On the Dynamic Interdependency of Unemployment and COVID-19 Deaths

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ABSTRACT

Using monthly data from U.S. counties, this paper offers evidence that rising COVID-19-related deaths appear to lead to reduced economic activity, but that reduced economic activity, in turn, helps to achieve its stated purpose: reducing subsequent deaths. Using a dynamic panel seemingly-unrelated regression model, the paper estimates that a one percentage point increase in the unemployment rate leads to approximately 3,300 fewer COVID-19-related deaths nationally in the subsequent month. From a policy perspective, that finding offers suggestive evidence that lockdowns (and other restrictions), while economically painful, appear to be effective at reducing subsequent deaths.

JEL Classification: E24; J01; H10.
Keywords: pandemic; labour force; SUR.

1. INTRODUCTION

This paper investigates the dynamic interplay between COVID-19 deaths and unemployment. Using monthly county-level data, the paper specifies and estimates a dynamic simultaneous equations panel estimator with correlated random effects. Results show that COVID-19 deaths lead to increased unemployment, perhaps as the result of lockdowns. However, that increased unemployment, in turn, tends to reduce COVID-19 deaths during the subsequent month. To that end, the results appear to offer suggestive evidence that lockdowns (and other restrictions), despite causing economic pain, appear to achieve their stated purpose in reducing deaths.

A sizable branch of research, scattered across several academic disciplines, seeks to determine the relationships between pandemic health events and economic problems (Meltzer *et al* 1999; Brainerd and Siegler 2003; Clark 2007; Karlsson *et al* 2014; Jordà *et al* 2020; Rodríguez-Caballero and Vera-Valdés 2020). More recently, a quickly-emerging literature is investigating the effects of COVID-19 on different aspects of the economy. Some studies examine the effect of the disease on consumer spending (Chen *et al* 2020; Bachas *et al* 2020) and, most closely-related to our work, labour markets (Bartik *et al* 2020; Bauer and Weber 2020; Cajner *et al* 2020; Chetty *et al* 2020; Couch *et al* 2020;

Forsythe *et al* 2020; Kong and Prinz 2020; Kurmann *et al* 2020). Several studies attempt to quantify the direct effects of COVID-19 deaths on unemployment (Auray and Eyquem 2020; Kong and Prinz 2020; Crossley *et al* 2021). Fernandez-Villaverde and Jones (2020) provide a detailed analysis of correlations in COVID-19 deaths and negative macroeconomic outcomes.

The main concern in this paper is that spikes in unemployment, once manifested, potentially feed back to future COVID-19 deaths; indeed, the stated reason for lockdowns is that, by reducing human interactions, subsequent damage caused by the virus should be smaller. While previous studies have attempted to establish a link between lockdowns and subsequent deaths (Von Batten 2020; Matthay *et al* 2021), our study is the first to model the two simultaneously. Although we do not aim to identify the specific causal mechanisms through with unemployment and deaths interact (Chetty *et al* 2020), our findings do conform with the looser Granger style of causality, in which our two main variables offer predictive power toward each other.

2. Data

The dataset consists of all 3,141 counties and county equivalents in the United States for the months April 2020 to May 2021 for a total of 43,974 county/month observations. County-level unemployment rates come from the Bureau of Labor Statistics (BLS) Local Area Unemployment Statistics. The top row of Table 1 reports the mean and standard deviation of county unemployment rates.

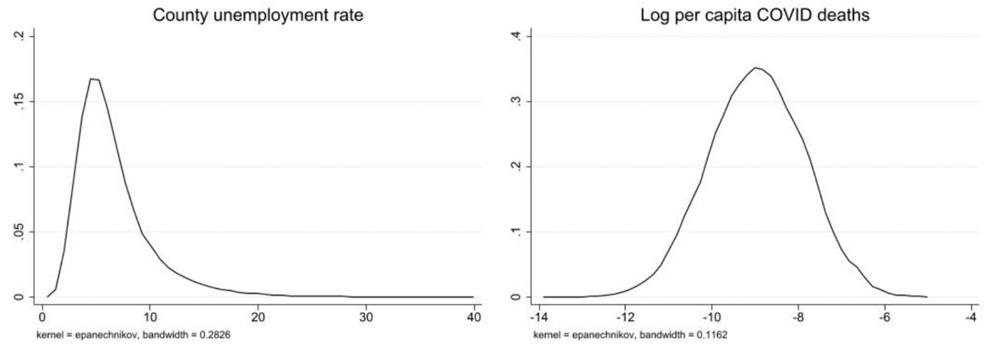
Table 1: Sample means

N = 43,974 county/month observations
April 2020 – May 2021

	Mean	*Standard deviation*
Unemployment rate	6.71	3.59
COVID deaths	13.29	76.70
Per capita COVID deaths	0.0002	0.0003
Log per capita COVID deaths	–8.93	1.11

County-level COVID-19 deaths come from the nonpartisan initiative USAFacts, which aggregates data from the CDC (Centers for Disease Control and Prevention) and state and local agencies.[3] They report daily cumulative COVID-19 deaths for each county, which we sum to arrive at end-of-month totals.[4] To arrive at a per capita measure of county deaths, we divide by county population, which also comes from USAFacts. Finally, given the highly-asymmetric distribution of per capita deaths, we calculate $\ln\left(\frac{deaths+1}{population}\right)$, which, as shown in Figure 1, produces a fairly symmetric distribution, suitable for regression-based modeling. Table 1 reports means and standard deviations for

Figure 1: Kernel density estimates



those various measures of deaths, although it is the logged version of per capita deaths that we model in subsequent sections.

3. Methods

Let $u_{i,t}$ denote the unemployment rate in county *i* in month *t*, and let $d_{i,t}$ denote (log) per-capita COVID-19-related deaths in county *i* in month *t*. We jointly model county-level unemployment and deaths using a dynamic panel version of a seemingly-unrelated regression (SUR) model. Let the two equations of the SUR setup follow

$$u_{i,t} = \beta_0 + \beta_1 u_{i,t-1} + \beta_2 d_{i,t-1} + \delta_{u,t} + \nu_{u,i} + \varepsilon_{u,i,t}$$

$$d_{i,t} = \gamma_0 + \gamma_1 u_{i,t-1} + \gamma_2 d_{i,t-1} + \delta_{d,t} + \nu_{d,i} + \varepsilon_{d,i,t}$$

where the δ terms represent month effects (i.e. month dummies). The two equations are linked via an assumption of joint normality of the error terms $(\varepsilon_{u,i,t}, \varepsilon_{d,i,t})$.

Each equation is dynamic in the sense that one-month lagged unemployment appears in the unemployment equation, and similarly one-month lagged deaths appear in the deaths equation. Such dynamic setups are appropriate if past values directly affect current values, or if, following a change in unemployment or deaths, they revert partially, but not completely, to their previous values during subsequent months. Whatever the source, results presented below point to strong serial persistence in both unemployment and deaths, attesting to the importance of a dynamic setup.

Our main interests, however, are the *cross dynamic* links present in the two equations. Specifically, one-month lagged deaths appear in the unemployment equation, while one-month lagged unemployment appears in the deaths equation. Our hypothesis is that rising deaths lead to reduced economic activity – perhaps owing to voluntary or involuntary lockdowns – which boosts the unemployment rate the next time it is reported. In that case, we expect $\beta_2 > 0$.

But that reduced economic activity, if it works as desired, should reduce subsequent deaths, in which case we expect $\gamma_1 < 0$.

The ν terms in each equation capture time-invariant county-specific effects that remain *unobserved* in our data source. For example, certain counties (e.g. college towns) might have naturally low unemployment rates as a result of the types of jobs predominant in those areas. The term $\nu_{u,i}$ captures such unobserved factors in the first equation. In the second equation, certain counties might be predisposed toward high death rates as a result of demographic or environmental factors. The term $\nu_{d,i}$ captures such patterns in the second equation.

Both of the ν terms are treated as random effects, in the sense that they remain uncorrelated with other variables appearing on the right-hand sides of the equations. That assumption, normally problematic in microeconometric settings, seems less tenuous here given the relatively parsimonious nature of the two equations. Nevertheless, to permit some degree of correlation between the random effects and other right-hand side variables, we adopt the method of Mundlak (1978) and include intra-county time averaged per capita deaths in the unemployment equation, and intra-county time averaged unemployment in the per capita deaths equation.

We also must confront the so-called "initial conditions" problem, in that the first period of our data does not offer the genesis of unemployment or (to a lesser extent) COVID-19-related deaths in each county, but rather realisations of ongoing processes. To address the initial conditions problem, we adopt the suggestion of Wooldridge (2005) and condition the random effect in the unemployment equation on "initial" unemployment, and the random effect in the deaths equation on "initial" deaths. (We treat April 2020 as the "initial" month.) Therefore, combining the Mundlak terms and the initial conditions, the two random effects are specified as

Unemployment equation: $$\nu_{u,i} = \eta_{u,1}\bar{d}_{i,\cdot} + \eta_{u,2}u_{i,1} + \xi_{u,i}$$

Deaths equation: $$\nu_{d,i} = \eta_{d,1}\bar{u}_{i,\cdot} + \eta_{d,2}d_{i,1} + \xi_{d,i}$$

where $\bar{u}_{i,\cdot}$ and $\bar{d}_{i,\cdot}$ denote intra-county time averages of unemployment and per capita deaths, $u_{i,1}$ and $d_{i,1}$ denote initial values (in April), $\xi_{u,i}$ and $\xi_{d,i}$ denote time-invariant county-specific random terms, and the η terms are estimable parameters.

The estimation procedure applies to months June 2020 to May 2021, inclusive, in order to accommodate initial conditions and lagged values. Estimation of all parameters uses a multi-step maximum likelihood procedure introduced by Biorn (2004) and implemented in the user-written Stata module xtsur (Nguyen and Nguyen 2010). For a discussion of consistency of dynamic random effects models estimated by maximum likelihood, see Hsiao (2003 pp 73-80). Note that our use of a wide panel with a short time dimension obviates concerns about unemployment or deaths showing nonstationary time series patterns.

4. Results

Estimates for the dynamic panel SUR model appear in Table 2. The precisely-estimated components of the random effect terms illustrate the importance of including time-averages and initial conditions. The main results, however, appear near the top of the table.

Table 2: Dynamic panel SUR estimates

	Unemployment $_t$		Log per capita COVID deaths $_t$	
	Coeff.	St. Err.	Coeff.	St. Err.
Unemployment $_{t-1}$	0.559**	(0.003)	–0.046**	(0.003)
Log per capita covid deaths $_{t-1}$	0.022**	(0.006)	0.397**	(0.005)
Month dummies	Yes		Yes	
Components of random effects				
Initial unemployment (April 2020)	0.069**	(0.003)	–	–
Initial log per capita deaths (April 2020)	–	–	0.528**	(0.005)
Time-averaged unemployment	–	–	–0.035**	(0.005)
Time-averaged deaths	–0.244**	(0.008)	–	–

* p < .10 ** p < .05

First, both unemployment and deaths, not surprisingly, show strong serial persistence, with lagged values of each being strongly positively linked to current values. Such serial persistence speaks to the importance of modeling each dynamically. Our main concern, however, rests on the *cross dynamic* effects. The left-hand panel shows that an increase in deaths in the previous month leads to an increase in unemployment in the current month. Because the standard deviation of monthly log per capita COVID-19 deaths equals approximately 1, the coefficient (0.022) implies that a one standard deviation increase in log per capita COVID-19 deaths during the previous month boosts the unemployment rate by a relatively modest 0.02 points during the subsequent month. That effect could be because state and local governments respond to rising deaths by restricting economic activity, or it could stem from people, out of fear, voluntarily reducing their economic activity.

But the right-hand panel, in turn, suggests that an increase in unemployment reduces deaths during the subsequent month. In terms of magnitude, the coefficient (–0.046) implies that a one percentage point increase in the unemployment rate reduces next-month per capita COVID-19 deaths by about four percent of one standard deviation. Although not a perfect apples-to-apples comparison, the standard deviation for *unlogged* COVID-19 deaths per 100,000 residents is about 25. Then, four percent of that number amounts to about one less death per 100,000 people. Considering the size of the U.S. population (about 330,000,000 as of this writing), we conclude that a one percentage point increase in the unemployment rate reduces monthly deaths by approximately 3,300 nationally.

That effect might stem from some sort of natural cyclical pattern inherent in COVID-19 deaths, a topic of active research amongst epidemiologists. Or the effect might indicate that reductions in economic activity, despite introducing their own type of suffering, ultimately succeed in affecting their primary purpose: slowing the spread of the virus. We should note, however, that when two-month lagged unemployment was added to the deaths equation, that two-month lag was statistically insignificant (although the one-month lag remained significant). Consequently, whatever benefit higher unemployment has on reduced deaths appears to be relatively short-lived.

Of course, COVID-19 deaths might induce people to drop out of the labour force, thus creating unexpected, even perverse, effects on unemployment rates. To that end, Table 3 estimates the same dynamic panel SUR setup, but adds as an additional control in each equation (the log of) each county's labour force divided by its total population size. The addition of that variable should account for changes in labour force participation separate from any effects on unemployment. As the table indicates, the cross-dynamic effect of COVID-19 deaths on unemployment loses statistical precision, but the other cross-dynamic effect – unemployment on deaths – remains almost unchanged. Thus, the paper's main finding seems robust to potential changes in county-level labour force participation rates.

Table 3: Dynamic panel SUR estimates – Adding log (labour force/population)

	$Unemployment_t$		Log per capita $COVID\ deaths_t$	
	Coeff.	St. Err.	Coeff.	St. Err.
$Unemployment_{t-1}$	0.572**	(0.003)	–0.041**	(0.003)
Log per capita covid $deaths_{t-1}$	0.008	(0.006)	0.313**	(0.005)
Log (labour force/population)	–0.693**	(0.038)	–0.724**	(0.091)
Month dummies	Yes		Yes	
Components of random effects				
Initial unemployment (April 2020)	–0.067**	(0.001)	–	–
Initial log per capita deaths (April 2020)	–	–	–0.056**	(0.007)
Time-averaged unemployment	–	–	–1.071**	(0.008)
Time-averaged deaths	–0.340**	(0.007)	–	–

* p < .10 ** p < .05

5. Conclusion

Rising COVID-19-related deaths appear to lead to reduced economic activity, whether voluntary or government-coerced. This paper explores whether that reduced economic activity, as measured by county-level unemployment rates, helps to achieve its stated purpose: reducing subsequent deaths. Using a dynamic panel seemingly-unrelated regression model, we do find evidence of such a pattern. Specifically, we estimate that a one percentage point increase in the unemployment rate leads to approximately 3,300 fewer COVID-19-related deaths nationally in the subsequent month. Whether that effect owes to some unknown cyclical feature of COVID-19, or whether it is a direct consequence of reduced economic activity, remains an important topic for future research.

From a policy perspective, this paper's findings offer suggestive evidence that lockdowns (and other restrictions), while economically painful, appear to achieve their stated aims by reducing subsequent deaths. What our results do *not* inform upon, however, is whether that tradeoff would pass a formal cost/benefit test. Such an analysis would require some measure of human life, such as Value of Statistical Life estimates calculated by the U.S. Environment Protection Agency, along with measures of economic damage, both short-run and long-run, caused by rising unemployment. Such a cost/benefit analysis represents a huge undertaking, but the ultimate verdict on the appropriateness of lockdowns (and other restrictions) rests on the conclusions from such a study.

Accepted for publication: 17 October 2021

Endnotes

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3. For information on how this variable was collected please see: https://usafacts.org/articles/detailed-methodology-COVID-19-data/.

4. There were a few county/month observations where cumulative deaths had decreased from one month to the next. These obvious data errors were corrected by hand. These corrections are available from the authors.

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