Lockdown Accounting[*]

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Abstract

We use an accounting framework to evaluate the aggregate impact of a common lockdown policy for 85 countries. We find that poorer countries devote more labor to essential activities that are unaffected by the lockdown, while richer countries can more easily substitute non-essential employment with work from home. The lockdown generates an employment response that is U-shaped in income: it drops by 32% in the poorest quintile of the distribution, by 36% in the middle quintile, and by 31% in the richest quintile. Annualized GDP declines by 39% in the bottom three quintiles and by 31% in the richest quintile. Agriculture, an essential sector, is key in sustaining employment and economic activity in poorer countries.

Keywords: Covid-19, structural change, work from home, lockdown

JEL classification: O11, O14, J21

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1   Introduction

Many countries have implemented social distancing and lockdown policies to tame the spread of Covid-19. These measures involve the closure of workplaces to limit interpersonal contact. They are likely to remain in place in some form for a significant amount of time (Kissler et al., 2020). So far, 114 countries have implemented policies that require closing or work from home for all but essential workplaces (Hale et al., 2020). We measure the effect of such lockdowns on employment and GDP for a large set of countries, focusing on how that effect varies by country income per capita.

Our framework consists of a static multi-sector model. We apply a lockdown policy that is common across countries but sector-specific in that it specifies the fraction of sectoral labor that is essential and therefore assumed to operate normally.[1] Non-essential labor can partially be substituted with work from home (WFH). We allow countries to differ along three dimensions: their sectoral employment and value added composition, and their sectoral ability to supply work from home.

We find that the lockdown generates an aggregate employment drop that is U-shaped in country income per capita. On average, employment declines by 32% in the poorest quintile of the distribution, by 36% in the middle quintile, and by 31% in the richest quintile. The impact on GDP, while also non-monotonic, is decreasing in income per capita over most of the support. It drops by 39% in the bottom three quintiles, but only by 31% in the richest quintile.[2]

The U-shaped pattern results from two countervailing forces. On the one hand, poor countries sustain employment by concentrating a larger fraction of their employment in essential sectors of the economy. In the bottom quintile, 60% of labor operates essential work, while in the top quintile it is only 52%. On the other hand, poor countries feature a lower ability to work from home. Under lockdown, the bottom quintile of countries can substitute only 21% of non-essential employment with work from home, compared to 37% in the top quintile.[3]

Our second finding is that agriculture plays a key role in that relationship. Outside the agricultural sector, the lockdown leads to a substantially larger reduction in both employment and GDP in low-income countries. This is because within the non-agricultural sector, it is rich countries that concentrate more employment in essential sectors, including finance and insurance, information and communication, and public administration. In the aggregate, this pattern is overturned by agriculture, an essential sector that employs more labor in poorer countries. Moreover, since agriculture's value added share is typically lower than its employment share, the employment responses in the poorest and richest quintiles are alike while the reduction in GDP is stronger in the poorest quintile.

Our framework makes a number of simplifying assumptions. Central among them is that during lockdown, sectoral labor supply is perfectly inelastic. It cannot move across sectors and it does not respond to changing economic conditions or the risk of disease contagion. In contrast, several recent papers on the aggregate effects of the Covid-19 pandemic analyze the endogenous change in consumption and labor supply to reduce the risk of infection (Brotherhood

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[1]Our policy experiment relies on an index of essential sectors assembled by Fana et al. (2020) based on lockdowns implemented in several European countries. Alternative scenarios can be performed with our "lockdown simulator" at https://work-in-data.shinyapps.io/work_in_data/, which illustrates the effects of arbitrary sectoral lockdown policies (set by the user) by country.

[2]GDP is measured on an annualized basis. A lockdown lasting, say, two months corresponds to one-sixth of the reported value.

[3]We construct WFH abilities from occupation-specific WFH ability rates computed in Dingel and Neiman (2020), coupled with country-specific occupational shares in each sector. In the working paper version of this paper (Gottlieb et al., 2020a) we constructed the WFH ability based on data from the World Bank's STEP skills measurement program. The aggregate employment and GDP responses followed a similar shape to the results here.

et al., 2020; Eichenbaum et al., 2020; Farboodi et al., 2020), including the reallocation across occupations (Aum et al., 2020) and sectors (Krueger et al., 2020). We also abstract from the impact of lockdowns on demand (Guerrieri et al., 2020) and bottlenecks due to sectoral linkages (Farhi and Baqaee, 2020). Our results should therefore not be read as macroeconomic predictions of the impact of lockdowns on any particular country. Nor do we evaluate the welfare consequences of distinct policies. Instead, we highlight the crucial role of the sectoral value added and employment composition of an economy. These are of first order importance for the effect of any lockdown and lead to distinct country-specific employment and output responses triggered by an identical set of policies.

We follow losely the literature that focuses on the short-run effect of sectoral lockdowns. They have been evaluated for specifc countries such as Germany (Fadinger et al., 2020) as well as France and a set of European countries (Barrot et al., 2020). Little, however, is known about the effect of lockdowns in poorer countries. This is despite the fact that poor countries are also implementing social distancing measures, often drastic ones.[4] One exception is Alon et al. (2020) who develop a rich heterogeneous agents framework augmented with an epidemiological model. They find that a lockdown generates a lower drop in employment and GDP in a typical developing than a typical advanced economy. The key element driving that outcome is the assumption that labor in poor countries can more readily circumvent the lockdown by resorting to informal activities. We, instead, focus on cross-country differences in the sectoral composition and WFH ability.

We also connect to the nascent literature measuring workers' ability to work from home during the Covid-19 pandemic. We follow the occupation-based approach proposed by Dingel and Neiman (2020) as it can be readily extrapolated to a large number of countries.[5] That paper, along with Gottlieb et al. (2020b) and Saltiel (2020), argues that workers in developing economies have significantly fewer options to execute work from home than their peers in advanced economies. Here, we add an additional perspective to these findings by showing that poorer countries have more employment in essential sectors for which the WFH ability matters comparatively less. The raw cross-crounrty variation in aggregate WFH ability therefore exaggerates the cross-country labor supply variation in the event of a lockdown.

This paper also connects to the literature on structural change. Our results emphasize the importance of agriculture in determining the impact of lockdowns as its size varies systematically with development (Kuznets, 1973; Gollin et al., 2002; Restuccia et al., 2008; Herrendorf et al., 2014; Duarte and Restuccia, 2019). Moreover, our sectoral WFH ability varies with the underlying occupational composition. Richer countries can execute more work from home because they have larger shares of high-WFH occupations, which relates to systematic occupational differences across the development spectrum (Duernecker and Herrendorf, 2016).

This paper is structured as follows. Section 2 proposes the theoretical framework, section 3 explains the parametrization, section 4 presents the results, and section 5 concludes.

2 Theoretical framework

We use a simple multi-sector accounting model to evaluate the impact of lockdown policies on employment and GDP. We assume that following the lockdown, the ratio of employment

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[4]Twenty-two low- and lower-middle income countries have implemented lockdowns with a stringency index above 80 (corresponding to the 75th percentile of the world distribution) (Hale et al., 2020).

[5]Other papers measuring WFH ability in advanced economies include Adams-Prassl et al. (2020a), Adams-Prassl et al. (2020b), Bick et al. (2020), Boeri et al. (2020), del Rio-Chanona et al. (2020), Alipour et al. (2020), Hensvik et al. (2020), Mongey and Weinberg (2020).

relative to trend in country c equals

$$n^c = \sum_{i=1}^{I} n_i^c \mu_i^c = \sum_{i=1}^{I} \left[\epsilon_i + (1 - \epsilon_i) h_i^c \right] \mu_i^c \tag{1}$$

where $n_i^c \in [0, 1]$ is the employment rate in sector i following the lockdown and $\mu_i^c \in [0, 1]$ is the pre-shock employment share of sector i. We posit that the lockdown policy leaves unaffected a fraction $\epsilon_i \in [0, 1]$ of essential employment in sector i. The remainder can be substituted at the rate $h_i^c \in [0, 1]$, which is the share of employment in sector i that can potentially be executed from home. Implicitly, we assume that work from home is as efficient as regular work. Equation (1) can alternatively be rewritten as

$$n^c = \underbrace{\sum_{i=1}^{I} \epsilon_i \mu_i^c}_{\equiv n_e^c} + \underbrace{\sum_{i=1}^{I} (1 - \epsilon_i) h_i^c \mu_i^c}_{\equiv n_h^c},$$

which separates labor into total essential work, n_e^c, and total work from home, n_h^c. In the absence of lockdowns, $n^c = n_e^c = 1$ and $n_h^c = 0$. Also, we define

$$h^c \equiv \frac{n_h^c}{1 - n_e^c} = \frac{\sum_{i=1}^{I} h_i^c (1 - \epsilon_i) \mu_i^c}{\sum_{i=1}^{I} (1 - \epsilon_i) \mu_i^c}$$

as the average work from home replacement rate of non-essential work.

GDP relative to trend is given by

$$y^c = \prod_{i=1}^{I} (n_i^c)^{\nu_i^c} = \prod_{i=1}^{I} \left[\epsilon_i + (1 - \epsilon_i) h_i^c \right]^{\nu_i^c} \tag{2}$$

where $\nu_i^c \in [0, 1]$ is the nominal value added share of sector i, $\sum_i \nu_i^c = 1$. In Appendix A.1 we show how to derive equation (2) from a close-economy featuring capital as well as intersectoral trade in intermediate inputs. The central assumptions are Cobb-Douglas production functions and utility; that labor and capital, post-shock, cannot move across sectors; that the sectoral drop in capital utilization is proportional to that of labor; and that all prices adjust competitively.[6,7] Our results describe employment and GDP changes relative to trend while a lockdown policy is in place. Hence, ignoring dynamic adjustments, the change in annual GDP with a two-month lockdown would be one-sixth of the reported change.

3 Data and measurement

3.1 Country-specific measures

We define sectors according to the one-digit ISIC classification. Country-specific sectoral value added shares ν_i^c are obtained from the United Nations Statistics Division and the World Input

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[6]Our analysis abstracts from factors other than the lockdown that affect employment and output. Such factors could be, among others, reductions in labor supply (voluntary or for health reasons), financial frictions, or frictions in final or intermediate goods markets. The model does, however, capture adjustments in the demand and supply of final and intermediate goods under the conditions spelled out in Appendix A.1.

[7]Fadinger et al. (2020) use a similar approach, with the difference that capital utilization does not change. The model in Barrot et al. (2020) features non-unitary elasticities of substitution both between intermediate inputs and between final goods, while capital utilization is implicitly proportional to labor.

Output Database.[8]

Country-sector-specific WFH rates are constructed as $h_i^c = \sum_o h_o \frac{\mu_{io}^c}{\mu_i^c}$, where h_o is the potential WFH ability of occupation o and where μ_{io}^c is the country-specific employment share of occupation o in industry i such that $\sum_o \mu_{io}^c = \mu_i^c$. We define occupations at the one-digit ISCO level and construct the occupational WFH ability from Dingel and Neiman (2020). The employment shares μ_{io}^c are obtained from ILO.[9] In total, we can measure ν_i^c, μ_i^c and h_i^c for 85 countries.

3.2 Lockdown policy

We construct the sectoral lockdown policy using the index of essential sectors assembled by Fana et al. (2020) who document activities exempt from the strict March 2020 lockdown decrees in Germany, Italy, and Spain.[10] In particular, they report for each country the degree to which two-digit ISIC sectors are considered essential and therefore the extent to which they are allowed to function normally. Their final index is an average across the three countries, justified by the fact that there is relatively little discrepancy between them. To aggregate up to one-digit sectors, we use employment weights: $\epsilon_i = \sum_{j \in i} \mu_j \epsilon_j$, where $\epsilon_j \in [0, 1]$ is the essential index and μ_j is the employment share of the two-digit sectors j belonging to one-digit sector i.[11]

We perform two manual changes. Fana et al. (2020) document that the sector *Education* (ISIC code P) is entirely essential in Germany and Italy, while non-essential in Spain, implying $\epsilon = 0.67$. Instead, we shut it down completely, $\epsilon = 0$. Our choice is guided by the fact that both Germany and Italy closed down all educational establishment in March 2020. Second, according to Fana et al. (2020), the sector *Real estate activities* (ISIC code L) is completely non-essential, implying $\epsilon = 0$. Instead, we assign it the value $\epsilon = 0.9$. We conjecture that restrictions to real estate employment activities such as brokerage have a minimal impact on bulk of the sector's value added, which consists mainly of imputed own-occupied housing as well as established rental arrangements.

Column (1) of Table 1 summarizes the essentialness score of each sector. Columns (2)-(5) report each sector's cross-country average WFH rate, employment rate, employment share, and value added share, respectively. The last line of Table 1 reports the correlation of ϵ with respect to these variables. At 0.14, it is weakly and positively related to the average WFH rate, $\overline{h}$. From this follows a strong correlation of 0.95 with the average post-lockdwon employment rate, $\overline{n}$. The score ϵ is almost completely unrelated (0.01) to the sector's average employment share, $\overline{\mu}$, and weakly correlated (0.14) with its value added share, $\overline{\nu}$.

4 Results

4.1 Aggregate economy

The upper half of Figure 1 plots the impact of the lockdown on employment and GDP against countries' per-capita income level. The effect on employment is U-shaped, with the largest drop

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[8]For each country, we consider the most recent observation over the period 2010-2019. Whenever possible, we follow the ISIC Revision 4 classification. For a few countries, we use the ISIC Revision 3.1 classification and impute the missing data.

[9]For each country, we consider the most recent observation over the period 2010-2019. In most countries, including poor ones, the data are from 2017.

[10]Lockdown policies were similar in North American jurisdictions, like the State of New York in the US and Ontario and Québec in Canada.

[11]The employment shares are averaged across all available countries using the ILO data at the two-digit ISCO level.

Table 1: Sectoral lockdown policy and cross-country average statistics

|	(1) Essential score, ϵ_i	(2) Mean WFH rate, $\overline{h}_i$	(3) Mean emp. rate, $\overline{n}_i$	(4) Mean emp. share, $\overline{\mu}_i$	(5) Mean VA share, $\overline{\nu}_i$
Agriculture / forestry / fishing (A)	0.93	0.12	0.94	0.17	0.10
Mining and quarrying (B)	0.09	0.18	0.25	0.01	0.03
Manufacturing (C)	0.32	0.19	0.45	0.13	0.15
Elect. / gas / steam / air cond. (D)	0.97	0.32	0.98	0.01	0.02
Water supply / sewerage (E)	1.00	0.20	1.00	0.01	0.01
Construction (F)	0.06	0.15	0.20	0.08	0.07
Wholesale and retail trade (G)	0.54	0.27	0.66	0.15	0.14
Transportation and storage (H)	1.00	0.20	1.00	0.05	0.05
Accom. and food service (I)	0.02	0.25	0.27	0.05	0.03
Information and comm. (J)	0.77	0.54	0.90	0.02	0.04
Finance and insurance (K)	1.00	0.52	1.00	0.02	0.05
Real estate (L)	0.90	0.41	0.94	0.01	0.07
Prof. / scientific / techn. serv. (M)	0.44	0.56	0.75	0.03	0.04
Admin. and support serv. (N)	0.20	0.28	0.42	0.03	0.02
Public admin. and defence (O)	1.00	0.43	1.00	0.05	0.07
Education (P)	0.00	0.59	0.59	0.07	0.05
Health and social work (Q)	1.00	0.46	1.00	0.06	0.04
Arts / entert. / recreation (R)	0.00	0.41	0.41	0.01	0.01
Other service activities (S)	0.23	0.27	0.43	0.03	0.02
Priv. househ. w/ empl. pers. (T)	0.29	0.14	0.39	0.02	0.00
Correlation coefficient with ϵ_i	1.00	0.14	0.95	0.01	0.14

Note: Columns (2)-(5) report averages across our sample of 85 countries.

occurring in countries with approximately one-quarter of US income level. The effect on GDP is slightly U-shaped: over most of the support, richer countries tend to experience less output loss.

Columns (2)-(6) of Table 2 present the results as cross-country averages by quintiles of income per capita. In column (2), the lockdown reduces employment by 32 percent in the poorest quintile, by 36 percent in the middle quintile, and by 31 percent in the richest quintile. Column (3) shows that GDP drops by 39 percent in the three lower quintiles and by 31 percent in the richest quintile. Notice that in the top quintile, employment and GDP fall by roughly the same amount, while in the poorer quintiles the GDP reduction is more pronounced than that of employment. This indicates that in poor countries, the lockdown disproportionately affects sectors with relatively high labor productivity.

Next, consider the lower half of Figure 1. The left pane portrays the fraction of essential work, n_e, per country. Over most of the support, it is downward-sloping in income. In other words, poor countries concentrate a larger fraction of pre-shock employment in sectors that are considered essential. The right pane of Figure 1 traces the work from home replacement rate, $h \equiv \frac{n_h}{1-n_e}$, namely the fraction of non-essential employment that can be substituted with work from home. This is clearly upward-sloping in income: richer countries have a higher ability to work from home. Columns (4) and (6) of Table 2 report the magnitudes. In the poorest quintile, 60% of pre-shock employment is essential, compared to only 52% in the richest quintile. In contrast, the poorest quintile can replace only 21% of non-essential employment with work from home, while the richest quintile replaces almost twice as much, 37%. The combination of these two countervailing forces rationalizes the pronounced U-shaped relationship between
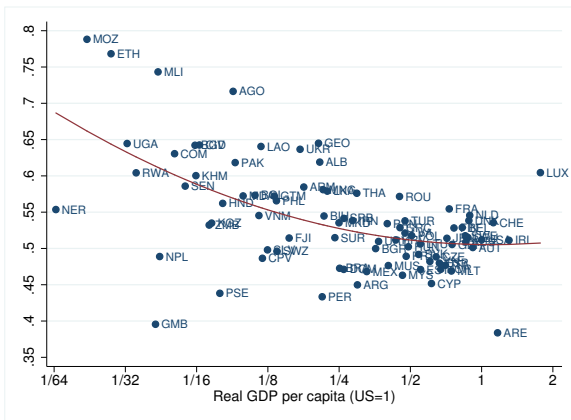
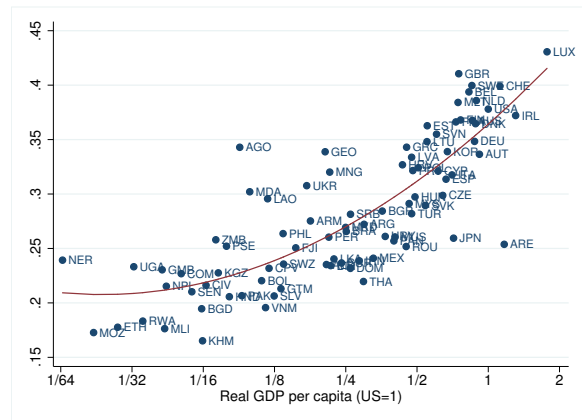Figure 1: The impact of lockdown on the aggregate economy
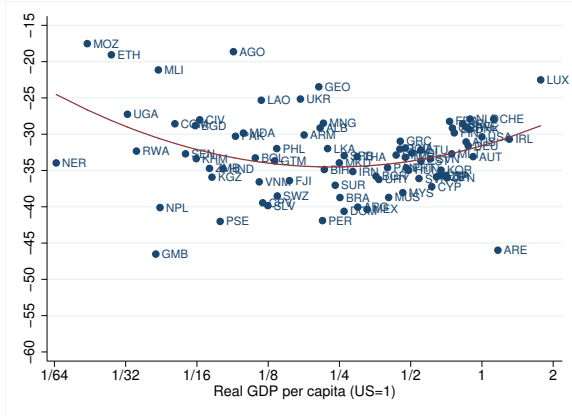
(a) Change in employment (%)
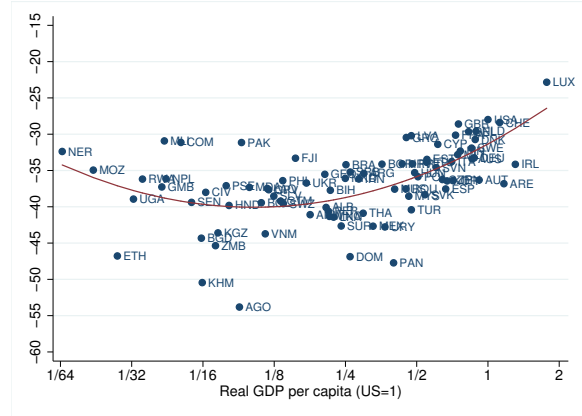
(b) Change in GDP (%)

(c) Fraction of essential employment

(d) Work from home replacement rate

Empirical real GDP per capita of each country corresponds to the 2017 PPP-adjusted series from Feenstra et al. (2015), normalized to the U.S. The trend line is a quadratic fit of the logarithm of real GDP per capita.

Table 2: Average impact of lockdown policies on country income groups, aggregate economy

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
		Aggregate economy					Non-agricultural sector				
	Income	Δ Emp	ΔGDP	n_e	n_h	h	Δ Emp	ΔGDP	n_e	n_h	h
Q1	0.05	-32%	-39%	0.60	0.09	0.21	-47%	-46%	0.40	0.13	0.22
Q2	0.14	-32%	-39%	0.57	0.11	0.26	-41%	-43%	0.44	0.15	0.27
Q3	0.30	-36%	-39%	0.52	0.13	0.26	-40%	-41%	0.45	0.14	0.26
Q4	0.55	-34%	-35%	0.50	0.16	0.32	-37%	-36%	0.46	0.17	0.32
Q5	0.95	-31%	-31%	0.52	0.18	0.37	-31%	-32%	0.51	0.18	0.37

Note: Column (1) reports the average empirical GDP per capita by quintile of the income distribution, normalized to the U.S. Columns (2) and (3) report the percent change in aggregate employment and GDP, respectively. Column (4) and columns (5) report the average post-lockdown essential and work-from-home employment, respectively, relative to total pre-lockdown employment. Column (6) reports the average rate at which non-essential labor is replaced with work from home. Columns (7)-(11) are analogous and cover the non-agricultural sector.

aggregate post-shock employment and income per capita.

4.2 Non-agriculture

We repeat the above exercise by excluding the agricultural sector from the analysis. As shown in Table 1, agriculture is a highly essential in that it shuts down only 7% of workplaces during lockdown. It is also a sector whose contribution to the economy varies widely with income per capita. It represents on average 38% (23%) of employment (value added) in the bottom quintile of countries, but only 2% (1%) of employment (value added) in the top quintile.

The upper panes of Figure 2 depict the lockdown effect on countries' non-agricultural employment and GDP. Now, both non-agricultural employment and non-agricultural GDP are clearly monotonically increasing in income. This is in stark contrast to the analogous results for the aggregate economy in Figure 1. Columns (7) and (8) of Table 2 summarize the results by income quintiles. The lockdown reduces employment by 47 percent in the bottom quintile and only by 31 percent in the top quintile. The decline in GDP follows a similar pattern: 46 percent in the bottom and 32 percent in the top quintile.

The lower panes of Figure 2 highlight the difference to the aggregate economy results. What stands out is the left pane where essential employment, n_e, is now *increasing* in income. It turns out that within non-agriculture, it is rich countries that concentrate more labor in sectors with a high essentialness scores. Examples include finance and insurance, information and communication, and public administration. Meanwhile, the relationship between the non-agricultural WFH replacement rate and income, depicted in the right pane of Figure 2, is similar to that of the aggregate economy. Altogether, within agriculture, both the sectoral composition and the WFH ability cushion rich countries more than poor countries.

This underscores the role of the agricultural sector in driving the cross-country relationship between the aggregate economic outcomes and income. As agriculture is mostly essential, it sustains aggregate post-lockdown employment and GDP in the poorest countries where it represents a large fraction of the economy. Moreover, as is well known, agriculture features relatively low labor productivity given that its employment share is larger than its value added share. This explains why aggregate employment drops by a similar magnitude on both extremes of the income distribution, while GDP falls more precipitously in the bottom quintile of countries than in the top quintile.
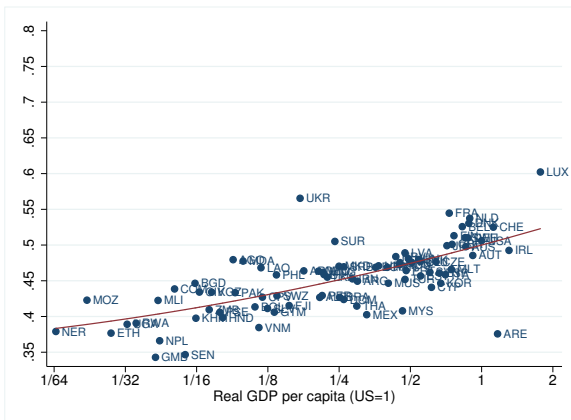
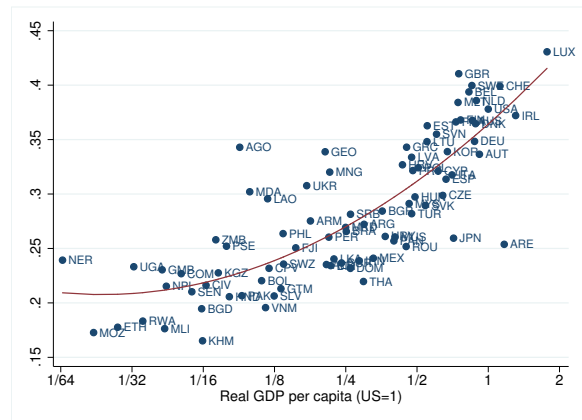Figure 2: The impact of lockdown on the non-agricultural sector
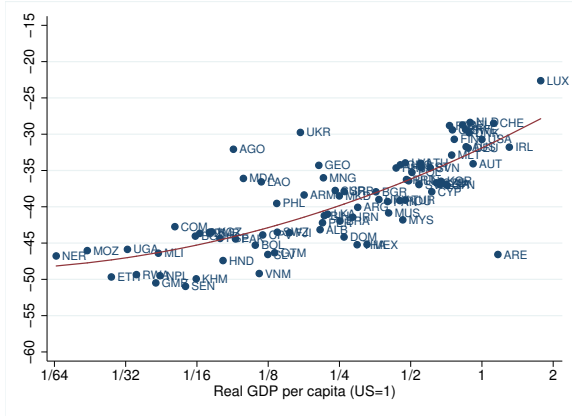
(a) Change in employment (%)
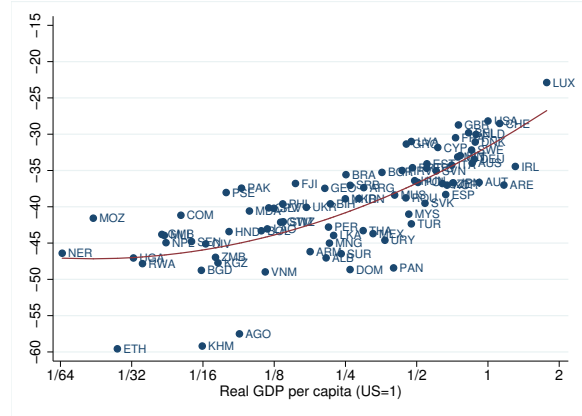
(b) Change in GDP (%)

(c) Fraction of essential employment

(d) Work from home replacement rate

Real GDP per capita of each country corresponds to the 2017 PPP-adjusted series from Feenstra et al. (2015), normalized to the U.S. The trend line is a quadratic fit of the logarithm of real GDP per capita.

5 Conclusion

This paper measures the impact of a common lockdown policy on employment and GDP for countries across the development spectrum. We argue that the employment composition favors poorer countries as they devote more labor to essential activities, particularly in the agricultural sector. Richer countries, on the other hand, are cushioned by their higher ability to work from home. Altogether, the employment response to a lockdown is U-shaped in income per capita. GDP, on the other hand, drops more strongly in low- and middle-income countries than in high-income countries. Our study is based on a particular sectoral lockdown policy. For alternative scenarios, we provide a "lockdown simulator" that allows simulating the effect of arbitrary sectoral lockdowns policies.[12]

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[12]Accessible at https://work-in-data.shinyapps.io/work_in_data/.

A Appendix

A.1 Model derivation

Here we derive the model that underpins equation (2) that used to calculate GDP relative to trend. Consider a closed economy where gross output in sector i is

$$g_i = z_i x_i^{\theta_i} \prod_{j=1}^{I} m_{ij}^{\gamma_{ij}},$$

with parameters $\theta_i \in [0, 1]$ and $\gamma_{ij} \in [0, 1]$ such that $\theta_i + \sum_{j=1}^{I} \gamma_{ij} = 1$. The sector's TFP is z_i and there are two types of production factors: x_i is a bundle of the sector's human and physical capital and m_{ij} is intermediate consumption of goods from sector j. Let p_i denote the price of output of sector i. Assuming perfect competition, profit maximization with respect to intermediate inputs implies $p_j m_{ij} = \gamma_{ij} g_{ij}$, $\forall i, j$. In particular, the sector's value added equals

$$V_i \equiv p_i g_i - \sum_{j=1}^{I} p_j m_{ij} = \theta_i p_i g_i.$$

The representative household chooses final consumption c_i to maximize utility

$$Y = \prod_{s=1}^{I} c_i^{\phi_i}$$

with parameters $\phi_i \in [0, 1]$ such that $\sum_{i=1}^{I} \phi_i = 1$. The optimality condition is hence $p_i c_i = \phi_i Y$, $\forall i$. The product market clears according to $c_i + \sum_{j=1}^{I} m_{ji} = g_i$, $\forall i$.

Let Y denote real GDP and $P \equiv 1$ its normalized price so that $PY = Y = \sum_{i=1}^{I} p_i c_i$. In equilibrium, it can be shown that GDP is

$$Y \propto \prod_{i=1}^{I} \left(z_i x_i^{\theta_i} \right)^{d_i}$$

with parameter vector $d = \phi'(I - \Gamma)^{-1}$ where I is the identity matrix and Γ is the matrix with elements γ_{ij}. In particular, d_i equals the Domar weight of sector i, $d_i = \frac{p_i y_i}{Y}$. If z_i is constant and the only exogenous shock occurs through the supply of x_i, then $Y \propto \prod_{i=1}^{I} x_i^{\nu_i}$ where $\nu_i = \theta_i d_i = \frac{V_i}{Y}$ equals the (constant) aggregate value added share of sector i in the economy. GDP relative to trend is then $y \equiv \frac{\tilde{Y}}{Y} = \prod_{i=1}^{I} \left(\frac{\tilde{x}_i}{x_i} \right)^{\nu_i}$ where $\tilde{x}_i / x_i$ denotes the relative utilization of factor x_i following the shock. Our final assumption is that capital and labor (l) enter homothetically into x and that they change in equal proportion following the shock, resulting in

$$y \equiv \frac{\tilde{Y}}{Y} = \prod_{i=1}^{I} \left(\frac{\tilde{l}_i}{l_i} \right)^{\nu_i}.$$

Economies can differ in their underlying parameters, which implies that v_i is country-specific.

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