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# IMF Working Paper

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A Mexican State-level Perspective on Covid-19 and its  
Economic Fallout

by Juan Pablo Cuesta Aguirre and Swarnali Ahmed Hannan

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I N T E R N A T I O N A L M O N E T A R Y F U N D

**IMF Working Paper**

Western Hemisphere Department

**A Mexican State-level Perspective on Covid-19 and its Economic Fallout**

**Prepared by Juan Pablo Cuesta Aguirre and Swarnali Ahmed Hannan**

Authorized for distribution by Rishi Goyal

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**Abstract**

Mexico has had one of the highest death tolls from Covid-19 and among the largest declines in output compared to peers. This paper utilizes data on Mexico's thirty-two states to better understand the relationship between health and economic outcomes. For instance, did the states with worse pandemic outcomes suffer more economically? What state-level characteristics impacted health and economic outcomes? Among the findings are: individual traits such as age and certain pre-existing conditions were associated with higher illness and fatality risks. States with higher initial health expenditure and capacity on average had a lower case fatality rate. The economic fallout was widespread well beyond the direct impact of the pandemic. Tourism-heavy states were particularly badly affected, while states with larger exposures to manufacturing exports performed better. These findings support the case for adequate health spending, fiscal lifelines for hard-hit workers and sectors, and further integration into global value chains to bolster economic outcomes and resilience.

JEL Classification Numbers: E6, H7, I1, J1, R1

Keywords: Covid-19, state-level data, economic activity, containment measures, pre-existing conditions

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## I. INTRODUCTION<sup>1</sup>

The Covid-19 pandemic has had a tragic toll on Mexico, with one of the highest number of deaths globally. As of early October 2020, Mexico had over 800,000 cases and over 80,000 fatalities. Output in the second quarter experienced its largest drop historically and one of the highest among G20 and Latin American peers, around 12 million workers lost their jobs, and the working poverty rate jumped from pre-pandemic 36 percent to 55 and 48 percent in May and June, respectively.

Against this backdrop, this paper studies the impact of the pandemic on health and economic outcomes across Mexico's thirty-two states. It asks four questions: (i) What is the relationship, if any, between the evolution of *cases and economic activity*? (ii) What is the role of *individual traits* (e.g., age, gender and health conditions) in determining case and death risks? (iii) What is the role of state characteristics and containment measures in reducing *case incidences*? (iv) What is the role of state characteristics in shaping *economic activity*? For the last two questions, the paper compares Mexico's experience to that of other countries, particularly its G20, emerging market, and regional peers.

The paper falls within a recent and growing literature that focuses on understanding the impact of Covid-19 (see Deb et al. 2020a for a literature review). The studies can be grouped into three categories:

- i. *Cross-country analysis* on the effectiveness of containment measures in reducing cases and economic activities: e.g., Deb et al. 2020a and 2020b, Chinazzi et al. 2020, and Hsiang et al. 2020. Focusing on local, regional, and national data of China, Korea, Italy, Iran, France, and USA, Hsiang et al. (2020) showed that containment policies significantly reduced the growth of Covid-19 infections. Deb et al. (2020b) found that containment measures led to a loss of about 15 percent in industrial production, but fiscal and monetary policy measures were effective in mitigating some of these economic costs.
- ii. *Country-specific analysis* on the Covid-19 impact: e.g., Campos-Vazquez et al. 2020, Tian et al. 2020, Cowling et al. 2020, and Chetty et al. 2020. Notably, Campos-Vazquez et al. (2020) analyze the universe of point-of-sale (POS) transactions in Mexico to conclude that consumption was highly heterogeneous across sectors and states, with those exposed to tourism the most affected. They also found the elasticity of POS expenditure with respect to geographic mobility to be slightly below 1, suggesting that spending in developing countries might be more responsive to mobility than in developed countries. Focusing on heterogeneity in the confinement measures within Mexico (proxied by Google mobility), the [second quarterly report](#) of

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<sup>1</sup> The authors would like to thank Rishi Goyal for overall guidance; Javier Ochoa for his excellent editorial assistance; Krishna Srinivasan, Alejandro Werner, Kevin Wiseman, Saiful Hannan, Nikolay Gueorguiev, John Hooley, Deniz Igan, Samir Jahan, participants at IMF Western Hemisphere Department Seminar, and colleagues from Secretaría de Hacienda y Crédito Público (SHCP, Mexico) and Banco de México for their helpful discussions, suggestions and comments.

Banxico (2020, Box 2) finds that containment measures were associated with improved health outcomes but lower economic activity in retail sales and IMSS employment<sup>2</sup>.

- iii. *Epidemiological models*, calibrated to Covid-19 dynamics to understand the implications of factors such as health costs and quarantines: e.g., Dudine et al. 2020 and Forslid et al. 2020. The former study found that, under capacity constraints, effective social distancing and quarantines can significantly reduce the additional health spending needed from \$0.6-1 trillion globally to \$130-231 billion.

To our knowledge, this is the first comprehensive study—looking at both case incidences and economic activities across a range of indicators—with a state-level focus for Mexico. Given that Mexico is a large emerging market with a high number of cases, it also contributes to the broader discussion of the impact of Covid-19.

The paper uses an extensive range of data on multiple frequencies (daily, monthly) and units (individual-, state-, and country-levels), compiling data across various government sources in Mexico and complementing this with different international sources (see Annex I for details). The methodologies employed are dictated by the questions posed and the availability of data (and its underlying frequency). To understand the role of individual traits, we employ probit regressions on an individual-level dataset since the outcome variable is of a binary nature. To understand the role of state-level characteristics on influencing cases and activities, panel regressions are used on monthly data. To determine the effectiveness of containment measures, local projection methods—appropriate to understand the impact of shocks—are used on daily data.

The key takeaways are as follows:

*Cases versus economic activity.* The economic fallout was widespread, not localized to high case states. For example, retail sales across all states dropped in April (compared to January 2020), ranging from 10-40 percent.

*Cases versus role of individual characteristics.* Age and certain pre-existing conditions (e.g., diabetes, obesity) were associated with higher cases and deaths. The predicted probability of a 20-year old testing positive, keeping all other control variables at mean, is 40.5 percent, while the equivalent probability for a 60-year old is 52.6 percent. Similarly, the probability of testing positive increases by 6.8 and 4.8 percentage points if an individual has obesity and diabetes, respectively.

*Cases versus role of initial (pre-Covid-19) state characteristics.* Richer and more densely populated states had higher cases. States with higher initial health expenditure and capacity (e.g. beds/ICU beds per capita) had, on average, lower deaths per cases. Containment measures were effective but less than that of other emerging markets.

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<sup>2</sup> Employees insured by Mexican Social Security Institute (IMSS).

*Economic activity versus role of state characteristics.* Tourist-exposed states were hit hard, but export-exposure more generally provided some cushion, particularly regarding retail sales. This could be due to: (i) higher remittances in exporting states; (ii) Mexico's less export decline relative to other countries; and (iii) possible supply chain resilience. The analysis also finds that states with higher population density fared worse, and containment measures and less mobility led to decreased economic activity.

The findings of the paper suggest that concerted policy efforts are required on many fronts to mitigate the detrimental effects of the pandemic. The health spending in Mexico needs to be stepped up owing to Mexico's comparatively lower health expenditure and capacity, lower Covid-19 related health spending thus far, and higher incidence of pre-existing conditions such as obesity and diabetes. Policies will need to support workers and firms of hard-hit sectors, particularly in the context of high informality within the economy. Finally, taking steps to facilitate investment and integration in global value chains would support growth and resilience.

The rest of the paper is organized as follows. Section II discusses the evolution of *cases and economic activity*, both from a cross-country and state-level perspective. Section III discusses how *individual traits* influence case and death risks. Section IV discusses the role of state characteristics and containment measures in determining *case incidences* and compares Mexico's experience to that of other countries. Section V determines the role of state characteristics and containment measures in determining *economic activity* and compares to international experience. Section VI concludes.

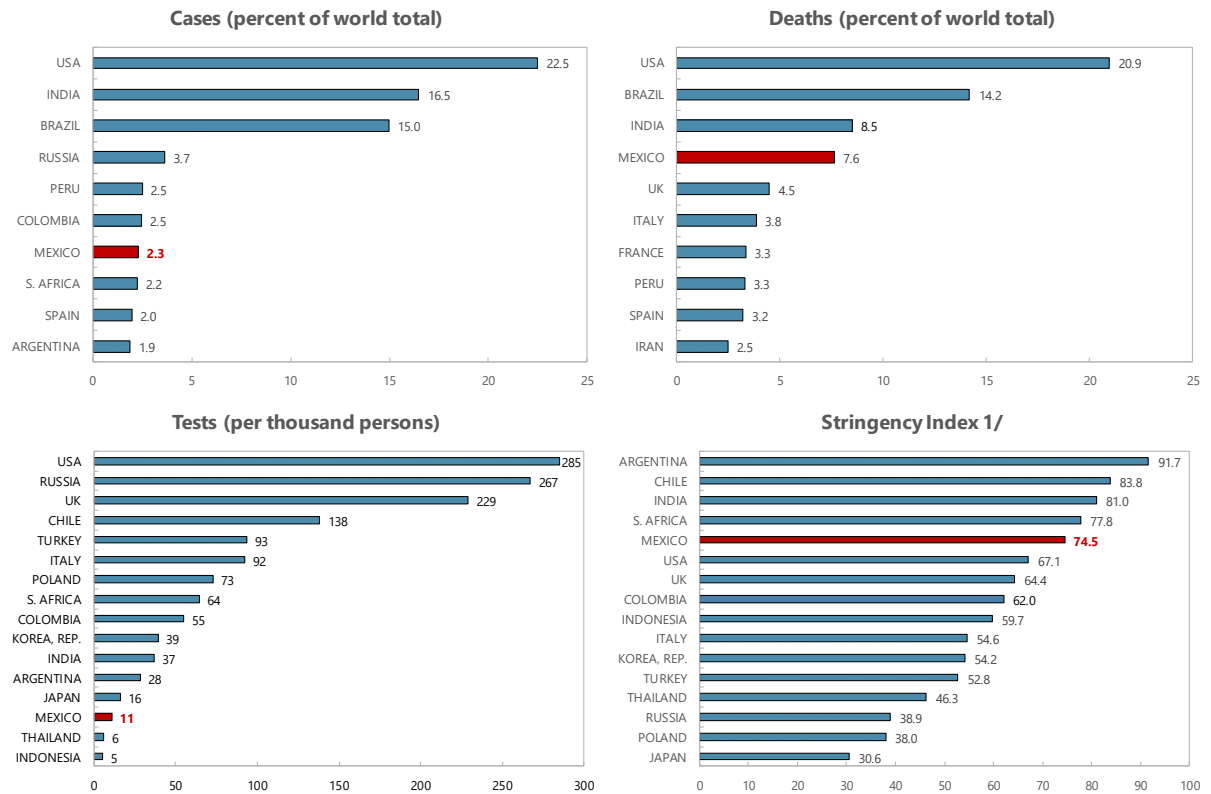
## II. CASES AND ECONOMIC ACTIVITY

Mexico has been one of the hardest hit countries from the Covid-19 pandemic (Figure 1). This is considered an underestimate as excess death statistics in certain states suggest fatalities are at least three times greater (e.g., [Zavala and Despeghel 2020](#)). Despite having one of the highest numbers of cases, Mexico significantly lags in testing with just 11 tests per 1000 persons, much lower than many G20 and emerging market peers. The commonly used containment measure, Oxford Stringency Index, suggests that policy efforts for social distancing have been relatively less strict than regional peers like Chile and Argentina, but tighter than other emerging markets like Turkey and Thailand.<sup>3</sup> However, one caveat with using these measures is that the announced policies may not necessarily completely reflect the actual implementation of these measures.

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<sup>3</sup> [The Oxford Stringency index](#) of the health policy response collects publicly available information on policies such as school closure, travel bans, etc., and records them on a scale from 0 to 100 (100=more stringent). The data is collected from publicly available information on a number of indicators of government responses. The stringency of those measures is then scored, and aggregated into a Stringency Index. The measure is for comparative purpose only, and should not be regarded as a rating of the effectiveness of a country's response.

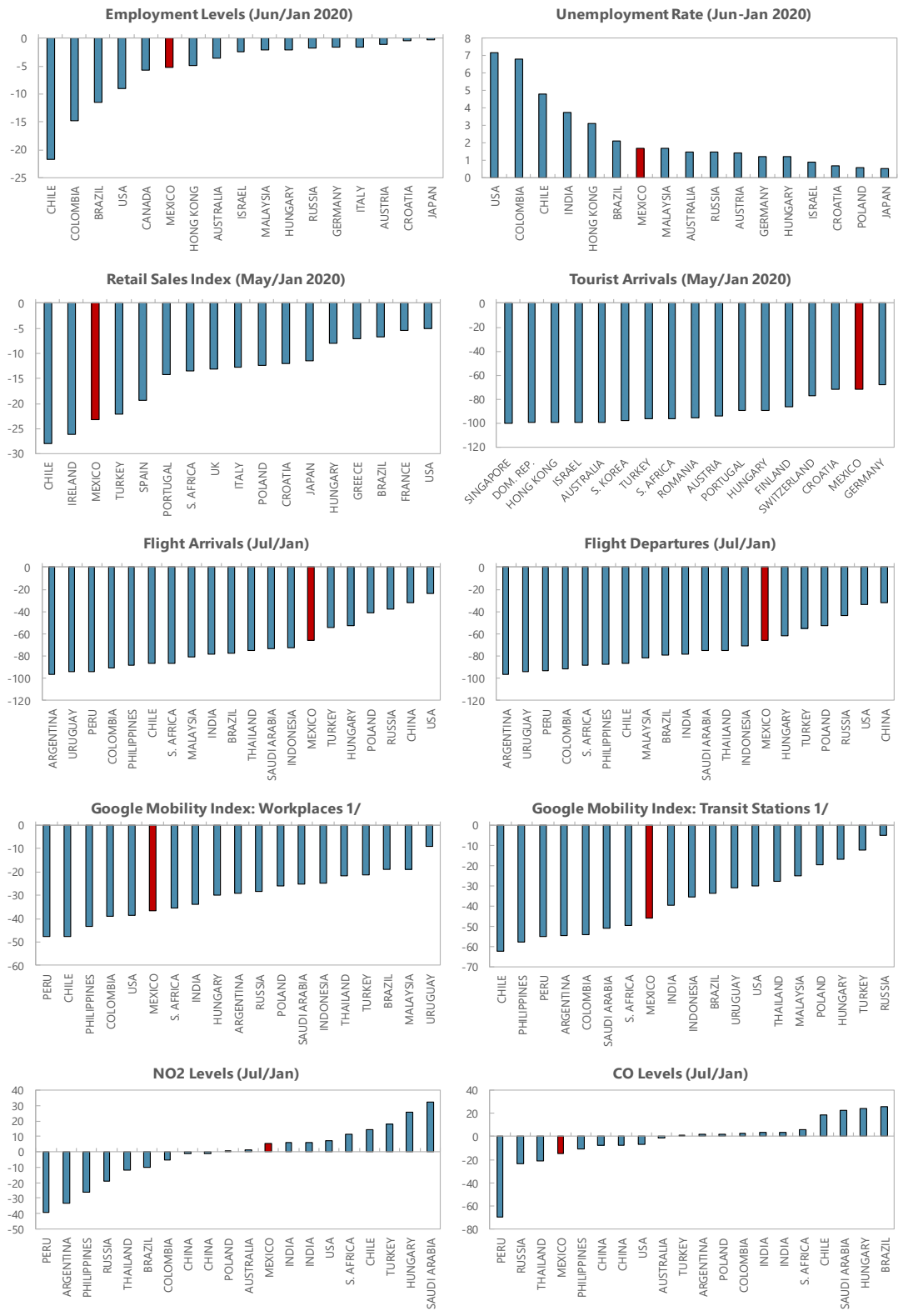
**Figure 1. Covid-19 Cases and Containment Measures, Mexico and Key Economies**



1/ Oxford University Stringency index of the health policy response. The Stringency index collects publicly available information on policies such as school closures, travel bans, etc., and records them on a scale from 0 to 100 (100 = more stringent).

Data as of September 12, 2020.

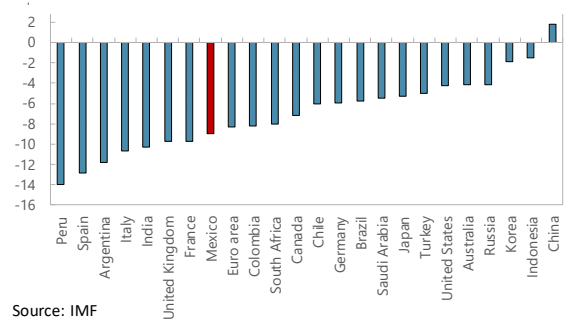
**Figure 2. Economic Activity in Mexico and Key Economies**



1/ Google Mobility Index shows change relative to a baseline. The baseline is the median value, for the corresponding day of the week, during the 5-week period Jan 3-Feb 6, 2020.

The hit in Mexico’s economic activity is also high from a cross-country perspective. A range of high frequency indicators suggests sharper drops compared to G20, regional peers, and key emerging markets (Figure 2). Retail sales in the country dropped by 23 percent since January 2020. Among comparator countries, only Ireland and Chile had higher drops. The loss in employment is on the high side, but lower than regional peers like Chile, Colombia, and Brazil. However, owing to the presence of high informality, the reported numbers probably do not fully account for the extent of job losses. Having said that, the decline in activity is substantial but comparable to other countries in indicators like tourist arrivals and flight arrivals/departures. The sharper drop in output compared to most peers is also borne out in the GDP data for the second quarter of 2020. Finally, October 2020 IMF WEO projections suggest that Mexico is likely to have one of the worst growth outcomes in 2020, compared to other G-20 emerging markets (Figure 3).

**Figure 3. 2020 Real GDP Growth Forecasts (percent)**

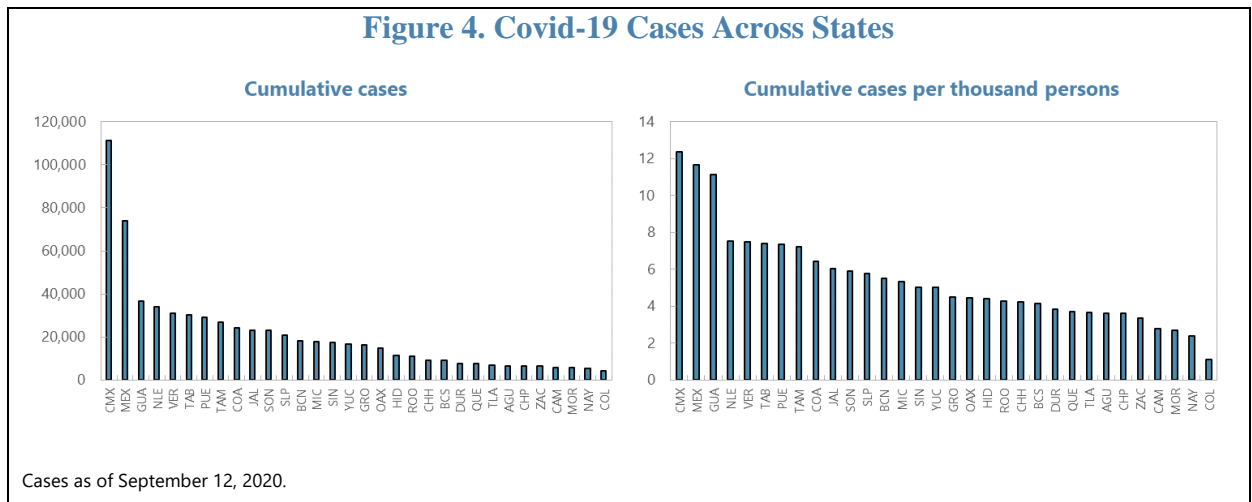


Source: IMF

**A. Cases across states**

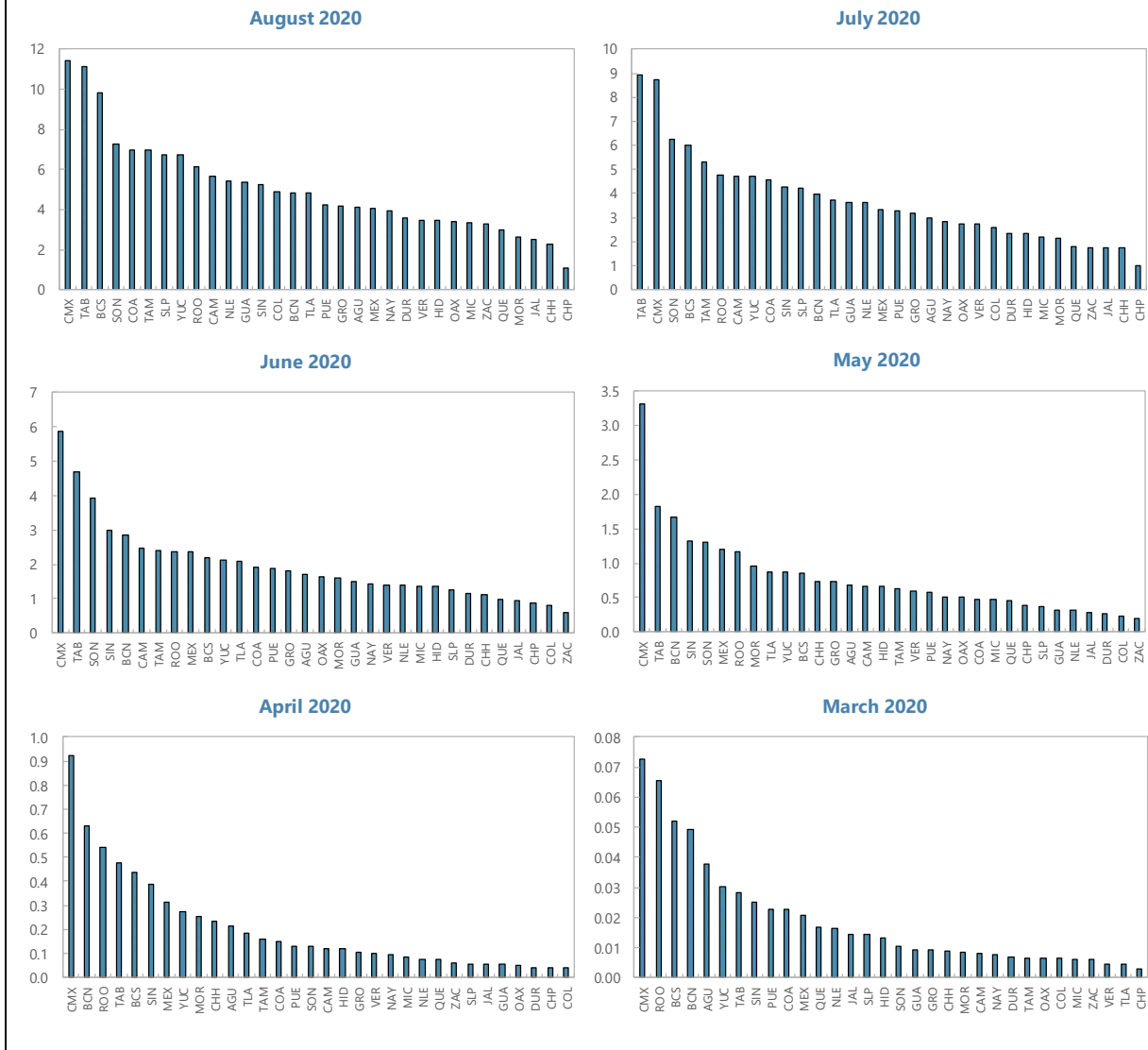
Though all states are affected, cases have been concentrated in a few states, ranging from higher than 111,000 affected persons in Mexico City to less than 4,100 persons in Colima. Even accounting for population, cases remain concentrated, ranging from 12.4 persons per thousand in Mexico City to 1.1 per thousand in Colima (Figure 4). In the initial months of the pandemic and until around May 2020, cases were even more concentrated, with Mexico City and Quintana Roo witnessing most cumulative cases per capita in March while Chiapas and Tlaxcala the least (Figure 5). By the end of August 2020, Mexico City and Tabasco had the highest number of cases per capita, while Chiapas and Chihuahua had the least.

**Figure 4. Covid-19 Cases Across States**





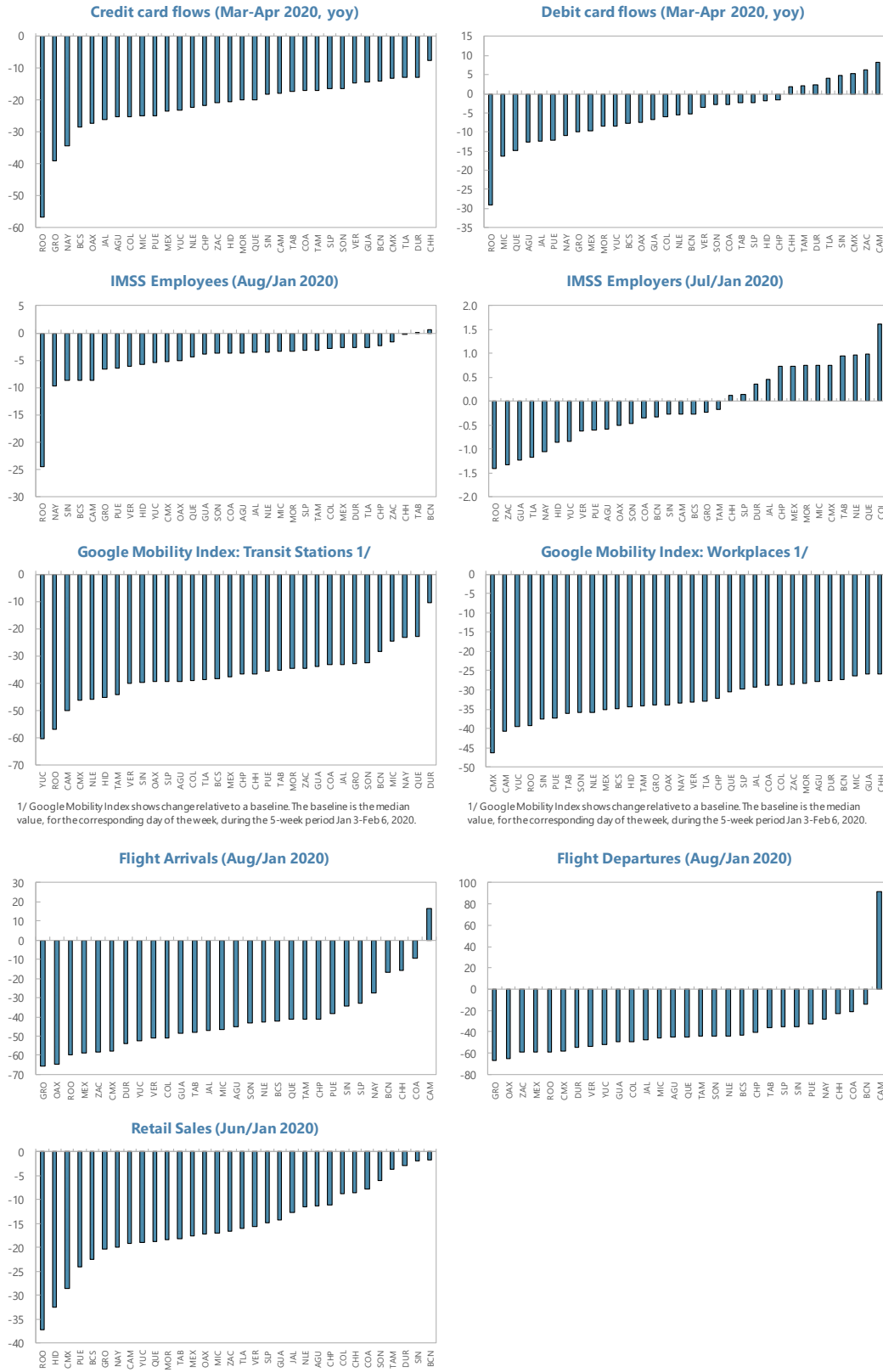
**Figure 5. Cumulative Covid-19 Cases Over Time (per thousand persons)**

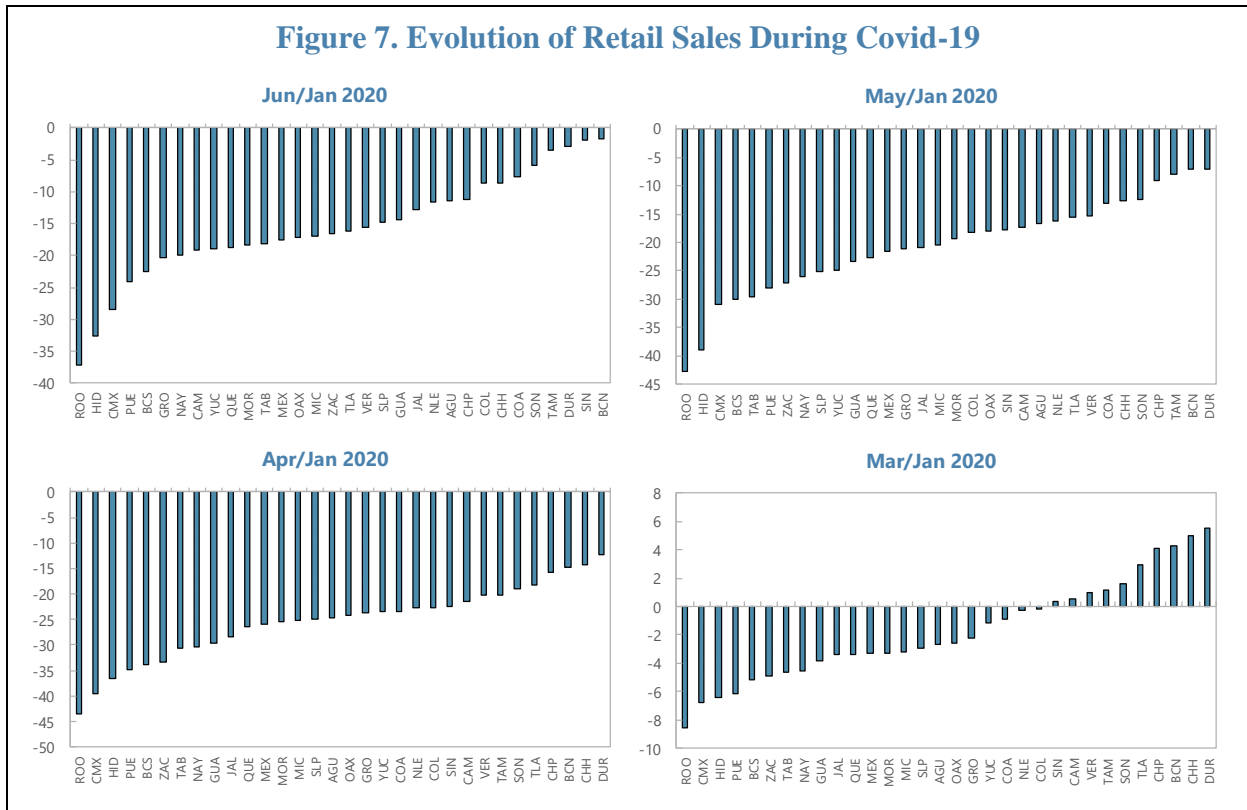


## B. Economic activity across states

As Figure 6 shows, the sharp fall in economic activity was widespread across all the states, evident from a wide range of high frequency indicators (debt/credit card use, employment, flight arrivals/departures, Google mobility index for workplaces/transit stations). By April 2020, retail sales growth, compared to January 2020, was negative for all states (Figure 7), with 43 percent decline in Quintana Roo (the highest drop amongst states) and more than 12 percent drop in Durango (the state with the lowest drop). The widespread drop in activity is also evident from other activity indicators since January 2020: IMSS-insured employees (ranging from -25 percent in Quintana Roo to -2 percent in Zacatecas), credit card flows (from -57 percent in Quintana Roo to -7 percent in Chihuahua), Google mobility workplaces (from -46 percent in Ciudad de Mexico to -26 percent in Chihuahua).

Figure 6. Economic Activity Across States



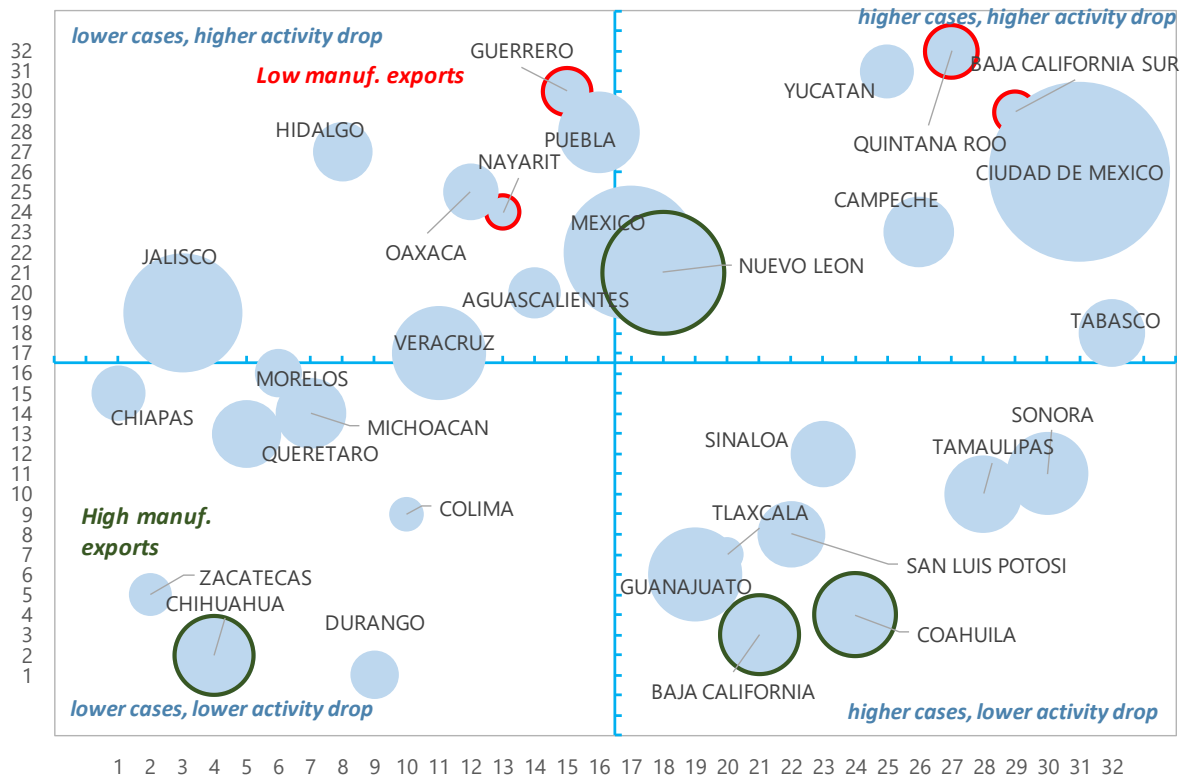


### C. Cases and economic activity across states

The economic fallout was widespread, not localized to high case states. Figure 8 ranks cases and activity drop, with a lower ranking suggesting lower cases (or lower output drop). States in the top-right quadrant (e.g., Quintana Roo, Mexico City) had comparatively higher cases per capita and sharper output drop, while states in the top-left quadrant had higher output drop despite lower cases (e.g., Oaxaca, Hidalgo). Notably, some states with high manufacturing export-exposure (e.g., Baja California, Chihuahua, Coahuila) had less output drop, while low manufacturing export- and high tourist-exposure states (e.g., Baja California Sur, Quintana Roo, Guerrero) had higher output drop.<sup>4</sup> Section V empirically tests this finding and shows that states with high tourist-exposure fare disproportionately worse, controlling for other factors, while there is some evidence that export-exposed states fared better, particularly in retail sales.

<sup>4</sup> High- and low-manufacturing exposure states are taken from Chiquiar et al. (2017).

**Figure 8. Rankings, Cases per Capita and Economic Activity**



Source: National authorities and IMF staff calculations. Data as of July 2020. Cases are in per capita terms. Economic activity includes the average of the percent change (July 2020-January 2020/earlier; 2020 March-April year-over-year changes for debit/credit flows) of the following variables: debit and credit card flows, IMSS employees and employers, retail sales, Google workplaces and transit stations.

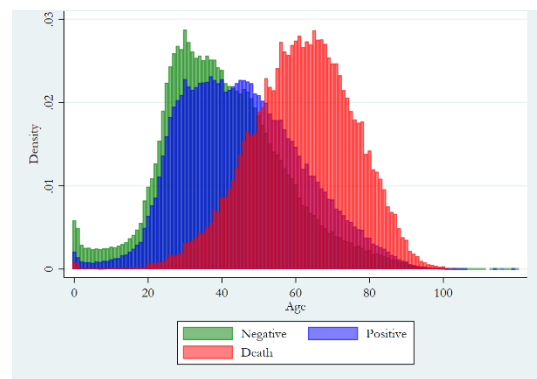
### III. CASES—THE ROLE OF INDIVIDUAL TRAITS

Before diving into the contribution of state-level differences to health outcomes, it is worth discerning the common risks of case and fatality incidences across states. In this section, we determine whether individuals with certain characteristics or pre-existing conditions are more prone to Covid-19. We use a dataset containing individual-level information for people who tested for Covid-19. The dataset contains more than 800K observations and includes information such as age, gender, pre-existing conditions, other conditions, smoker, residence (both state and municipality), etc. In particular, the dataset contains information across a wide set of diseases and pre-existing conditions: obesity, diabetes, hypertension, immunocompromised, pneumonia, chronic obstructive pulmonary disease (COPD), hypertension, cardiovascular disease.

## A. Stylized facts

Table 1 provides a snapshot of some of the key variables in the dataset. Though younger people have taken more tests, older people have tended to test positive for Covid-19. About 68 percent of the people who tested are below 50 years, while 62 percent of the people who tested positive are in that age range. Among the people who tested for Covid-19 and are below 25 years, 34 percent have tested positive. The equivalent number is 45 percent for the age-group 25-50. On the other hand, 32 percent of the people who tested are above or equal to 50 years of age, but 38 percent of the people who tested positive are in the age group. Amongst the 50-75 age-group who took tests, 56 percent tested positive, while the equivalent number is 59 percent for the age-group above 75 years. Figure 9 brings out this point further by plotting the histogram of the age-distribution versus cases that were negative (tested for Covid-19 and outcome was negative), positive (tested for Covid-19 and outcome was positive), and deaths (conditional on testing positive for Covid-19). The age-distribution of individuals testing negative is tilted toward a younger age-profile, but shifts toward an older age-profile for individuals testing positive, and an even older age-profile for individuals who died.

**Figure 9. Histogram—Age Distribution of People Who Took Covid-19 Tests**



Other than the age-profile, Table 1 also reports the gender composition and statistics related to some of the health conditions. While the testing data are split almost equally among men and women, 53 percent of the positive tests were for male and 47 percent for female. In terms of health conditions, the table suggests that individuals with obesity, diabetes, and pneumonia had a higher chance of testing positive: amongst the people who took tests and had diabetes, 55 percent tested positive. 70 percent of the people who took the test and reported pneumonia tested Covid-19 positive. All these numbers suggest that some of the pre-existing and health conditions could increase the likelihood of testing positive for Covid-19.

**Table 1. People who Tested for Covid-19, A Snapshot**

	ALL		POSITIVES		
	1	2	3	4	5
	Persons	Percent of all	Persons	Percent of positive cases	Percent of each group (3/1)
<b>Number of observations</b>	<b>847,163</b>		<b>399,868</b>		
<b>Age</b>					
<25	94,803	11	32,279	8	34
25-50	484,120	57	215,862	54	45
50-75	234,358	28	131,826	33	56
>=75	33,882	4	19,901	5	59
<b>Gender</b>					
Female	424,887	50	186,897	47	44
Male	422,276	50	212,971	53	50
<b>Health Conditions</b>					
Obesity	137,147	16	75,603	19	55
Diabetes	105,839	12	64,170	16	61
Asthma	25,882	3	10,793	3	42
Pneumonia	119,698	14	83,391	21	70

Data as of 28th July 2020

## B. Probit model

In this section, a probit model is used to determine how factors such as age, gender, and health conditions influence the probability of testing positive and the probability of death. The choice of probit model is motivated by the discrete outcome of tests. One of the advantages of using a probit model for such an analysis is that it also takes into consideration non-linear relationships.

The probit model is used to study two events (or, left-hand-side/dependent variables):

Probability of testing positive (1=positive; 0=negative)

Probability of death (1=death; 0=positive)

The independent, or the right-hand-side, variables include age, gender, health conditions. The data include a wide set of health conditions. An unrestricted to restricted specification approach is used to determine which health conditions influence the probability of interest. For both cases (probability of testing positive and probability of death), we start with a specification that includes all the health conditions and then remove the ones that are not statistically significant or are not of the expected sign.

*Prob(testing positive=1|taking test) OR Prob(death=1|testing positive)*

*= function (age, gender, variables representing health conditions)*

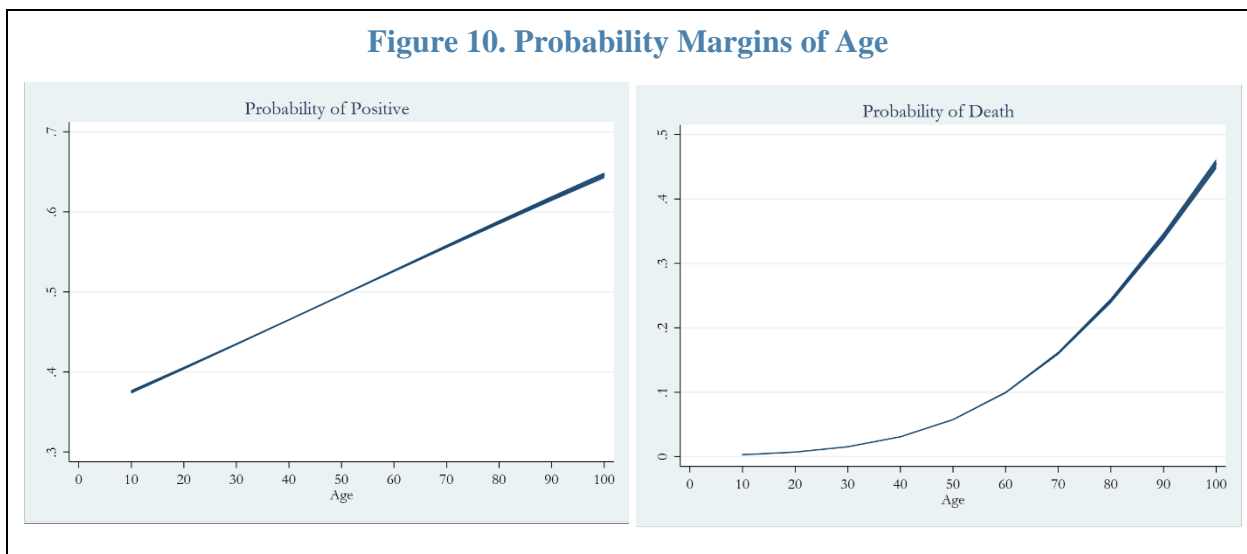
## Results

Using this approach, we find that age is an important determinant of testing positive and death. In addition, gender and health conditions such as pneumonia, obesity, diabetes, and hypertension are associated with a higher probability of testing positive. Gender and health conditions such as pneumonia, kidney-related disease, diabetes, immunocompromised, obesity, hypertension, COPD, and other diseases are associated with a higher probability of death.

*Age.* To gauge a sense of magnitude of these effects, Figure 10 plots the probability margin of age versus probability of testing positive and death. Probability margin is an exercise—commonly used for probit models—that computes how the predicted probability changes as one dependent variable (in this case, age) is changed and other dependent variables are kept at their mean levels.

The probit analysis confirms that, after controlling for other relevant factors such as health conditions, the probability of testing positive increases with age. The predicted probability of a 20-year old testing positive, keeping all other variables at their mean, is 40.5 percent; while the predicted probability of a 60-year old is 52.6 percent. The increase in probability owing to age is thus both statistically significant and of a meaningful magnitude.

The probability of death increases non-linearly with age, particularly after around 50 years. An age increase from 20 to 30 raises the probability of death by 0.8 percentage points, while an age increase from 40 to 50 years raises the likelihood by 2.7 percentage points. An age increase from 60 to 70 raises probability by 6.1 percentage points.



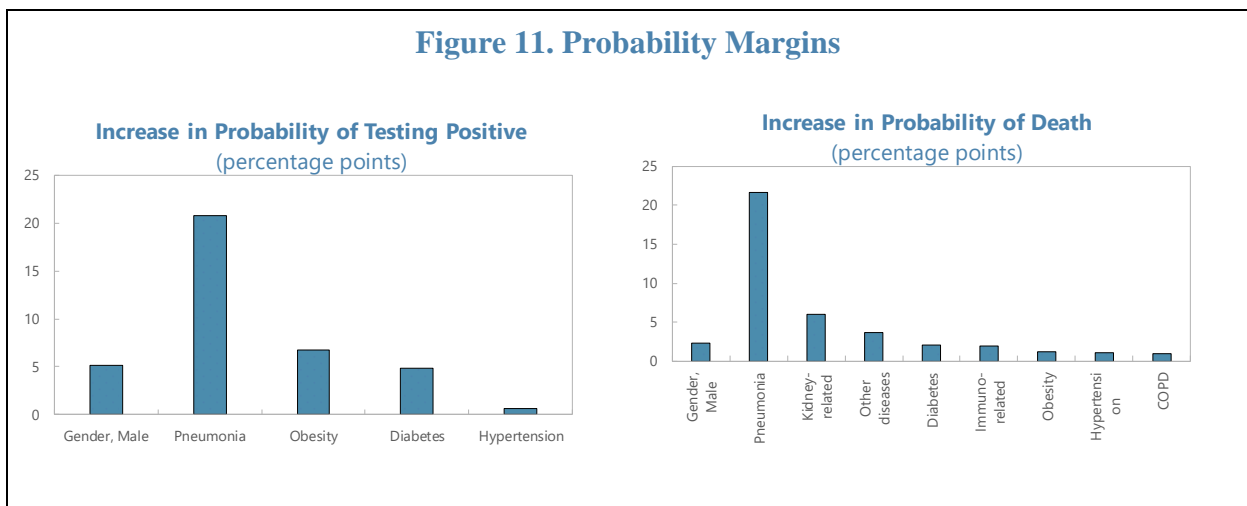
*Health conditions and other factors (Figure 11).* Some of the pre-existing conditions increase the probability of testing positive. Keeping all other independent variables at mean, the probability of testing positive increases by 6.8 percentage points if a person is obese and by 4.8 percentage points if the person has diabetes. The probability of testing positive increases by 20.7 percentage points if the person has pneumonia. The probability of death is found to

be associated with a larger set of pre-existing conditions, with factors such as kidney-related diseases increasing the probability by 6 percentage points. In addition, for both testing positive and death, the likelihood increases if the person is a male.

The results should be taken as a general support for the higher risks associated with age and certain health conditions, than a precise identification of the health conditions and the associated probabilities. In particular, the latter is meant to be indicative. Caveats associated with this work include: (i) Many reports suggest that Mexico's fatalities could be underestimated by around three times (e.g. [Zavala and Despeghele 2020](#)); and (ii) The analysis does not control for other factors that could be relevant (e.g. individual's income, living conditions, inclination to go for testing, etc.). The former would suggest that the sample of observations might not be completely representative, while the latter could bias the results.

Notwithstanding the caveats, these findings are corroborated by recent reports that suggest that age, certain pre-existing conditions and co-morbidities can increase risks related to Covid-19 (see CDC 2020 and Apicella et al. 2020 for further information and compilation of relevant literature on this issue, and [Worldometers](#) for the U.S. data on age-sex-demographics). In a March 2020 [Situation Report](#), the World Health Organization states that Covid-19 infects people of all ages. However, evidence at that point suggested that two groups of people were at higher risk of getting severe Covid-19: (i) older people (people above 60 years; the risk of severe disease gradually increasing with age starting from 40 years); and (ii) those with underlying medical conditions, such as cardiovascular disease, diabetes, respiratory disease, and cancer. Apicella et al. (2020) state that fatalities are high in older patients, in whom co-morbidities are common.

The findings of this section imply that it could be important to protect vulnerable populations such as the elderly and those with co-morbidities due the phased re-opening. This is especially needed in a context of high informality and limited savings/safety net and if a widely available, cheap, and effective vaccine will take time to develop (Hannan et al., 2020).





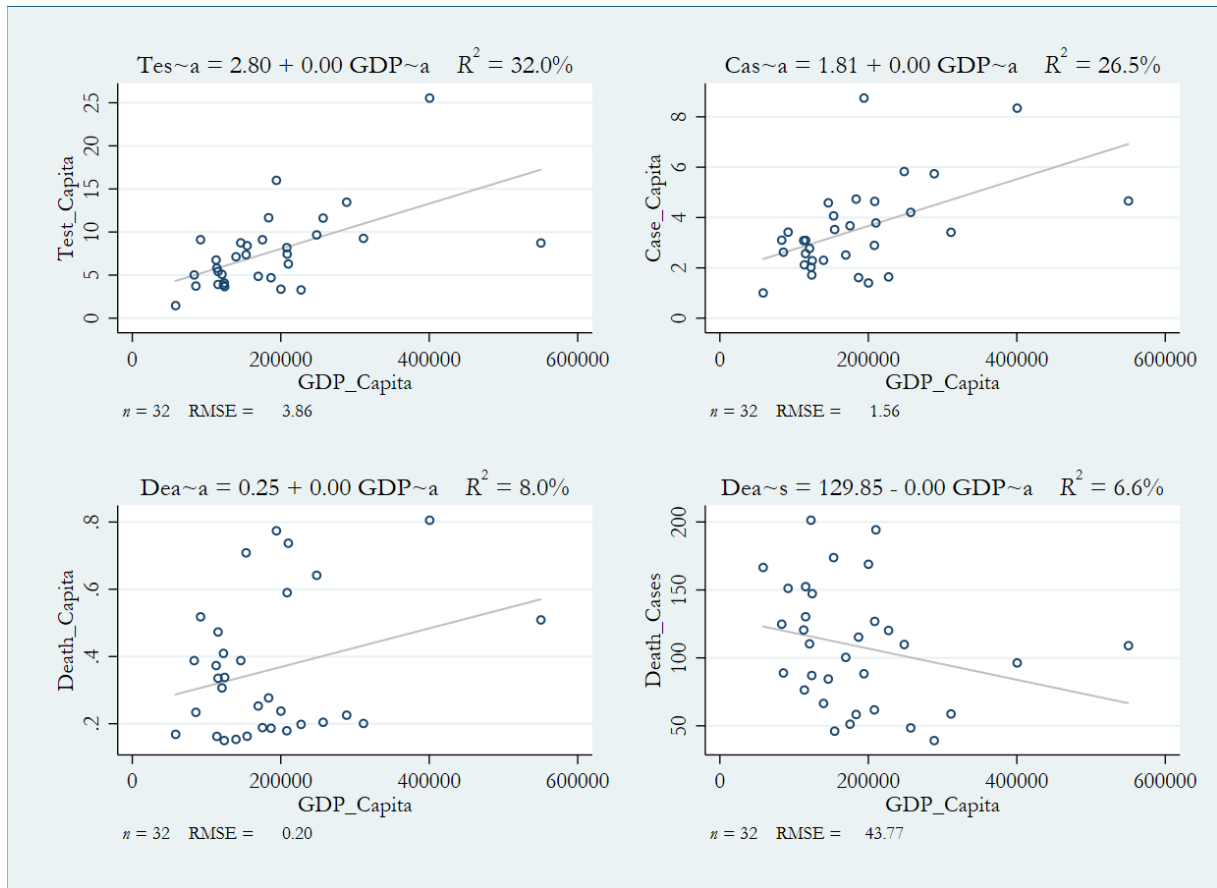
#### IV. CASES—THE ROLE OF STATE CHARACTERISTICS

In this section, we determine whether state characteristics such as income per capita, population density, health expenditure, and measures have an impact on Covid-19 case incidences (both number of cases and deaths). The key findings of this section are that richer and more densely populated states had higher cases, although the latter could be influenced by some outliers. Higher health expenditure and higher health capacity are associated with fewer deaths and death-to-case (or case fatality) ratios. Finally, containment measures were associated with declining covid-19 cases (controlling for other important indicators), but were less effective than that of other emerging markets. While Figure 1 (chart on stringency index) compares containment measures in Mexico to other countries, the emphasis here is on the *effectiveness* of measures in reducing cases for a given percent change in the stringency measure.

##### A. Stylized facts

*Income per capita.* Figure 12 plots income per capita versus different Covid-19 indicators as of end-July 2020, represented in cumulative terms. The charts suggest that richer states had higher cases, which could be because of higher testing. Richer states had higher tests per capita—the strong relationship evident from the high R-square. They also had higher cases per capita and higher deaths per capita; however, R-squares are lower than that of tests per capita, hinting at a weaker relationship. In spite of higher tests, cases, and deaths, richer states had lower deaths per cases. The lower deaths per cases could reflect better facilities in treating the patients or it could reflect that the denominator in death-to-case ratio is higher because of higher testing. In the empirical analysis, we will control for these effects when trying to understand initial factors such as income per capita and health expenditure.

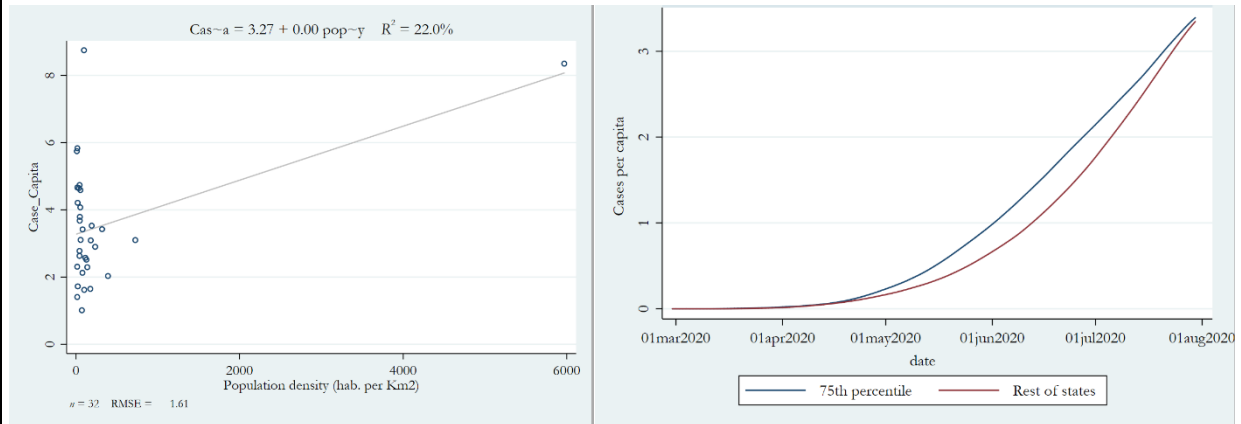
**Figure 12. Income per Capita versus Covid-19 Case Incidences 1/**



1/ The y-axis is presented in cumulative terms, per 1000 of the denominators; as of end-July 2020. For example, Test\_Capita is number of tests per 1000 persons.

*Population density.* The left-hand-side of Figure 13 plots cumulative cases per capita at end-July 2020 versus population density. The chart suggests that densely populated states had more cases. However, this could be influenced by one outlier (Mexico City which has substantially higher density than other states). The right-hand-side chart splits the states into the 75<sup>th</sup> percentile (states that are in top 75<sup>th</sup> percentile in terms of population density) and the rest of the sample. The chart plots the evolution of average cases per capita for these two groups over time. In the initial months of the pandemic, more densely populated states had more cases. However, this difference seems to have lessened with time.

Figure 13. Role of Population Density 1/



1/ The left-hand-side chart shows cumulative covid-19 cases per 1000 persons as of end-July 2020. The right-hand-side chart shows average covid-19 cases per 1000 capita, where cases per capita is the average of the states' (belonging to that particular group) 7-day moving average.

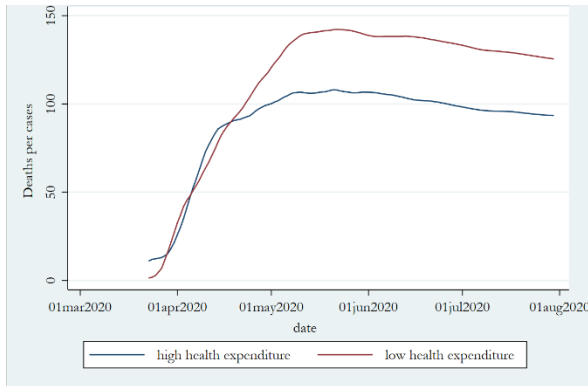
*Health expenditure and capacity.* Figure 14 documents the evolution of average deaths per 1000 cases, grouping states by their health expenditure per capita and capacity, which is represented by indicators such as health expenditure per capita, beds per capita (both total and available), and ICU beds available per capita.<sup>5</sup> The data for health expenditure per capita is taken from Ministry of Health (Annex I). For each indicator, the average deaths per cases are higher over time for low health expenditure/capacity states (states that are below 50<sup>th</sup> percentile for an indicator). This suggests that the health expenditure and capacity of states could have played a role in containing the effects of the pandemic. We will explore this further in the regression analysis section.

This relationship is broadly in line with studies that show health capacity can play a role in mitigating Covid-19 effect. Deb et al. (2020a) show that social distancing measures are more effective in countries with stronger health systems (better health security and better health index). In particular, stringent containment measures may have reduced the number of cases by more than 97 percent in countries with strong health systems but did not have statistically significant effects in countries with weak health capabilities.

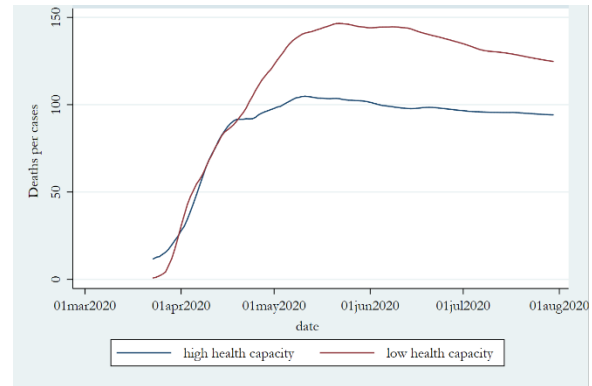
<sup>5</sup> Available beds/ICU beds, estimated by Institute for Health Metrics and Evaluation ([IHME](#)), refers to excess bed capacity/ICU bed capacity at that location. This is the total number of beds/ICU beds that exist at that location minus average number of total beds/ICU beds used normally at that location.

**Figure 14. Health Indicators Versus Evolution of Average Deaths per 1000 Cases 1/**

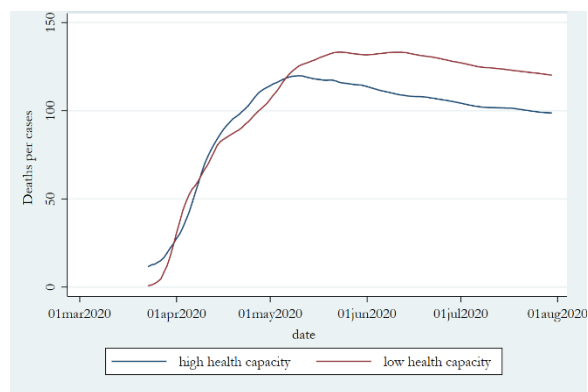
**Health expenditure per capita**



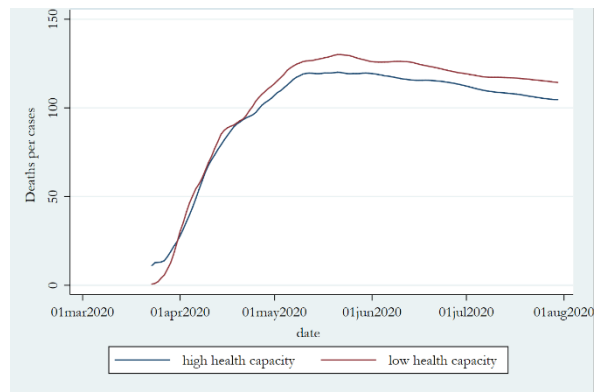
**Beds per capita**



**Beds available per capita**



**ICU beds available per capita**



1/ For each indicator, high health expenditure/capacity represents states with above or equal to 50<sup>th</sup> percentile for that indicator, while low health expenditure/capacity refers to states with health expenditure/capacity lower than 50<sup>th</sup> percentile. The y-axis represents the average deaths per cases across the states of the group, where deaths per cases is the 7-day moving average of cumulative deaths per 1000 cumulative cases.

## B. Regression analysis

In this sub-section, we perform two types of regression analyses. To understand the role of state characteristics, we use panel regressions using monthly data. To explore the effectiveness of containments measure, we employ Jorda's (2005) local projection methods on daily data.

**Table 2. State-level Regression Results—The Role of State Characteristics on Covid-19 Incidences**

	(1)	(2)	(3)
per 1000 persons/cases	Cases per capita	Deaths per capita	Deaths per cases
GDP per capita	0.1949 (0.1461)	0.0845* (0.0381)	116.7290 (70.9899)
Population density	-0.0000 (0.0001)	0.0000 (0.0000)	0.0233** (0.0068)
Health expenditure per capita	-0.0351 (0.0198)	-0.0116** (0.0032)	-20.6712* (8.3886)
Measure	0.1511*** (0.0174)	0.0543*** (0.0088)	71.7072 (84.5947)
Test per capita	0.3626*** (0.0214)	0.0151*** (0.0029)	-11.7767*** (2.0354)
Observations	130	130	109
R-squared	0.9233	0.7413	0.3977
Number of groups	26	26	26

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Regressions include 1- or 2-lags of dependent variables

Population density is habitat per km<sup>2</sup>; health expenditure is million pesos per capita;

GDP per capita is million pesos per capita; test per capital is per 1000 persons

### Role of health indicators and other state characteristics

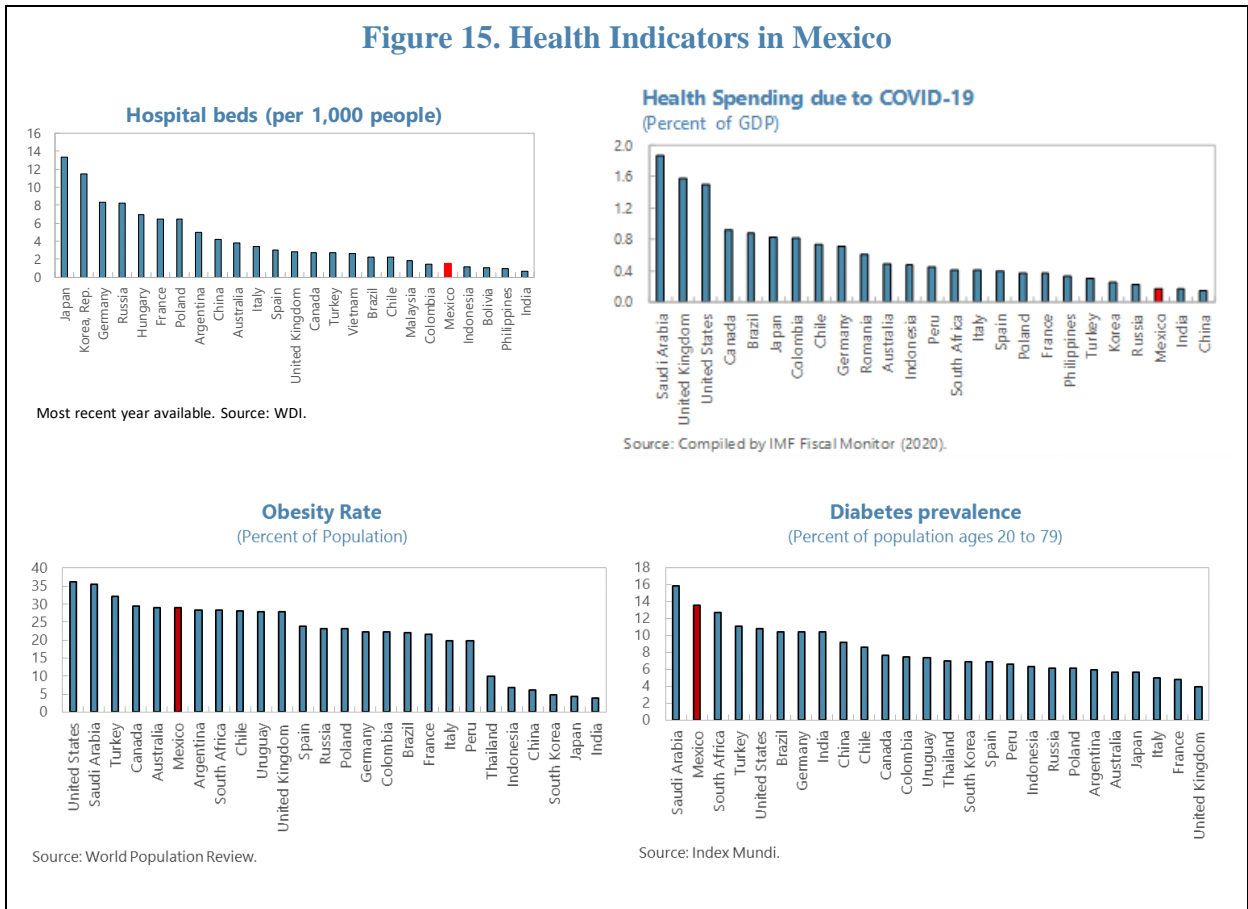
In this section, we are interested in understanding the role of state characteristics in influencing case incidence as measured by: (i) cases per capita, (ii) deaths per capita, and (iii) deaths per cases. We employ panel regressions on monthly data, March-July 2020, where the independent variables, informed by our stylized fact exercise, include: (i) income per capita, (ii) population density, (iii) health expenditure per capita, (iv) containment measures<sup>6</sup>, and (v) tests per capita. The last variable is useful to control for the fact that some states conducted a higher number of tests than others and could thus have a higher number of cases. In addition, the regressions also include 1- or 2-lags of dependent variables to control for any potential autocorrelation. The regressions include Driscoll-Kraay standard errors.<sup>7</sup> Since the variables

<sup>6</sup> Monthly containment measures are computed as follows for 26 states (where data are available from IHME): an equally weighted average of the following six measures of restrictiveness in: (i) educational facilities, (ii) business places, (iii) non-business places, (iv) gatherings, (v) travelling, and (vi) home. For example, educational facilities report the start date for educational facilities closed and, if applicable, the end date for educational facilities closed. The daily data are converted to monthly series as follows: measures taken in the first 10 days of the month are assigned 1, measures taken between the first 10 to 20 days are assigned 2/3, and measures taken after 20 days are assigned (1/3). Similar proportions are used to assign numbers where there are end dates of measures. Different weights are assigned since measures implemented early in the month would be in place for a longer time during the month, compared to measures that were implemented towards the end of the month.

<sup>7</sup> Since Driscoll-Kraay methodology is based on large T asymptotics, one should be somewhat cautious with using this methodology to panel datasets including a large number of groups but a small number of observations over time. The results do not change when panel regressions using robust standard errors are used instead.

representing state characteristics (e.g., income per capita, health expenditure per capita) include pre-pandemic data, there is no endogeneity concern related to state characteristics and Covid-19 case incidences.

Table 2 reports the regression results. States that have higher health expenditure per capita were associated with lower deaths per capita and lower deaths per cases (columns 2 and 3), controlling for factors such as income per capita, tests per capita, and containment measures; and this effect is statistically significant, underscoring the importance of initial health conditions in mitigating pandemic effects. In addition, the state-level regressions suggest that richer states had more deaths per capita, while highly populated states had more deaths per cases (though the latter could be driven by one state’s markedly high population density). Given that multiple forces could determine Covid-19 outcomes which are not included in the regressions, the analysis points towards correlation (controlling for key factors where data is available) rather than causation.



Beyond regression results, the importance of health indicators is also visible from Mexico’s pre-Covid-19 health indicators and Covid-19 related health spending measures (Figure 15). Mexico’s pre-Covid-19 health expenditure and capacity are lower than other G20 and regional peers (Hannan et al., 2020). In addition, co-morbidity factors are high because of high obesity and diabetes incidences. All these factors would suggest that Mexico’s health spending related to Covid-19 should be higher. However, thus far, health spending due to

Covid-19 has been relatively low compared to other G20 and regional peers. The stylized fact charts and state-level regression results, pre-Covid-19 health expenditure/capacity and Covid-19 health response, and cross-country evidence suggest that increasing health spending could help to mitigate the negative Covid-19 effects.

### Role of containment measures

In this section, we gauge the effectiveness of containment measures in reducing new cases, using daily data and local projection methodology. Both state- and country-level regressions are employed to determine the effectiveness of containment measures across states, and to compare how Mexico fared relative to other emerging markets.

*State-level regressions.* The dynamic response of new cases (per 100,000 persons) to containment measures are estimated using local projection methods (LPM; Jorda 2005) using the following specification. The regression approach can be comparable (but not identical) to Deb et al. (2020a).

$$y_{i,t+k} - y_{i,t-1}$$

$$= \alpha^k + \beta^k \Delta T_{i,t} + \gamma^k \text{Health}_i + \sigma^k \text{Income\_per\_capita}_i + \theta^k \text{Population\_density}_i + \theta^k \Delta \text{Test\_per\_capita}_i + \nu^k X_{i,t} + \varepsilon_{i,t}$$

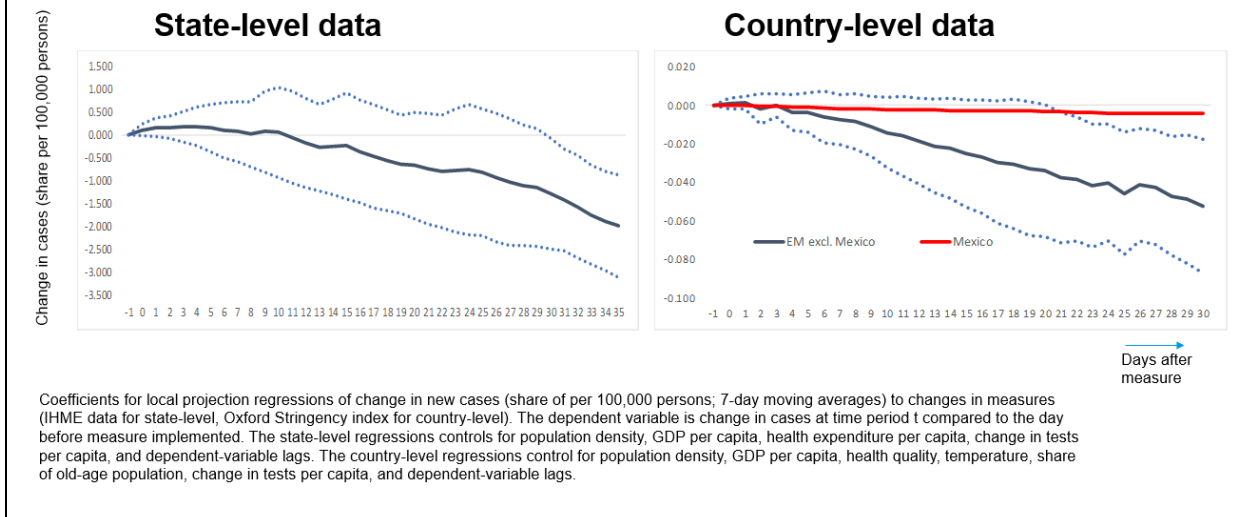
where:

- $y_{i,t+k}$  is the daily change in new cases per 100,000 persons (the underlying new cases per capita series expressed as 7-day moving average) of state  $i$  at time  $t+k$ ,
- $\alpha_i$  is regression constant,
- $\Delta T_{i,t}$  is the daily change in containment measures,
- Regressions control for health expenditure per capita, income per capita, population density, change in tests per capita (7-day moving average),
- $X_{i,t}$  contain two lags of  $\Delta Y_{i,t}$ ,
- $\varepsilon$  is an unexplained residual.

The containment measures are the daily average of the measures discussed in footnote 6. The change in containment measures is the daily change of the average of these measures.

Figure 16 reports the impulse responses. The negative coefficients suggest that the measures have been effective in reducing new cases per capita: a change in measure (shock) is associated with a decline in new cases per capita. However, the results are not statistically significant until a long period of about 30 days, indicating that measures might have taken a long time to become effective. The key findings are robust to alternative lag lengths of the dependent variable, using raw new cases per capita (instead of 7-day moving average), controlling for tests (instead of change in tests), and including a lag of the shock variable (change in measures).

**Figure 16. The Effect of Containment Measures on Cases**



*Country-level regressions.* A similar set-up is used for country-level regressions, where the country sample includes G20 emerging markets and other key emerging markets. The Oxford stringency index (footnote 3) is used for the containment measures. The state-level regressions include changes in containment measures, whereas country-level regressions include percent changes in containment measures. In addition to the control variables used for state-level regressions, country-level regressions control for median temperature and the share of the population aged 65 years and older. Instead of health expenditure per capita, healthcare access and quality index (HAQ index) is used to capture the quality of health across countries.

Both country-level Mexico and country-level emerging markets (excluding Mexico) show that the measures have been effective in reducing new cases per capita. Both the effects are statistically significant. However, in terms of magnitude of the coefficient, the results suggest that, for each percent change in measures, other emerging markets witnessed a higher drop in cases compared to Mexico. This suggests that measures might have been less effective in Mexico compared to other emerging markets. One caveat of this exercise is that the estimates are more reliable in a panel setting (that is, for emerging markets) than for a single-country set-up (country-level regression for Mexico) since there is greater variability across countries than across states or time-series within a country. In addition, the statistical significance of the cross-country regression could depend upon the number of lags (of the dependent variable). However, Mexico's coefficients continue to be less negative for the number of lags tested, suggesting less effective measures.



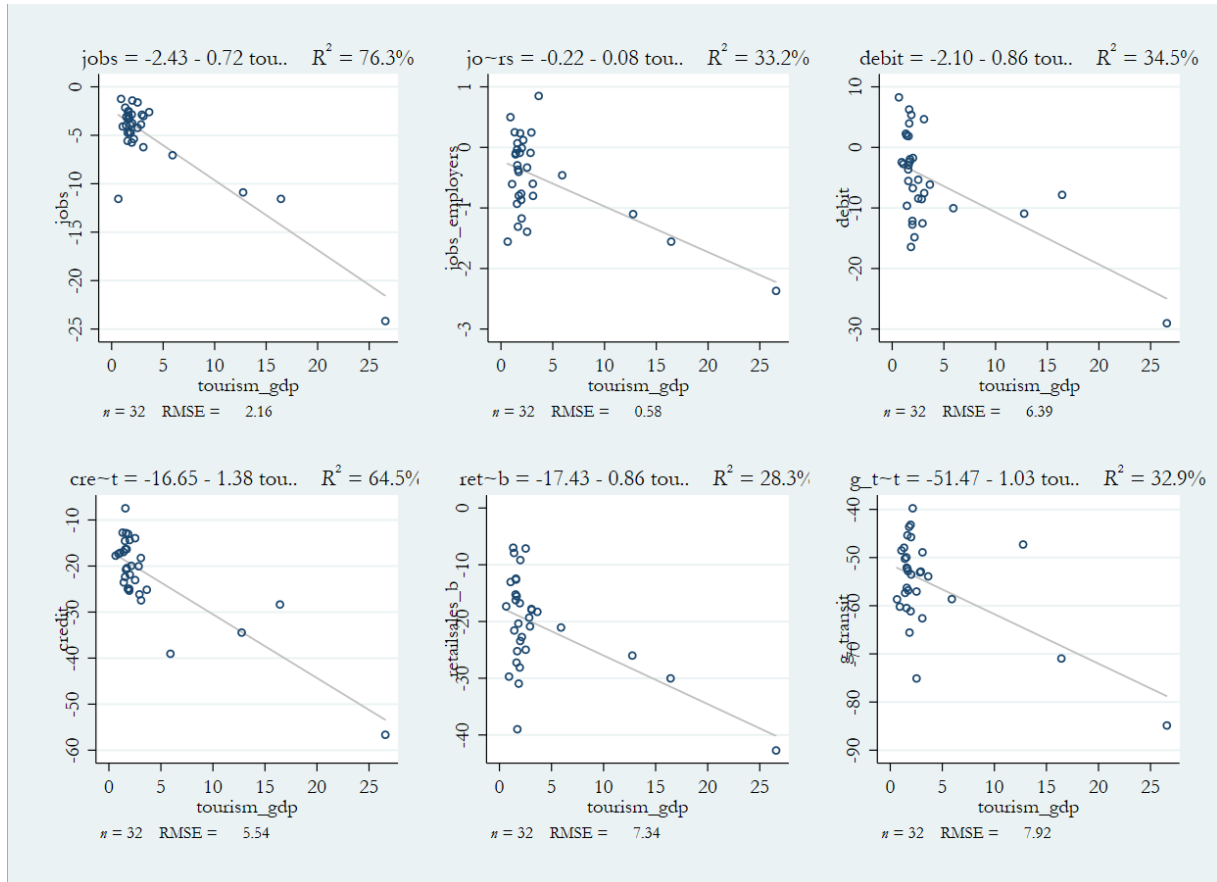
## V. ECONOMIC ACTIVITY—THE ROLE OF STATE CHARACTERISTICS

Having found in Section II that economic activity dropped across the board, this section identifies the characteristics/features of states that resulted in differential activity drops. In other words, we determine whether state characteristics (e.g., tourism and export exposures, income per capita), containment measures, mobility indicators, and cases influenced economic activity during the pandemic.

The main findings of this section are that tourist-exposed states were hit hard: around 50-60 percent month-over-month decline in flight arrivals and departures can be attributable to this factor for highly exposed states (95<sup>th</sup> percentile). States' export-exposure provided a cushion to larger activity drops, particularly for retail sales. We explore some of the channels for this comparative resilience: (i) exporting states received higher remittances; (ii) Mexico's exports fell less than other countries; (iii) Mexico's exports to the U.S. remained resilient in the early part of the pandemic; and (iv) some suggestive cross-country evidence of supply chain resilience. Finally, we find that densely populated states fared worse, and containment measures and lower mobility decreased activity.

### A. Stylized Facts

*Tourism.* Figure 17 plots states' tourism-exposure in 2018 versus the May-Jan 2020 changes across a range of economic activity indicators. We focus on the drop from May 2020 compared to January 2020 since high frequency data suggest that activities bottomed out in May 2020 in Mexico. The simple scatterplots suggest a strong correlation between tourism-exposure and the drop across many economic indicators: IMSS-employment (R-square: 76 percent), debit card usage (35 percent), retail sales (28 percent), and Google transit stations (33 percent). This indicates that contact- and service-industries might have been strongly hit owing to the highly contagious nature of the pandemic. Some of these states experienced large activity drops even when cases were comparatively lower. Nayarit and Guerrero—the third and fourth highest tourist-exposed states in Mexico—had the second and third largest drop in credit card usage in March and April (the largest drop being another tourist-exposed state Quintana Roo), when both these states had comparatively lower number of cases. In the empirical section, we will try to explore this idea further, controlling for relevant factors.

**Figure 17. Tourism (share of GDP) versus Economic Activity (May-Jan 2020, percent) 1/**

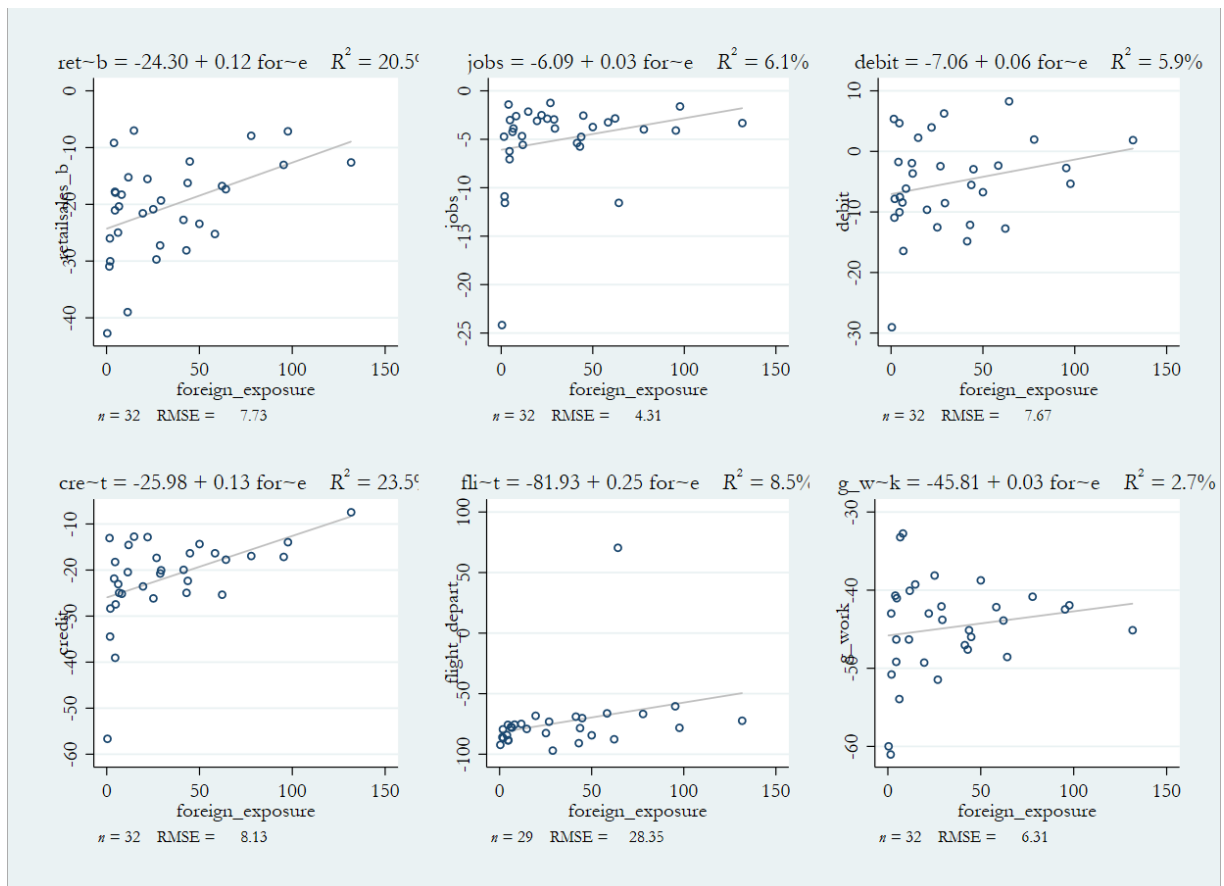
1/ The charts show May 2020 (or the latest data available) as a percent of January 2020. The exception is debit and credit cards which show year-over-year March-April 2020 growth.

*Export exposure.* Did export-exposed states get hit harder owing to the fall in global demand? Or did they show more resilience compared to states exposed to domestic demand and contact-intensive industries? Figure 18 suggests that the latter effect probably dominated, as higher export-exposed states (represented by 2018 state exports as a share of state GDP) experienced comparatively less drop in activity, evident from positive slopes between states' exports as a share of GDP and a wide range of activity indicators. In particular, higher export-exposed states had smaller drops in retail sales (R-square 21 percent) and credit card flows (24 percent). However, indicators such as debit card flows and Google work-place mobility suggest that this relationship is not always strong. In the subsequent parts of this section, we will empirically test this relationship and discuss some of the possible channels at work.

*Mobility (Apple drive), income per capita, and population density.* Annex II looks at the relationship between economic activity and other indicators of interest. The scatterplots suggest that lower mobility has been associated with higher activity drop, evident from the strong correlation in indicators such as employment, flight arrivals, and retail sales. The relationship between income per capita and economic activity is mixed. In richer states,

employment and Google work fell more, and debit card flows and flight arrivals/departures held up better; while retail sale drops show no relationship with incomes of states. The relationship between population density and activity indicators have been mostly negative with higher drops in densely populated states. However, this could be driven by one outlier state with substantially higher population density than others.

**Figure 18. Exports (share of GDP) versus Economic Activity (May-Jan 2020, percent) 1/**



1/ The charts show May 2020 (or the latest data available) as a percent of January 2020. The exception is debit and credit cards which show year-over-year March-April 2020 growth.

## B. Regression analysis

### State-level regressions

In this section, we empirically test the validity of the observations suggested by the scatterplots. We employ panel regressions on monthly activity data since the outbreak of the pandemic. The monthly frequency is motivated by the fact that some of the important economic activity indicators are on that frequency (e.g., employment, retail sales). The month-over-month changes in these indicators are regressed on variables representing state characteristics (income per capita, population density, tourism, and export exposure),

containment measures (or mobility indices), new cases, and lags of dependent variables.<sup>8</sup> Driscoll-Kraay standard errors are used in the regressions, with robustness checks using robust errors on panel regressions. Data until May 2020 are used since there is preliminary evidence that economic activity in Mexico troughed in May 2020. However, the results are robust if the most recent available information is used instead.

**Results.** Table 3 presents the regressions results for the nine activity indicators considered.

*Tourism.* The regressions confirm that, controlling for other factors, tourism-exposures have led to higher activity drop: the negative coefficients on tourism suggest that states with higher-tourist exposure had higher economic activity drop. This relationship is statistically significant for debit/credit card flows, retail sales, IMSS-employment, flight arrivals and departures, and Google transit station mobility. The regression results are robust to using panel regressions with robust errors, different lag assumptions, and removing states with extreme tourism exposures.

*Export exposure.* Though not as a widespread relationship across indicators and not as robust as tourism, the regressions suggest that higher exporting states had relatively less decline in activity. In particular, the evidence is strong for retail sales, indicating that export-exposure provided cushion to high-exporting states.

*Income per capita and population density.* As in the scatterplots, the relationship between activity and income per capita is mixed, contingent on the type of indicator used. The results suggest that richer states had higher employment loss, but comparatively less drop in flight arrivals and departures. Higher population-density states had higher drop in economic activity, but this could be influenced by one outlier state with substantially higher population density. When the outlier is removed, the coefficients on population density are not statistically significant and are of mixed signs.

*Measures/mobility.* Unlike the regressions on cases, the regressions on economic activity unequivocally suggest that stricter containment measures are associated with higher and statistically significant activity drop. Lower mobility also led to higher activity drop, evident from the regression results where mobility indicators are used instead of containment measures (Annex III). Since IHME's composite mobility indicator includes Google mobility reports (which contains Google workplaces and transit stations), the regressions where Google workplaces and transit stations are dependent variables and composite mobility is used instead of measures might be less reliable.

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<sup>8</sup> The only exception to this set-up is the regression on debt/credit flows. Debit/credit flows are expressed at March-April 2020 year-over-year growth owing to the availability of data in that format only. Accordingly, cross-section regressions are used instead of panel regressions and independent variables are modified.

**Table 3. State-level Regression Results—The Role of State Characteristics on Economic Activity**

VARIABLES	1	2	3	4	5	6	7	8	9
	debit/credit	retail	jobs	employers	flight_dep	flight_arr	g_work	g_transit	no2
<i>Initial conditions</i>									
GDP per capita	17.3447 (13.4687)	-0.0004 (0.0446)	-0.0623** (0.0089)	-0.0077 (0.0058)	2.9211** (0.5209)	1.5694** (0.1899)	-0.9521 (9.1099)	-6.8372 (12.4137)	-0.8796 (2.3198)
Tourism (share of GDP)	-1.2259*** (0.2452)	-0.0074* (0.0025)	-0.0030** (0.0006)	-0.0003 (0.0001)	-0.0344* (0.0099)	-0.0310* (0.0101)	-0.5048 (0.2176)	-0.8930* (0.2570)	-0.0421 (0.0275)
Population density	-0.0003 (0.0015)	-0.0000** (0.0000)	0.0000* (0.0000)	0.0000 (0.0000)	-0.0002** (0.0000)	-0.0002* (0.0000)	-0.0014** (0.0002)	-0.0012 (0.0005)	0.0000 (0.0001)
Exports (share of GDP)	0.0060 (0.0401)	0.0003* (0.0001)	0.0000 (0.0000)	-0.0000 (0.0000)	-0.0019 (0.0008)	-0.0004 (0.0007)	-0.0311 (0.0108)	-0.0224 (0.0083)	0.0018 (0.0019)
<i>Measure/mobility</i>									
Measure	-8.9596 (36.0161)	-0.4395*** (0.0403)	-0.0358*** (0.0029)	-0.0178** (0.0025)	-2.6883** (0.3472)	-2.6615** (0.3697)	-83.2430*** (7.1650)	-79.1684*** (7.3274)	-0.0812 (0.0827)
<i>Cases</i>									
Cases (per 1000 persons)	6.4332 (8.4052)	0.0074 (0.0153)	0.0017 (0.0043)	0.0018* (0.0005)	0.2655 (0.1000)	0.3543** (0.0627)	-7.4611*** (0.6650)	-3.7857* (1.1680)	0.0433 (0.0770)
Observations	26	78	78	78	69	71	78	78	26
R-squared	0.7037	0.8011	0.6400	0.5634	0.6895	0.6309	0.8854	0.8867	0.3794
Number of groups		26	26	26	23	24	26	26	9

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Regressions include lag of dependent variables

Population density is habitat per km2; GDP per capita is million pesos per capita

### *Economic significance of tourism results.*

The negative effect on tourist states is also corroborated by Campos-Vazquez et al. (2020). As mentioned earlier, the paper used the universe of point-of-sale (POS) transactions to show that consumption declines were highly heterogeneous across sectors and states, with states and activities related to tourism the most hurt.

Our results too are of economic significance, particularly for highly-tourist exposed states (Figure 19). For instance, for states highly exposed to tourism (95<sup>th</sup> percentile), around 50-60 percent drop in monthly flight arrivals and departures could be attributable to that factor. States in the 75<sup>th</sup> percentile witnessed a drop of around 10 percent. Highly exposed-tourism states had 20 percent drop in year-over-year debit/credit card flows, while those in the 75<sup>th</sup> percentile witnessed 3.5 percent drop. Similarly, 12 and 5 percent monthly decline in retail sales and employment, respectively, could be attributable to tourism in highly exposed tourist states.

**Figure 19. Impact of Tourism (Share of GDP) on Economic Activity**



## Country-level regressions

How do Mexico's results compare to cross-country experience? The same regression methodology is used on cross-country level data, focusing on ten economic activity indicators. In addition to controls used in state-level regressions, median temperature is included. The Oxford Stringency Index is used for containment measures, rather than the measures compiled by IHME. Tourism as a share of GDP is from 2018, while exports as a share of GDP is from 2015.

The regression results, reported in Table 4, suggest that tourism had a negative effect on economic activity: countries with higher tourism exposure as a share of country GDP had higher drop in Google mobility indicators (workplaces and transit stations) and carbon monoxide emissions. However, the effect is not as pervasive across a wide set of indicators as Mexico's state-level results suggest. The cross-country results also confirm that countries with higher exports as a share of GDP had less drop in retail sales, again suggesting that export exposure possibly acted as a cushion. In line with Mexico's state-level results, there is a strong relationship between containment measures and economic activity: countries that had more stringent measures had a higher activity drop. This is also confirmed by Deb et al. (2020b)—the authors find that containment measures had a large impact on economic activity, with a loss of about 15 percent in industrial production over a 30-day period following their implementation.

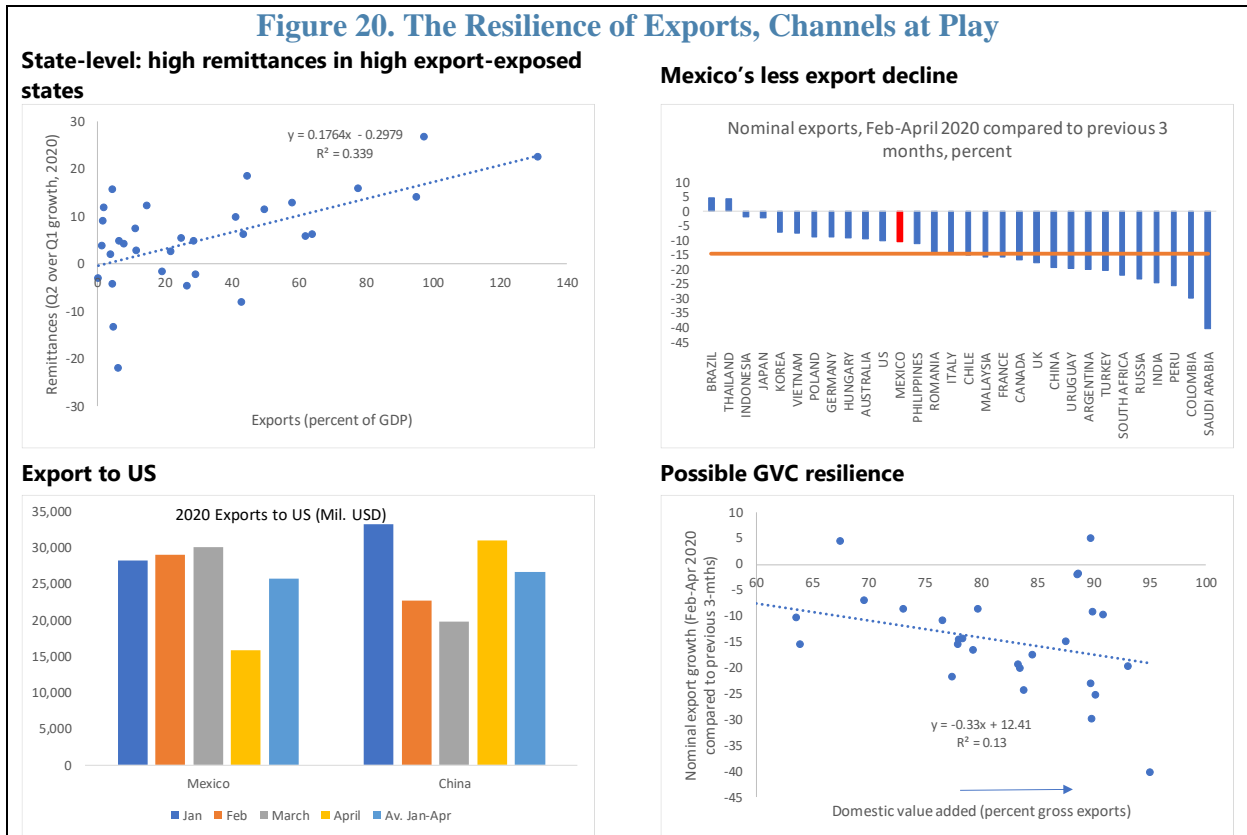
**Table 4. Country-level Regression Results—The Role of Country Characteristics on Economic Activity**

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	retail	employment	unemploy- ment rate	flight_dep	flight_arr	tourist_arriv al	g_work	g_transit	NO2	CO
<b>Initial conditions</b>										
GDP per capita	6.8257** (1.3821)	0.6185 (0.2398)	-1.4149 (12.2650)	11.4014 (7.1019)	11.9740 (7.5989)	-21.8593 (8.4372)	-27.7541 (37.2550)	-0.5826 (81.4448)	0.3093 (1.9730)	2.5434** (0.2636)
Tourism (share of GDP)	0.0018 (0.0030)	0.0044 (0.0017)	-0.0140 (0.0672)	-0.0281 (0.0221)	-0.0311 (0.0242)	0.0180 (0.0435)	-0.7011* (0.1789)	-1.2773** (0.2655)	-0.0206 (0.0136)	-0.0198** (0.0020)
Population density	-0.0001 (0.0001)	0.0001 (0.0000)	0.0009 (0.0007)	-0.0005 (0.0006)	-0.0005 (0.0007)	0.0001 (0.0014)	-0.0092 (0.0078)	-0.0111 (0.0117)	-0.0005** (0.0001)	-0.0006 (0.0002)
Exports (share of GDP)	0.0023** (0.0004)	0.0003 (0.0004)	-0.0297 (0.0221)	0.0062 (0.0049)	0.0084 (0.0060)	0.0234 (0.0250)	0.0686 (0.0391)	0.1356 (0.1197)	0.0017 (0.0027)	0.0022 (0.0030)
Temperature	0.0081 (0.0029)	-0.0003 (0.0010)	0.0157 (0.0566)	0.0159 (0.0197)	0.0201 (0.0233)	0.0233 (0.0701)	0.4087* (0.1343)	0.3213 (0.4364)	0.0167** (0.0035)	-0.0008 (0.0028)
<b>Measure</b>										
Stringency index	-0.0050** (0.0011)	-0.0003** (0.0001)	0.0321** (0.0052)	-0.0329** (0.0045)	-0.0345** (0.0048)	-0.0633** (0.0121)	-0.7672** (0.0981)	-0.7193** (0.0895)	-0.0016 (0.0011)	-0.0018 (0.0008)
<b>Cases</b>										
Cases per million	-0.0000 (0.0000)	-0.0000*** (0.0000)	0.0001 (0.0002)	-0.0001 (0.0001)	-0.0001 (0.0001)	0.0002** (0.0000)	-0.0032** (0.0007)	-0.0028 (0.0012)	-0.0000 (0.0000)	0.0001* (0.0000)
Observations	69	60	68	120	120	46	117	117	108	84
R-squared	0.6893	0.2843	0.1329	0.7019	0.7004	0.6545	0.7602	0.6636	0.1070	0.2290
Number of groups	23	22	24	40	40	17	39	39	36	29

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Regressions include lag of dependent variables



### C. The Role of Exports—Possible Channels at Play

Both the state- and country-level analysis suggest that export exposure might have acted as a cushion in preventing further activity loss, particularly in retail sales. Some of the channels at play for this resilience could be (Figure 20):

*Higher remittances in higher export-exposed states.* One of the positive surprises during the pandemic has been strong remittance inflows to Mexico. A disaggregated look at the remittance data suggests that states with high export-exposure had higher remittance growth in Q2 2020, compared to Q1 2020. Against the backdrop of a sharp activity drop within the domestic economy, strong remittances in export-exposed states could explain the relatively resilient retail sales performance.

*Mexico's less export decline.* In the initial months of the crisis, Mexico's export decline was sharp but on the lower side compared to G20, key emerging market, and regional peers. Notably, Mexico's exports to the U.S. remained resilient initially, when China's exports to the U.S. dropped markedly. All this suggests that the negative effect of global domestic demand contraction may have been, to some extent but not completely, offset in Mexico owing to factors such as trade diversion from China, proximity to the U.S., and the expected ratification of the USMCA trade agreement.

*Possible GVC resilience.* In the initial phase of the pandemic, countries with higher supply-chain integration witnessed lower nominal export decline. Admittedly, there could be other

forces at play, including the oil price changes, that precludes a strong conclusion between supply chain linkage and export-change following the pandemic. This link could be studied further in a formal econometric framework in future studies.

## VI. CONCLUDING THOUGHTS

This paper conducts a comprehensive study of the impact of Covid-19 in Mexico. It has sought to examine the early evidence of health and economic outcomes during the initial months of the Covid-19 pandemic using Mexico's state-level data in a systematic and holistic manner. This evidence-based approach is intended to help inform policy choices in the midst of considerable uncertainty. As lockdowns are eased, the economy recovers, and more data become available on the effects of the pandemic, future studies could seek to build upon the approach of this paper and delve deeper into its findings, including focusing on causality and endogeneity issues, to the extent that the state-level data allow.

Overall, the findings of the paper imply that concerted policy efforts on multiple fronts are required.

In line with international experience, age and certain pre-existing conditions are found to be associated with higher risks of testing Covid-19 positive and death in Mexico. This is particularly worrying since Mexico's co-morbidity factors are high because of an elevated incidence of obesity and diabetes, among others. During phased re-opening, it would be important to protect vulnerable populations such as the elderly and those with co-morbidities. This is especially needed in a context of high informality and limited savings/safety net and if a widely available, cheap, and effective vaccine will take time to develop.

On average, states with lower health indicators (per capita: health expenditure, beds, and ICU beds) witnessed higher case fatality rates. States with higher health expenditure per capita, controlling for factors such as income per capita, had lower deaths and lower deaths-per-cases. Combined with facts that both pre-Covid-health expenditure/capacity and Covid-19 related health spending are on the lower end of G20 and regional peers, these findings suggest that investing in the health system can help contain the pandemic and are important for saving lives. Taking into consideration these factors and simulations from a model that combine country-specific projections of people requiring hospitalization and assumptions of spare capacity and costs of providing health care (Dudine et al. 2020), Hannan et al. (2020) suggest that health spending could be increased by around 0.6-1.5 percent of GDP.

The fallout in economic activity has been widespread and not localized to high case states, with tourist-exposed states witnessing higher decline in economic activities as measured by debit/credit card flows, retail sales, and IMSS employment. The impact is likely to be even more severe when informal jobs and firms are taken into account. This calls for larger emergency lifelines and fiscal support to help vulnerable households and viable firms, particularly in the context of high informality in Mexico—as a significant proportion of the population might not have recourse to traditional automatic stabilizing channels to smooth out consumption. Hannan et al. (2020) propose a near-term fiscal support of 2.5-3.5 percent of GDP, with 1.2 percent of GDP for informal workers in hard-hit industries and 0.4 percent



of GDP for wage subsidies for formal workers in hard-hit industries. They also propose combining such support with a credible announcement of a medium-term tax reform to close fiscal gaps, finance needed public investment and social spending, and put debt on a firm downward trajectory.

The paper also finds that export exposure provided resilience to states, supporting economic activity particularly from a high drop in retail sales. With domestic demand expected to continue lagging, consideration should be given to facilitate investment that promotes broader integration into global or North American value chains. In that regard, complementary structural reforms to improve the business climate could help to fully reap the benefits of the recently implemented USMCA trade agreement.

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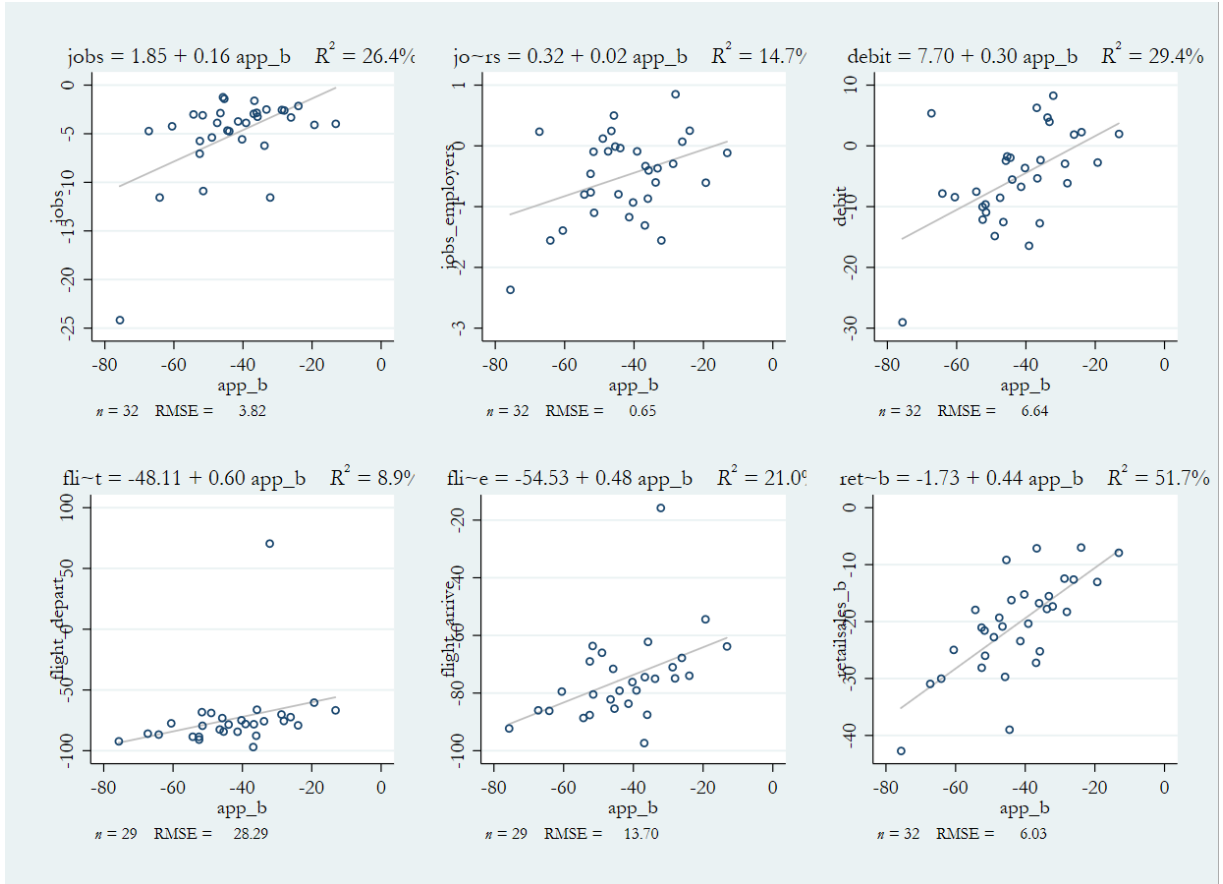
## ANNEX I. DATA SOURCES

Table AI.1. Data Sources

	State level	International
<b>Covid-19 indicators</b>		
Cases and deaths	Ministry of Health (MoH)	Johns Hopkins University (JHU)
Tests	IHME	IMF STA Database
Patient characteristics	Ministry of Health (MoH)	N/A
UCI availability	IHME	IHME
Hospital beds	Ministry of Health (MoH), IHME	IHME
Ventilator use	Ministry of Health (MoH), IHME	IHME
Health expenditure per capita	Ministry of Health (MoH)	Healthcare Access and Quality (HAQ) Index
<b>Economic activity</b>		
Flight arrivals and departures	FlightRadar 24	FlightRadar 24
Credit and debit card flows	Hernandez (2020)	
Employees	IMSS	Haver analytics
Employers	IMSS	Haver analytics
Population	INEGI	UN
FDI	INEGI	WDI
Tourism share of GDP	INEGI	WDI
Retail sales	INEGI	Haver
Remittances	INEGI	Haver
CO	Air Quality Index (AQI)	Air Quality Index (AQI)
NO2	Air Quality Index (AQI)	Air Quality Index (AQI)
Google Mobility	Haver	Haver
Apple Mobility	Haver	Haver

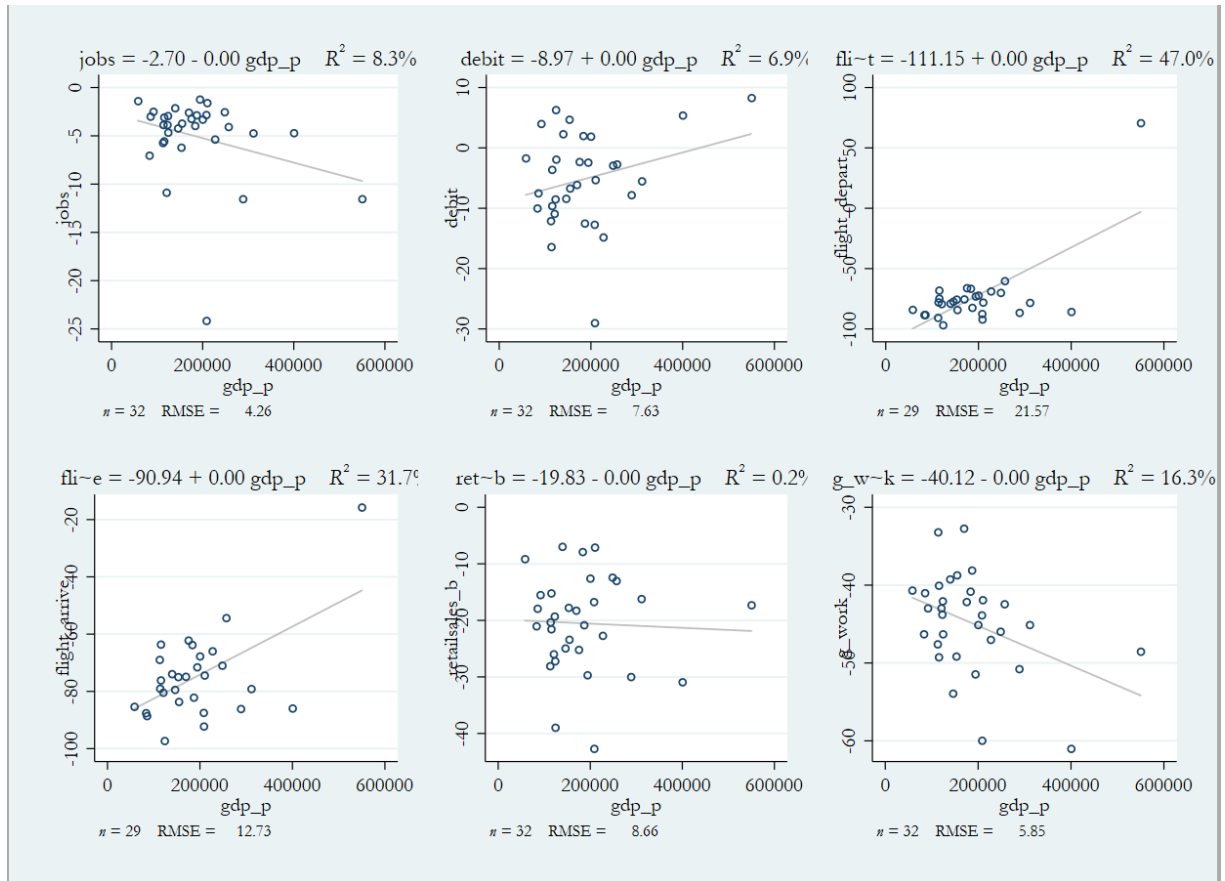
**ANNEX II: ECONOMIC ACTIVITY VERSUS STATE CHARACTERISTICS, FURTHER STYLIZED FACTS**

**Figure AI.1. Mobility (Apple Drive; May-Jan 2020, percent) versus Economic Activity (May-Jan 2020, percent) 1/**



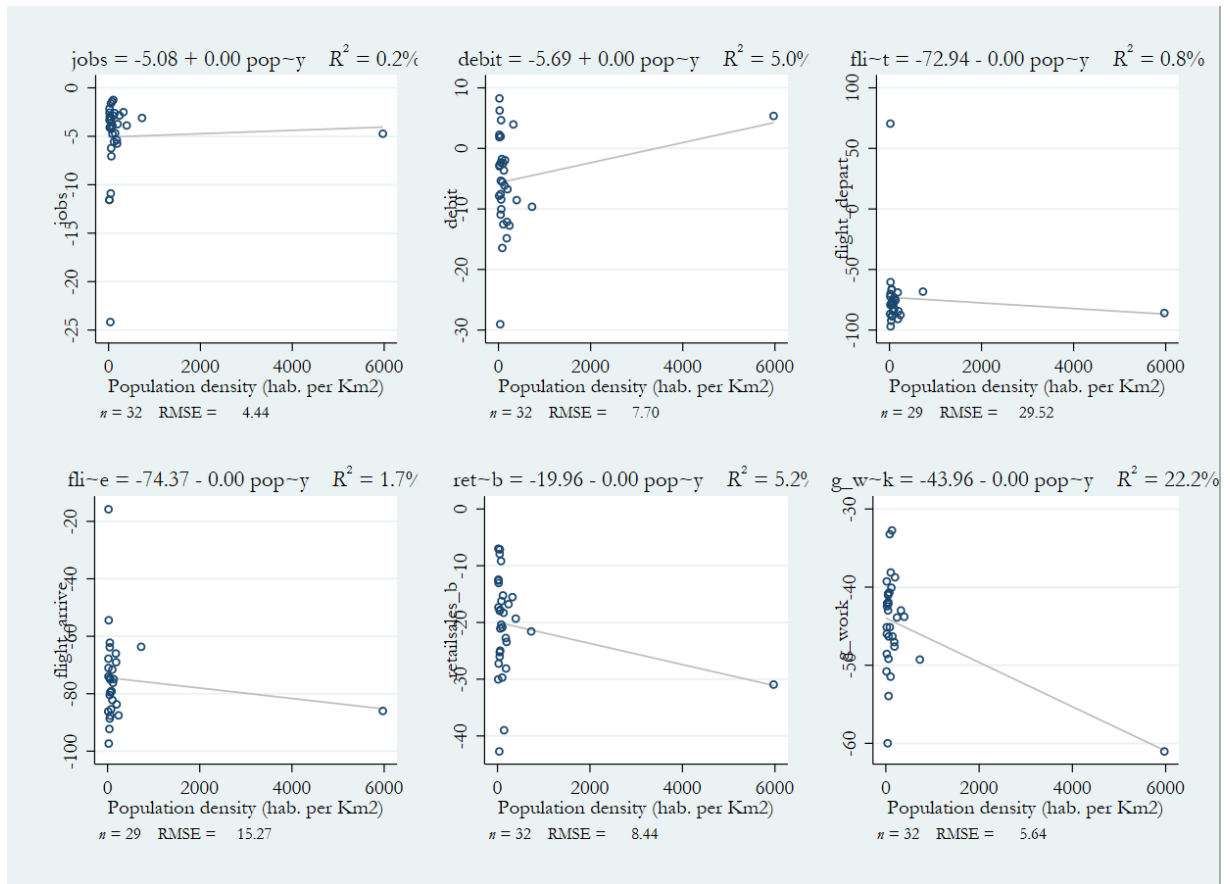
1/ The charts show May 2020 (or the latest data available) as a percent of January 2020. The exception is debit and credit cards which show year-over-year March-April 2020 growth.

**Figure AL.2. GDP per capita (pesos per capita) versus Economic Activity (May-Jan 2020, percent) 1/**



1/ The charts show May 2020 (or the latest data available) as a percent of January 2020. The exception is debit and credit cards which show year-over-year March-April 2020 growth.

**Figure AI.3. Population Density versus Economic Activity (May-Jan 2020, percent) 1/**



1/ The charts show May 2020 (or the latest data available) as a percent of January 2020. The exception is debit and credit cards which show year-over-year March-April 2020 growth.

### ANNEX III: ECONOMIC ACTIVITY VERSUS STATE CHARACTERISTICS, FURTHER STATE-LEVEL REGRESSIONS

**Table AIII.1. State-level Regression Results—The Role of State Characteristics on Economic Activity, Using IHME’s Composite Mobility Instead of Containment Measures**

VARIABLES	1 debit/credit	2 retail	3 jobs	4 employers	5 flight_dep	6 flight_arr	7 g_work	8 g_transit	9 no2
<b>Initial conditions</b>									
GDP per capita	16.8814 (10.8577)	0.0231 (0.0125)	-0.0579** (0.0068)	-0.0041 (0.0038)	2.5455** (0.4062)	1.4105** (0.2900)	-0.3750 (1.8283)	-5.9082 (3.6486)	-1.9953 (1.4819)
Tourism (share of GDP)	-1.0033*** (0.2216)	-0.0035 (0.0013)	-0.0027* (0.0007)	-0.0002 (0.0001)	-0.0115 (0.0055)	-0.0078 (0.0049)	0.1781*** (0.0153)	-0.1621** (0.0274)	-0.0425 (0.0354)
Population density	-0.0001 (0.0013)	-0.0000* (0.0000)	0.0000** (0.0000)	0.0000 (0.0000)	-0.0002* (0.0000)	-0.0001 (0.0001)	-0.0006 (0.0002)	-0.0001 (0.0003)	0.0001 (0.0001)
Exports (share of GDP)	0.0287 (0.0338)	0.0005 (0.0002)	0.0001 (0.0001)	0.0000 (0.0000)	-0.0005 (0.0007)	0.0011 (0.0008)	0.0099 (0.0060)	0.0308* (0.0094)	0.0013 (0.0025)
<b>Measure/mobility</b>									
Composite mobility	0.4060** (0.1927)	0.0054*** (0.0004)	0.0006*** (0.0000)	0.0002*** (0.0000)	0.0290** (0.0037)	0.0297** (0.0035)	0.8701*** (0.0760)	0.8971*** (0.0641)	0.0023 (0.0010)
<b>Cases</b>									
Cases (per 1000 persons)	10.9017 (7.2132)	0.0620*** (0.0058)	0.0051 (0.0037)	0.0028* (0.0007)	0.5315*** (0.0411)	0.6113*** (0.0539)	1.6126** (0.3094)	3.8057* (0.9379)	0.1107 (0.0659)
Observations	32	96	96	96	87	89	96	96	35
R-squared	0.7022	0.8482	0.6885	0.6656	0.7174	0.7010	0.9289	0.9391	0.2770
Number of groups		32	32	32	29	30	32	32	12

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Regressions include lag of dependent variables

Population density is habitat per km<sup>2</sup>; GDP per capita is million pesos per capita

**Table AIII.2. State-level Regression Results—The Role of State Characteristics on Economic Activity, Using Apple Drive Instead of Containment Measures**

VARIABLES	1 debit/credit	2 retail	3 jobs	4 employers	5 flight_dep	6 flight_arr	7 g_work	8 g_transit	9 no2
<b>Initial conditions</b>									
GDP per capita	13.0464 (9.4875)	-0.0376 (0.0352)	-0.0464* (0.0119)	-0.0056 (0.0027)	0.5315 (1.0237)	0.2715 (0.6889)	0.9558 (14.2599)	-11.6870 (5.3830)	-2.6582 (1.1789)
Tourism (share of GDP)	-0.8841*** (0.2046)	-0.0052** (0.0010)	-0.0018 (0.0010)	-0.0000 (0.0000)	0.0100 (0.0040)	0.0130** (0.0020)	0.2014 (0.0955)	0.1500 (0.1425)	-0.0421 (0.0368)
Population density	0.0007 (0.0012)	0.0000 (0.0000)	0.0000*** (0.0000)	0.0000* (0.0000)	0.0001* (0.0000)	0.0001** (0.0000)	0.0006 (0.0007)	0.0018 (0.0008)	0.0001* (0.0000)
Exports (share of GDP)	0.0032 (0.0307)	0.0004** (0.0001)	0.0000 (0.0000)	-0.0000 (0.0000)	-0.0019** (0.0002)	-0.0017** (0.0003)	-0.0531** (0.0083)	-0.0434 (0.0208)	0.0019 (0.0022)
<b>Measure/mobility</b>									
app (mom change)	53.5039*** (15.8033)	-0.1830 (0.0011)	-0.0128 (0.0001)	-0.0046 (0.0000)	-0.3768 (0.0056)	-0.3331 (0.0060)	0.2122 (0.0339)	-0.5018 (0.0457)	-0.1633*** (0.0001)
<b>Cases</b>									
Cases (per 1000 persons)	9.8252 (6.3582)	-0.1830 (0.1440)	-0.0128 (0.0053)	-0.0046 (0.0020)	-0.3768 (0.3731)	-0.3331 (0.3168)	0.2122 (0.9150)	-0.5018 (2.0673)	-0.1633*** (0.0222)
Observations	32	96	96	96	87	89	96	96	35
R-squared	0.7596	0.6405	0.6279	0.5279	0.5398	0.5796	0.9269	0.9182	0.3790
Number of groups		32	32	32	29	30	32	32	12

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Regressions include lag of dependent variables

Population density is habitat per km<sup>2</sup>; GDP per capita is million pesos per capita