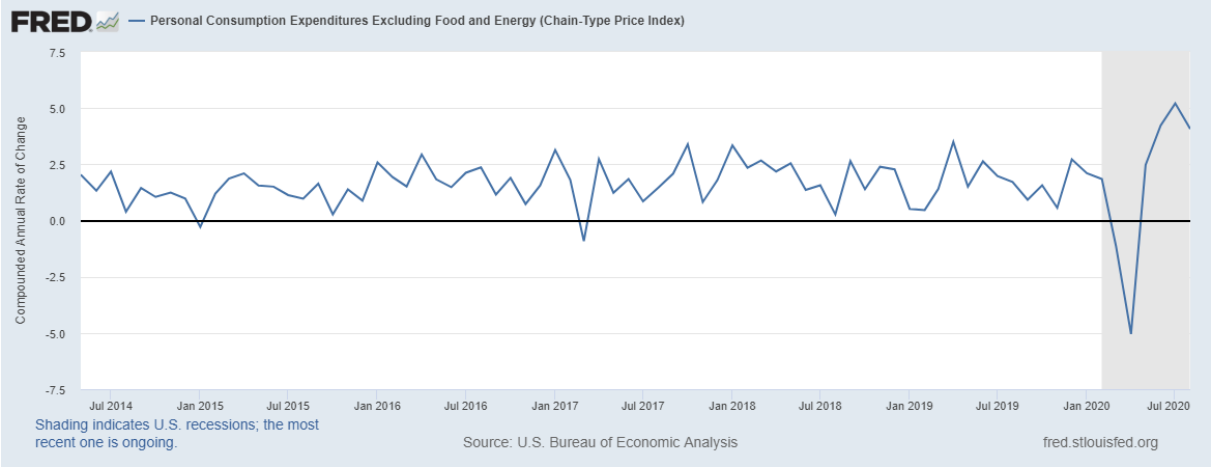

Figure 1 shows that inflation declined during the worst of the covid crisis in April 2020. This suggests that demand factors may have played a dominant role.

These notes follow the following paper:

Guerrieri, V., Lorenzoni, G., Straub, L. and I. Werning. 2020 "Macroeconomic Implications of Covid-19: Can Negative Supply Shocks Cause Demand Shortages?" NBER Working Paper # 26918.

This paper develops a New Keynesian DSGE model to try to explain the interaction of demand and supply shocks. The paper's main premise is that covid-19 represents an initial supply shock which then causes a reduction in demand.

First, some terminology:

i) A DSGE model is a *Dynamic Stochastic General Equilibrium Model*. Dynamic means that the model's current behavior depends on either its past behavior or expectations of the future. This is in contrast to a static model which depends only on current conditions. (An example of a static model is the Keynesian Cross) Stochastic means that the model includes randomness, including shocks to both AS and AD. General Equilibrium means that prices (inflation) are jointly determined along with output rather than being taken as given. Most modern macroeconomic models are DSGE models.

ii) I describe the model as New Keynesian because, like other Keynesian models such as AD/AS, it assumes that sticky prices or wages lead to an upward sloping AS curve. The "new" adjective, however, means that firms' behavior in the model is connected to their profit maximization problem and households choices are connected to their utility maximization problem. This is also a hallmark of modern macroeconomic models. It is often referred to as "microeconomic foundations."

The Model

We will focus on the version of the model which begins on page 11. We begin, as usual, by laying out the basic assumptions of the model and considering how plausible they are. As always, the validity of a model depends on the quality of its assumptions.

We assume that there are two distinct sectors:

1. Some fraction of agents, ϕ, work in sector one. $1-\phi$ fraction of agents work in sector 2. Workers are perfectly specialized, in the short-run they cannot switch sectors. For simplicity, workers always supply a constant amount of labor, $\bar{\eta}$.

Think of sector 1 as a sector that requires a lot of face to face interaction (e.g. restaurants) and is thus especially vulnerable to a pandemic. In contrast, think of sector 2 as being industries less vulnerable, or those including essential workers and which are less likely to be shut down during the pandemic.

2. For simplicity, production is linear: $Y_{jt} = N_{jt}$.

3. Workers in both industries have a taste for variety where they like to consume the output of both sectors. The degree of elasticity between the two goods is $\frac{1}{\rho}$. As this term increases, households are more willing to substitute between the two types of output. Lower values instead suggest that the goods are compliments.

The authors begin by presenting the case of *complete markets*. This means that there are no market failures (*e.g* externalities, public goods, etc.) in the model. It also means that all workers have access to credit and are able to borrow against there future income. This will be important. If unemployed workers have this access, then the model will behave very differently than if they do not.

An important feature of complete markets models is that equilibrium is necessarily Pareto Efficient.

Next, we can define the real interest rate as follows:

$$1 + r_t = (1 + i_t)\frac{P_{2t}}{P_{2t+1}} \tag{1}$$

This is standard. $\frac{P_{2t}}{P_{2t+1}}$ is just the inverse of the inflation rate. Taking logs:

$$r_t = i_t - \pi_{t+1} \tag{2}$$

Note that π_{t+1} does not have an expectations operator ion it. This is for simplicity. We are assuming that households have *perfect foresight* where they can see the future. Again, this is not intended to be realistic, rather the process of forming expectations is just not what this paper is about. Likewise, the pandemic occurs in period 0 and lasts for one (hopefully short) period.

Workers in sector 2 also use the following rule to choose consumption. This is not an assumption, rather it is the result of solving the households' utility maximization problem:

$$U_{c2}(c_{1t}, c_{2t}) = \beta(1 + r_t)U_{c2}(c_{1t+1}, c_{2t+1}) \tag{3}$$

where $U_{c2}(c_{1t}, c_{2t})$ is the marginal utility of consumption. The intuition here is that households like to smooth their consumption. If, however, the real interest rate is unusually high, they will save more, consume less today, and consume more tomorrow. This equation is just a different version of the IS/Euler Equation from ECO 270.

To see why this is consistent with utility maximization, consider the following example. A household in sector 2 is deciding whether to consume now or save in order to consume next period.

i. If it consumes the unit of output today, it obtains the marginal utility of consumption, $U_{c2}(c_{1t}, c_{2t})$.

ii. If it saves the unit, it will be able to consume $(1 + r_t)$ units in period $t + 1$. Multiplying by the marginal utility of consumption yields $(1 + r_t)U_{c2}(c_{1t+1}, c_{2t+1})$. This is then multiplied by the discount factor, which captures households' impatience, to get the term on the right hand side of (3).

iii. In equilibrium, the household must be indifferent between these two options. Equation (3) thus sets them equal. Otherwise, the household could benefit by moving consumption from period t to $t + 1$ or vice-versa.

Furthermore, because consumption equals income:

$$c_1^* = y_1^* = \phi\bar{\eta} \tag{4}$$

$$c_2^* = y_2^* = (1 - \phi)\bar{\eta} \tag{5}$$

where c_1^* and c_2^* are the average levels of consumption for all workers in the economy. If $\phi = \frac{1}{2}$ and $\bar{\eta} = 1$, then one-half unit of each good is produced. There are 0.5 sector 1 workers, each consuming 0.5 units of each good and 0.5 sector 2 workers each consuming 0.5 units of each good.

Pandemic Shock, Complete Markets

When the pandemic hits, workers in sector 1 cannot produce. This captures the closures of the sectors vulnerable to the illness and may approximate the U.S. economy of April 2020. Define the pandemic period as $t = 0$

$$c_{10} = Y_{10} = 0 \tag{6}$$

Because workers in sector 1 are able to borrow, they are able to maintain their consumption so that all workers are able to continue consuming c_2^*. We can use (3) to see what happens. Rearranging:

$$1 + r_0 = \beta^{-1}\frac{U_{c2}(0, c_2^*)}{U_{c2}(c_1^*, c_2^*)} \tag{7}$$

Whether this represents an increase or a decrease is ambiguous. The authors consider two cases:

i) Suppose that the two goods are compliments. If so, then the lack of good one reduces the marginal utility of consumption from good 2 (the numerator). The real interest rate then

goes down. If nominal interest rates (set by the monetary authority are unchanged), then the current price level, seen in 1, also declines. This is a negative demand shock.

ii) Instead assume that the two goods are substitutes. Now, the lack of demand causes the marginal utility of consumption for good 2 to rise. Real interest rates and the price level thus increase. This is an increase in aggregate demand.

In the paper, the authors discuss which case is more realistic. The answer is not obvious, but they suggest that it may be #2. This does not fit the data well, however, because it implies that an initial adverse supply shock caused an increase in prices. If so, then covid-19 should be inflationary. Furthermore, this analysis assumes a constant nominal interest rate. In reality, the Fed lowered rates which should lead to even more inflation which is not seen in the data.

An interesting point of discussion is whether the equilibrium is efficient. Under complete markets it is, that is no agent can be made better off without harming anyone else. The authors note, however, that if wages are sticky (an example of incomplete markets), then the real wage can get stuck inefficiently high, leading to an inefficient decline in output.

Incomplete Markets

The authors now add an inefficiency to the mode. Specifically, the assume that a fraction, μ, of workers in sector 1, the one hit by the pandemic, are credit constrained. This means that they have limited ability to smooth the adverse income shock over time.

To make the math easier, I will deviate from the paper. Assume that all workers are fully credit constrained ($\mu = 1$)s o that workers in sector 2 must consume all of good 2.Equation (7) becomes:

$$1 + r_0 = \beta^{-1} \frac{U_{c2}(0, \frac{c_2^*}{1-\phi})}{U_{c2}(c_1^*, c_2^*)} \tag{8}$$

Compared to (7), the marginal utility of consumption for good 2 is lower because workers in sector 2 are now consuming more of it. If one half unit of good 2 is produced and there are 0.5 workers in sector 2, they will each consume 1 unit instead of 0.5 units like they did with complete markets.

The real interest rate is thus lower than in (7), making it more likely (but not certain), that the aggregate demand is reduced instead of increased.

Here is some intuition. With credit constraints, the impact of the pandemic falls even more harshly on workers in the affected sectors. Lacking income, they are unable to afford the output produced by the sectors still operating. But because this output is less valuable to those working in sector 2, demand falls. If it does so by enough, then inflation may decrease as seen in Figure 1.

Here is an example in the context of covid-19. Consider a sector like motor vehicles that continues to operate through the pandemic. The problem is that covid-19 has closed many of the things that make cars useful (there is less need to commute, or to drive to recreational events, etc.). Thus even workers who are unaffected by covid-19 directly have less demand for cars. This is a reduction in aggregate demand (people want fewer cars even though the ability to produce them has nit been affected. (Note: I recognize that covid-19 did shut down some parts of the motor vehicle industry so the example should not be taken literally).

Figure 2 from the paper (on page 14) and Figure 3 (on page 18) show how the likelihood of a negative demand effect depends on two parameters. The first is $frac1\rho$, the elasticity between the two goods, When this is low (compliments), adverse demand effects (described as "Keynesian supply shocks") are more likely. The second is 1σ, the intertemporal elasticity of substitution. This captures how willing households are to shift consumption from period to period. Figure 3 shows that with credit constraints, adverse demand shocks can occur even if the two goods are close substitutes.

Other Results

1. Recent research has identified cases where, when interest rates are at their zero lower bound, adverse supply shocks can be expansionary. This is because, at the zero lower bound, the consequence of higher inflation can be cause higher output. The authors note that this effect is not present here. In other words, a trade war is not helpful during covid-19.

2. The authors also consider the effectiveness of fiscal policy. They find that ordinary government spending has a multiplier of 1. They also find that the transfer multiplier (representing taxes on workers in sector 2 that are used to pay unemployment benefits to workers in sector 1) has a multiplier equal to μ, which is constrained to be between zero and 1. The authors note that both figures are relatively low. They note that because sector 1 is closed, it cannot be stimulated by fiscal policy in the ordinary way. This reduces fiscal policy's effectiveness.

3. The authors consider a pair of other policies. These include a payroll tax cut for employers, and monetary policy which lowers interest rates. Both may improve outcomes.

4. Finally, the authors make the point that if health is also included in the utility function, shutting down sector 1 may be efficient. This is simply acknowledging tradeoffs between employment and public health.