Consumption and geographic mobility in pandemic times. Evidence from Mexico

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Abstract

We analyze the universe of point-of-sale (POS) transactions before and during the COVID-19 lockdown in Mexico. We find three key results. First, consumption in Mexico fell by 23 percent in the April-June quarter of 2020 and by 16 percent from April to September of 2020 as compared to expected levels. Second, reductions in consumption were highly heterogeneous across sectors and states, with states and activities related to tourism the most affected. Third, using variation over time and states, we estimate the elasticity of POS expenditures with respect to geographic mobility (measured using cellphone location data) to be slightly less than 1. This estimate suggests that spending in developing countries may be more responsive to mobility than in developed countries, and that mobility indicators could be used as a real-time proxy for consumption in some economies.

Keywords Consumption · Point-of-Sale · Credit card · Debit card · Mexico

JEL D12 · E20 · E21 · G51 · O54

1 Introduction

The economic consequences of COVID-19 are significant. Lockdown and health measures have substantially decreased geographic mobility, causing a reduction in economic activity. The traditional economic indicators that measure these effects, like gross domestic product (GDP) and the industrial production index (IPI), are published by national statistical agencies with a lag: in Mexico, approximately two months after

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the fact. Researchers and policy-makers across the world are trying to overcome this delay by analyzing high-frequency data to quantify the magnitude of the shock and make prescriptions to avoid a more severe economic contraction (see, for example, the weekly economic index of Lewis et al. 2020; the index of expenditures of Baker et al. 2020; and the labor market index of Kahn et al. 2020). Given the possibility of future waves of COVID-19, it is extremely important to measure the relationship of mobility and economic activity. In this paper, we use aggregated daily point-of-sale (POS) transaction data and cellphone location data in Mexico to quantify the magnitude of the shock and to estimate the effect of mobility patterns on POS expenditures.

It is now well known that a supply shock may cause a demand shock in the economy, thus amplifying the initial economic impact (Guerrieri et al. 2020). Sectors related to services, such as restaurants and tourism, are directly affected by a pandemic. One could then expect that the total shock should be proportional to the income losses of these sectors. However, income generated in other sectors may be affected as well, depending on the value of current versus future consumption and the value of goods and services not provided during the pandemic. If we have a high intertemporal elasticity of substitution (e.g., people can modify their consumption patterns relatively easily to spend more later rather than now) and a low intra-temporal elasticity of substitution (e.g., people prefer to buy the same goods and services, and there are no good substitutes for their consumption patterns), then a demand shock exacerbates the original shock, which can present an even greater problem in the presence of uncertainty and incomplete markets.

It is thus important to estimate how total expenditure is changing over time and which sectors are most affected, an estimate that requires high frequency data. POS expenditure data may meet the requirements for such analysis. Indeed, there are recent articles that make use of such information. In the United States, Baker et al. (2020) use de-identified non-random data from a Fintech company at the transaction and individual level. They find a spike in total spending when cases begin to increase (late February and early March) but a subsequent decrease of close to 50 percent with respect to January and early February. In Spain, Carvalho et al. (2020a, 2020b) use all POS transactions of customers of a commercial bank and transactions of others using the POS terminals of that bank. As in the U.S. study, they find a spike before the mid-March lockdown and then a sharp decline in total expenditure: 60 percent with respect to the same period in 2019. In Denmark, Andersen et al. (2020a) use data from the country's largest retail bank. They find a decrease in total spending of around 25 percent after lockdown starts. Similar results have been found in other countries: the United Kingdom shows a decline of 46 percent from April 2019 to April 2020 (Hacioglu et al. 2020), France a decline of 60 percent (Bounie et al. 2020), Portugal a reduction of 55 percent in total purchases in April (Carvalho et al. 2020a, 2020b), and China a decline of 42 percent (Chen et al. 2020).

POS data is useful for shedding light on causes and potential solutions for the current crisis. Using U.S. data, Chetty et al. (2020) argue that the drop in POS expenditures is driven mainly by rich households due to health concerns. Expenditures in poor households generally returned to 2019 levels after their stimulus payments arrived. Employment losses are greater in higher-income zip codes, especially in personal services like restaurants and barber shops. They conclude that economic recovery goes hand in hand with safety concerns.

In this paper we follow Chetty et al. (2020) to study how the COVID-19 pandemic affects point-of-sale (POS) consumption patterns. We analyze the evolution of consumption by type of expenditure and estimate how mobility patterns are related to consumption. The main hypothesis we test is whether there is a close relationship between consumption and mobility (as proxied by cell phone location data). We hypothesize that in less developed countries the relationship between mobility and consumption is stronger than in developed countries. The underlying argument is that mobility restrictions in poorer economies are associated with lesser income-generating capacity, which in turn leads to lower consumption levels. The economic factors behind this relationship are a smaller share of jobs that can be performed remotely, the lack of a safety net that can compensate for income lost due to mobility restrictions, and a greater share of hand-to-mouth consumers in less developed economies. According to our hypothesis, the combination of these elements should lead to a stronger relationship between mobility and consumption in less developed economies. The relationship between consumption and mobility is key to a better understanding of the speed and characteristics of the recovery in different economies as lockdowns end. It could also be important for the post-pandemic world, since we cannot rule out significant and more permanent changes in mobility patterns or future waves of the pandemic.

Our paper makes important contributions to this literature. First, we show that the response in developing countries may be different than in developed countries. Although Mexico is an upper middle-income country, its financial sector is not as developed as in other countries. According to the World Bank (2020), domestic bank credit to the private sector accounts for only 27 percent of GDP, while in countries with similar consumption patterns, like China, Denmark, France, Spain, and the United Kingdom, it is close to or above 100 percent. Only in the United States is it less than that, and even there it is 52 percent of GDP. Also, the number of POS terminals in Mexico per 100,000 population is the lowest among similar countries (approximately 1000 in Mexico versus 2000 in China and 3000 in the other countries). Finally, internet penetration in Mexico (around 64 percent) is less than in the United States (76 percent) or similar European countries (all above 80 percent). Although this may mean that POS data are not as comprehensive for Mexico, our results indicate large negative effects of the pandemic, although not as large as those in other countries.

Second, the data we analyze for Mexico includes all POS transactions in the country, in contrast to the data in previous studies, which is limited to selected banks or companies. The comprehensive nature of our data allows us to benchmark the effect of COVID-19 on POS expenditures to traditional measures like total consumption and GDP. Third, although we follow previous literature in calculating expenditure losses with respect to 2019, we also propose a simple model to calculate a counterfactual of what expenditure would have looked like in the absence of the pandemic.

Finally, we estimate the elasticity of POS expenditures with respect to measures of geographic mobility using variation over time within states in Mexico. We use mobility measured through cell phone activity by Google and Apple. This elasticity is important, as it could be used in theoretical models and simulation exercises to calculate expenditure losses for future waves of the pandemic. It is also an important

consideration in the debate about the impact of lockdown measures on the level of expenditures.

We use the universe of point-of-sale (POS) transactions from January 1, 2019 to September 30, 2020, which is public data from the Banco de México (the Mexican central bank), consisting of aggregated daily information on total expenditures and certain other categories. This POS expenditure data provides important information about general consumption patterns. In 2019, there were 157 million debit and credit cards in Mexico, and the National Financial Inclusion Survey (INEGI 2018) shows that more than two-thirds of the Mexican population (68 percent) aged 18–70 have at least one such financial product. In 2019, the average POS expenditure per transaction was \$630 MXN (approximately \$31 USD). Approximately 10 million transactions take place through POS terminals every day, 73 percent of which are with debit cards and the remaining 27 percent with credit cards. The average monthly total debit and credit card expenditure was almost \$187 billion MXN during 2019 (approximately \$9.2 billion USD). Annual total POS expenditure thus represents about 8 percent of GDP and 14 percent of consumption.

We are able to provide the first direct estimates of the elasticity of POS expenditures with respect to geographic mobility. Previous studies have provided only indirect or implicit estimates for this elasticity. For example, using the results in Andersen et al. (2020b), we can estimate an elasticity of 0.2 by exploiting the between-country variation in spending and mobility for Sweden and Denmark: consumption declined 29 percent in Denmark and by 25 percent in Sweden (Fig. 3 in that study). Using mobility measures based on cellphone location data available from the Apple Corporation (2020) for early April, we find that mobility decreased by only 12 percent in Sweden while it declined by 32 percent in Denmark. The implicit elasticity of POS expenditures with respect to mobility is thus around 0.2. In the current study, since we have daily data for expenditures in Mexico at the subnational level, we are able to estimate the elasticity of consumption with respect to mobility indicators by exploiting both the time and geographic variation in the data.

We find three key results. First, the percent loss in POS expenditures with respect to the estimate without the pandemic is 23 percent for April–June. This estimate is much lower than for other countries. The estimate for Spain and France (for the last two weeks of March) is close to 50 percent (Bounie et al. 2020; Carvalho et al. 2020a, 2020b), for Portugal it is 55 percent (Carvalho et al. 2020a, 2020b), and for Denmark it is 30 percent (Andersen et al. 2020a). Although estimates for the U.S. vary, our result is similar to the live results from POS data in Chetty et al. (2020). In terms of GDP and consumption, for the April–June quarter it implies a loss of 2.6 percent of quarterly GDP and 3.9 percent of quarterly private consumption.

Second, losses vary significantly across sectors and regions. While some sectors were severely hit, like tourism, food services, and transportation, others, like insurance and telecommunications, were barely affected. This result is similar to that found in other studies. Mexican states that are highly dependent on tourism (beach resorts and other tourist destinations) are among the most affected.

Third, we estimate the elasticity of POS expenditures with respect to geographic mobility in Mexico, as measured using cellphone location data from Apple (2020) and Google LLC (2020). Our estimates show that this elasticity is in most cases non-significantly different from one (0.93 using Apple's measure of mobility in one

specification, and 0.91 for both Google's and Apple's measures of mobility in another). These estimates are much larger and more precisely estimated than the estimate of 0.2 derived by comparing the effect of mobility on spending in Sweden and Denmark, as described above. This result suggests that POS expenditures in developing countries could be more responsive to mobility patterns than in developed countries, an interesting possibility that calls for further research. It may be possible, for example, that internet penetration and the strength of e-commerce affect the magnitude of this elasticity. This result is also important because it suggests that in economies like Mexico's, mobility indicators, which can be observed almost in real time, could serve as a good proxy for the behavior of expenditures.

2 Data and Methods

The data includes all point-of-sale (POS) transactions in Mexican territory, which is information collected by the Banco de México under its mandate to assure a well-functioning payment system.¹ The data is aggregated by type of card (debit or credit), at the state and national levels, and by type of expenditure, on a daily basis, from January 2019 to September 2020. We observe only aggregate information; we do not observe any individual transactions, any information about whether the credit or debit card is foreign or Mexican, or whether the transaction took place on the internet or in a physical location.

Most of the previous literature uses either a part of the universe of transactions or a sample of households. Our use of the full universe of transactions allows us to calculate total losses in the economy. However, one key challenge is how to construct a valid counterfactual for comparison. In general, previous studies calculate the percent change in 2020 with respect to 2019. This seems reasonable if the financial sector is stable. However, because transactions in Mexico were already growing before the pandemic arrived, it seems more appropriate to construct a counterfactual scenario using data from 2019 and 2020. We propose a simple model that predicts the daily (t) outcome in 2020 (POS_t^{2020}) based on both the 2019 outcome (POS_t^{2019}) and pre-pandemic data observed for 2020.² We also include dummy variables related to paydays, Mondays, Fridays, and for the month of December.

$$POS_t^{2020} = \alpha + \beta POS_t^{2019} + dummies + \varepsilon_t \quad (1)$$

The regression is estimated for all days from January 1, 2020 to February 18, 2020. We select the final model minimizing the mean squared error for the prediction for February 19 to March 11, 2020, that is, during the pre-lockdown period. Then, we make a prediction for all the remaining days in 2020. All of the predictions are in

¹ The data is available at: <https://www.banxico.org.mx/SieInternet/consultarDirectorioInternetAction.do?sector=21&accion=consultarDirectorioCuadros&locale=es>; the POS series is CF888.

² We compare this model with other ARIMA models with the form $POS_t^{2020} = \alpha + \beta POS_t^{2019} + \theta ARIMA + dummies + \varepsilon_t$ in terms of the root mean squared predicted error (RMSPE) for February 19 to March 11. This comparison is for total, credit, and debit expenditures, varying the introduction of dummies. For a complete table of the evaluated models, see supplementary material Table S1. For simplicity, we choose the model with dummies to make the predictions. All sectors use the same methodology, except for insurance, which uses an ARIMA(7,0,0) because of its seasonality.

constant pesos (MXN) of July 2018. The percent effect of the pandemic can then be calculated as:

$$\Delta\% Effect_t = \frac{POS_t^{2020} - \widehat{POS}_t^{2020}}{\widehat{POS}_t^{2020}} \quad (2)$$

The comparison with respect to 2019 replaces the predicted value $\widehat{POS}_t^{2020}$ with the value in 2019, POS_t^{2019} . As the daily expenditures are noisy, in some cases we smooth the lines in the figures by a simple moving average for the previous two weeks. We show below multiple estimates for total expenditures, for credit and debit cards, for type of expenditure, and at the state level.

We also calculate the elasticity of total expenditures with respect to indicators of geographic mobility, obtained from Google LLC (2020) and Apple (2020). Google tracks mobility using the location history of the Google accounts on people's mobile devices; we use this data to calculate the percent change compared with the median value for baseline days in the five-week period January 3 to February 6, 2020. We focus on the mobility trends for workplaces. Apple mobility is an index with a baseline set at January 13, 2020. Apple also uses people's mobile devices to track their location (monitoring the requests made to the Apple map application). For Apple, we use the mobility measure based on driving.³ Data is available for the period January 13 to September 30.⁴ For purposes of comparability between the Google and Apple datasets, we change the baseline to February 17. We thus obtain a dataset for the period February 15 to September 30, with each row including two columns: the percent change of total POS expenditure from state s in week w , and the mean percent change in mobility from each source from state s in week w . The percent change is with respect to February 17 in all columns.

$$\Delta\%POS_{s,w}^{2020} = \beta\Delta\%Mobility_{s,w}^{2020} + \delta_s + \delta_w + \varepsilon_{s,w} \quad (3)$$

The regression controls for fixed effects of week and state. The first control is for shocks that affect all states at the same time, and the second is for permanent differences across states. For example, some states may specialize in occupations or industries that make them either more resilient or more susceptible to an economic shock, and this specialization may at the same time be correlated with geographic mobility.⁵

³ One concern is whether Apple's and Google's mobility measures are indeed good proxies. The National Institute of Statistics and Geography, INEGI, reports monthly figures for mobility on public transportation in the country's three largest cities: Mexico City, Monterrey, and Guadalajara. The correlation of these figures with Apple's is between .77 and .97 and with Google's is between 0.96 and 0.99. According to Apple, mobility declined by 67% during May, and INEGI's figure for mean mobility on public transportation also fell by 67%. We thus conclude that these measures are a good proxy for mobility.

⁴ Two days, May 11 and May 12, were not available. We impute values for these days with the mean values for May 10 and May 13.

⁵ In particular, some states may be more prepared for telecommuting than others, making them more resistant to employment losses. If the latter states show greater mobility and expenditure, that could bias the elasticity estimate.

Table 1 Descriptive statistics

	May 2019			May 2020		
	Total Amount (millions of pesos)	Avg. Transaction amount (pesos)	Share (%)	Total Amount (millions of pesos)	Avg. Transaction amount (pesos)	Share (%)
Total	\$206,669	\$601		\$172,800	\$589	
Tourism	\$5333	\$2580	2.6	\$786	\$1988	0.5
Education	\$6851	\$4026	3.3	\$4607	\$4639	2.7
Health Care	\$8239	\$524	4.0	\$7757	\$485	4.5
Food Services	\$11,747	\$383	5.7	\$2681	\$257	1.6
Trade	\$42,312	\$473	20.5	\$32,978	\$462	19.1
Transportation	\$8961	\$589	4.3	\$1833	\$286	1.1
Insurance	\$5153	\$1811	2.5	\$5445	\$2207	3.2
Telecomm. Services	\$6394	\$701	3.1	\$6779	\$525	3.9
Gasoline	\$18,400	\$616	8.9	\$10,979	\$538	6.4
Other	\$35,244	\$641	17.1	\$ 41,564	\$601	24.1
Supermarkets	\$28	\$348	0.0	\$19	\$314	0.0
Big-Box Stores	\$58,007	\$630	28.1	\$57,373	\$692	33.2

Notes: Authors' calculations. Amounts are in constant MXN for July 2018

3 Descriptive results

The first case of COVID-19 in Mexico was diagnosed on February 27, later than in European countries. On March 14, the government announced the suspension of non-essential activities and rescheduled mass events. A soft lockdown began on March 23. The government has taken different steps to address the health and economic shocks. First, it implemented recommendations for social distancing, travel restrictions, and the suspension of non-essential activities to prevent the spread of the virus. Second, the government and the Banco de México have taken action to mitigate the effects of the pandemic. Like other central banks across the world, the Banco de México has implemented measures to provide liquidity to the market, injecting the equivalent of 3.3 percent of GDP into the economy.⁶ The fiscal policy response has been more limited: it has offered access to microcredits and has implemented a frontloaded payment of some social programs (close to 1 percent of GDP). The government has also announced an austerity program and the continuation of some public works.

Table 1 shows the main descriptive statistics for May 2019 and May 2020, including the total amount spent in POS terminals, the average amount of each transaction, and the share of expenditures in each group. For simplicity the data is grouped into 12 categories: tourism (travel agencies and hotels), education

⁶ These measures have included bond swaps, loosened rules for minimum deposits from commercial banks, and facilities to swap assets with the central bank in order to obtain credit. These measures have the goal of directing credit to small and medium-sized business.

Fig. 1 Effect of COVID-19 on expenditures in POS terminals. Notes: Authors' calculations. Lines are smoothed using a moving average for the previous two weeks. Predicted line is obtained with Eq. (3), an OLS of the amount in 2020 with the amount in 2019. Expenditures are in constant pesos (MXN) of July 2018. Expenditures in January 2020 are 9 percent larger than in January 2019

(universities, colleges, basic education, and daycare), health care (pharmacies, hospitals, physicians, and dentists), food services (restaurants and fast food), trade (wholesale and retail), transportation (air transportation, ground transportation, tolls, parking lots, and car rental), insurance, telecommunications, supermarkets, big-box stores, and others.

The average transaction amount did not change substantially. It was \$601 in May 2019 and \$589 in May 2020 (in constant MXN pesos of July 2018). However, there was an overall decline of approximately \$34 billion, or 16 percent, representing an average monthly decline in total private consumption of 2.5 percent a month. The sectors with the largest expenditures in 2019 (a combined total of 80 percent) were big-box stores, trade, gasoline, food services, and other. In May 2020, most sectors showed reduced total POS transactions. Services related to tourism, food services, and transportation were hit especially hard. However, insurance, telecommunications, big-box stores, and other maintained or increased sales.

3.1 Aggregate results

Figure 1 shows smoothed lines of daily expenditure in POS terminals for 2019 and 2020. For comparison purposes, the series are in relative terms with respect to January 14 of each year. The red line is the index for 2019 and the blue line for 2020. Using the method described above, we obtain a prediction for 2020 using data for the early part of the year. The green line is the prediction for 2020. Before the lockdown, the patterns for 2019 and 2020 are similar. When the lockdown started, POS expenditures fell drastically. The worst days were in mid-April, with expenditures about 35 percent lower than in 2019 or in the prediction for 2020. After that point, expenditures slowly started to recover. By late May and early June, the shortfall was only about 15 percent lower than the prediction. During July and August the recovery continued, although it slowed down in September.

Fig. 2 Decline in POS expenditures. Note: Authors' calculations. This graph shows the difference between actual and predicted values, and the difference between actual 2020 and 2019 values (in constant pesos of July 2018)

Figure 2 shows the decline in POS expenditures by month (constant pesos of July 2018), with comparisons to 2019 and the predicted expenditures for 2020. The greatest decline is in April, with expenditures 30 percent lower than predicted and 23 percent lower than in the corresponding period in 2019. Subsequent months show lesser declines as compared to predicted levels: 22 percent in May, 18 percent in June, and only 7 percent in September. The decline in POS expenditures from the predicted figure for April through June is around \$149 billion MXN, a loss of 3.9 percent of an average quarter of private consumption in 2019, and a loss of 2.6 percent of an average quarter of GDP. For the third quarter, the losses amount to \$57 billion MXN, a third of the loss in the second quarter. From April to September there is a decline in POS expenditures of 16 percent.

Fig. 3 Changes in consumption patterns by sector. Smoothed lines. Notes: Authors' calculations. Comparison is to predicted sales in each sector. Constant pesos (MXN) of July 2018. Smoothed with moving average of the previous two weeks

3.2 Results by sector

Figure 3 shows the change in consumption patterns by sector. The lines are smoothed using a moving average of the previous two weeks (Leatherby and Gelles 2020), and the comparison is to the predicted sales in each sector. The comparison with respect to 2019 can be found in the Supplementary Materials (Figures S1-S3). After the beginning of the lockdown, there is a sharp decline in education, tourism, food services, and transportation. Only education recovers, but at the end of May it is still about 40 percent below its predicted levels and it has remained stagnant during the pandemic. Tourism, food services, and transportation fell from 80 to 90 percent by mid-April. They have slowly recovered since but still are 40 percent below their predicted levels. Because of the decline in mobility and in domestic prices, POS expenditures for gasoline decrease by almost 50 percent in mid-April and by 35% by the end of May as compared to the prediction. By August and September, expenditures on gasoline have remained relatively stagnant, around 20 percent below the prediction.

Similar to the experience of other countries, POS expenditures in big-box stores increased in the last two weeks of March, an effect of panic buying to stockpile goods. Other sectors, like insurance, health care, and telecommunications, were not affected by the mobility restrictions. At least with insurance and telecommunications, this is likely related to direct billing options as well as the inelasticity of demand for this type of goods. While in the U.S. there was a large decline in health expenditures in April (Chetty et al. 2020), in Mexico the decline was smaller and it quickly recovered, by the end of May.

Figure 4 summarizes previous estimates. It indicates the percent difference of POS expenditures in 2020 with respect to the predicted expenditures and with respect to the same period in 2019 (in constant pesos). Total expenditure losses are 16 percent of predicted levels, whereas second quarter losses were 23 percent: one quarter of expected POS sales did not take place. Total expenditures were 11 percent lower than

Fig. 4 Summary of expenditure losses. April-September 2020. Note: Authors' calculations. This graph shows the change in expenditures relative to 2019 values and to predicted values for 2020. Constant pesos (MXN) of July 2018

in the same period in 2019. Comparisons are difficult because lockdowns were implemented at different times in different countries, but the Mexican loss estimate is among the lowest. In the last two weeks of March, France and Spain had expenditure losses of 50 percent (Bounie et al. 2020; Carvalho et al. 2020a, 2020b); in April, Portugal had losses of 55 percent (Carvalho et al. 2020a, 2020b) and Denmark had more moderate losses of approximately 30 percent.

The comparison with the U.S. depends on the source. The estimates of Baker et al. (2020) imply a decline of 50 percent, while Chetty et al. (2020) find a decline of 30 percent in the last two weeks of March. In fact, the change in All Expenditures in Fig. 3 is very close to that found in Chetty et al. (2020). The decline in expenditures in the U.S. was larger before mid-April. Stimulus payments began on April 15 in the U.S., and POS expenditures recovered faster around that date. The decline in POS expenditures from January to mid-June was 10 percent in the U.S., while in Mexico it was still 20 percent. There is significant heterogeneity across sectors, however. Those affected most severely in Mexico were tourism, food services, and transportation, where expenditures declined approximately 80 percent. This is similar to what previous studies have found in Denmark, Spain, the United States, and other countries (Andersen et al. 2020a; Baker et al. 2020; Carvalho et al. 2020a, 2020b; Chetty et al. 2020; Leatherby and Gelles 2020).

Some sectors in Mexico even had gains or only small losses. Expenditures on insurance increased slightly in the period, and expenditures on telecommunications decreased slightly. We interpret these sectors as supplying highly inelastic necessities. Expenditures in big-box stores decreased by only 2.6 percent. The pattern for these stores is mixed: in mid-March their expenditures increased, in mid-April they declined, and by the end of May they fully recovered. This group includes large supermarkets (such as Walmart and Soriana) as well as department stores (such as Liverpool, Palacio de Hierro, and Sears). It is likely that sales increased in large supermarkets and decreased in department stores.

Fig. 5 Losses by state in total POS expenditure (percent). Notes: Authors' calculation. The map shows the percent change of POS expenditures from April to September with respect to the predicted sales for each state. Constant pesos of July 2018. The data at the state level is non-public proprietary information of the Banco de Mexico. Aggregate information is provided in the supplementary material

There were decreased sales in gasoline, trade, small supermarkets, and other, which accounted for close to 50 percent of all expenditures in 2019 (Table 1, although these losses were stronger during the second quarter of 2020). The decline in trade and gasoline (16 and 28 percent, respectively) is directly related to restrictions in mobility.

3.3 Results by state

We estimate the model in Eq. (1) for each state in Mexico. Figure 5 shows percent losses by state with respect to the predictions of the model. States shown in purple are the hardest hit and those in yellow are the least affected. The hardest hit regions depend on international tourism: Quintana Roo, Yucatan, and Guerrero. These states lost all expected revenue from the spring vacation season. Other states closer to Mexico City are also greatly affected: Michoacán, Estado de México, Puebla, and Morelos, probably related to the loss of domestic tourism around Easter. Mexico City is not as affected as other states. We suspect that here the effects of the pandemic were partially compensated by online sales, but our data unfortunately does not distinguish online from other sales. Finally, states in the north are not as affected as the rest, an effect of greater mobility than in the rest of Mexico, as explained in the next section.

4 Consumption and mobility

We use geographic mobility data from Google LLC (2020) and Apple (2020) through September 2020. There is an ongoing debate about the relationship between

mobility and POS expenditures. The case and evidence from Sweden are relevant.⁷ Unlike other European countries, Sweden did not impose a lockdown in response to the COVID-19 pandemic, which was responsible for a higher mortality rate than in similar Nordic countries. One might expect that the lack of restrictions on mobility at least lessened the economic effects of the pandemic. However, Andersen et al. (2020b) found that this was not the case. Sweden experienced a 25 percent reduction in POS expenditures from March 11 to April 12; the corresponding figure for Denmark was 29 percent. Apple's measure of driving mobility for early April shows a reduction in Sweden of 12 percent and a reduction in Denmark of 32.4 percent. The between-country variation suggests that the elasticity of mobility is around 0.20. However, elasticity may depend on the relative importance of internet sales, which depends in turn on the depth of the financial sector. In a less developed country like Mexico, in-person sales and therefore mobility may matter much more than in developed economies.

To show how mobility and expenditures are related, we use Google's measure of workplace mobility and Apple's measure of driving mobility. We calculate mobility and expenditure patterns for each of the 34 weeks and 32 states under study. We thus have a panel dataset with 1088 observations. The patterns are shown in Fig. 6. The variation in the mobility measures is positively correlated with the variation in the total amount spent. Panel A uses Google's workplace mobility and it finds a coefficient of 0.7 using a simple OLS regression. Panel B uses Apple's driving mobility and it finds a coefficient of 0.8 with the same type of regression. States with the largest declines in mobility are related to the largest declines in expenditures at the weekly level. Moreover, if we restrict the estimation up to the second quarter of 2020, when the mobility restrictions were strongest, we find a closer relationship between mobility and POS expenditures (a coefficient of 0.9 using Apple's measure).

In order to analyze this claim more carefully, we estimate different versions of Eq. (3) using the full period and restricted to the second quarter of 2020. Panel A in Table 2 estimates the relationship between changes in POS expenditures and mobility in Mexico including week and state fixed effects up to the second quarter of 2020. These effects control for permanent differences across states (for example, density or geographic characteristics) as well as for temporal shocks that affect all states at the same time. Table 2 shows the results for all expenditures as well as for expenditures differentiated by credit versus debit card. The elasticity coefficient for total expenditure using Google's mobility is 0.73; for Apple's mobility it is 0.93. These estimates, which exploit the within-state variation, are very similar to those obtained simply by pooling the spending and mobility information (Fig. 6). All of the estimates in Panel A are very precisely estimated and they are all statistically significant. The elasticity using Apple's mobility information is not statistically different from 1. The elasticity for credit card spending is greater than for debit cards, regardless of the mobility indicator used. The estimates using the full period are in general slightly lower.

Panel B in Table 2 estimates the same spending-mobility relationship but instead of including fixed effects it includes as an additional control variable the proportion

⁷ <https://www.politico.eu/article/swedens-cant-escape-economic-hit-with-covid-19-light-touch/>, <https://www.ft.com/content/93105160-dcb4-4721-9e58-a7b262cd4b6e>.

Fig. 6 Relationship between mobility (Google and Apple) and POS expenditures. Notes: Authors' calculations. Each dot is the percent change of mobility or POS expenditures (constant pesos of July 2018) in week w with respect to February 17 for each of the 32 states in Mexico. Period of estimation is February 15 to September 30

of work that can be performed by telecommuting from home in each Mexican state, as estimated by Monroy-Gómez-Franco (2020). This specification exploits both the between and the within variation across states in Mexico to estimate the elasticity of POS expenditures with respect to mobility. The elasticity results obtained with this specification have larger standard errors, but they are similar for both mobility indicators (0.91). In both cases, they are statistically different from 0 but not from 1. As before, credit cards are more elastic with respect to mobility than debit cards. These estimated elasticities are also much larger than that implied by Andersen et al. (2020b) for the case of Sweden (0.2). This is true even using data up to the third quarter of 2020.

To further analyze these results, in Fig. 7 we show Apple's mobility measure (blue line) and POS expenditures (red line) in high- and low-mobility states in Mexico. In

Table 2 Elasticity estimates: change in % pos expenditures with respect to change in % mobility

	Google: Workplace Mobility			Apple: Automobile Mobility		
	Total	Credit	Debit	Total	Credit	Debit
Period February to June 2020						
A. Including state fixed effects						
Coefficient	0.73	1.09	0.56	0.93	1.33	0.74
Standard Error	[0.05]	[0.05]	[0.04]	[0.06]	[0.07]	[0.05]
R ²	0.45	0.54	0.35	0.46	0.44	0.41
Total Obs.	640	640	640	640	640	640
B. Controlling for telecommuting (without state fixed effects)						
Coefficient	0.91	1.34	0.67	0.91	1.03	0.85
Standard Error	[0.45]	[0.51]	[0.42]	[0.20]	[0.29]	[0.18]
R ²	0.57	0.63	0.51	0.65	0.66	0.62
Total Obs.	640	640	640	640	640	640
Period February to September 2020						
C. Including state fixed effects						
Coefficient	0.71	1.08	0.55	0.80	1.11	0.66
Standard Error	[0.05]	[0.05]	[0.04]	[0.05]	[0.07]	[0.04]
R ²	0.28	0.35	0.2	0.44	0.4	0.42
Total Obs.	1088	1088	1088	1088	1088	1088
D. Controlling for telecommuting (without state fixed effects)						
Coefficient	0.69	1.14	0.46	0.85	0.98	0.8
Standard Error	[0.38]	[0.44]	[0.36]	[0.17]	[0.24]	[0.15]
R ²	0.49	0.55	0.45	0.63	0.62	0.61
Total Obs.	1088	1088	1088	1088	1088	1088

Notes: Authors' calculations. The dependent variable is the percent change in POS expenditures in week w with respect to February 17 for each state in Mexico, and the independent variable is the percent change in mobility for the same period. The regression in Panel A includes fixed effects for state and week. Estimation period is February 15 to September 30. Panel B includes dummies for weeks and proportion of telecommuting (defined as in Monroy-Gómez-Franco 2020). Standard errors clustered at the state level in brackets

high-mobility states, mobility and POS expenditures declined close to 10 percent from early in the year to the end of May. By mid-June, mobility and expenditures in these states were similar to pre-pandemic levels. In low-mobility states the decline was close to 25 percent in mid-May and by mid-June it was still around 15 percent below pre-pandemic levels. After June, the correlation is still strong in low-mobility states but lessens in high-mobility states. The high correlation between spending and mobility in both types of states is evident. As expected, the estimates of the elasticity of spending with respect to mobility are also very high for each of these groups of states up to the second quarter of 2020: around 0.80 for high-mobility states and 1.04 for low-mobility states, and in both groups the elasticity for credit cards is larger than

Fig. 7 Apple's mobility and POS expenditures in high- versus low-mobility states. Notes: Authors' calculations. High-mobility states include Aguascalientes, Campeche, Chihuahua, Coahuila, Colima, Durango, Guerrero, Michoacán, Morelos, San Luis Potosí, Sinaloa, Sonora, Tamaulipas, Tlaxcala, Veracruz, and Zacatecas. Low-mobility states include Baja California, Baja California Sur, Chiapas, Mexico City, Estado de México, Guanajuato, Hidalgo, Jalisco, Nayarit, Nuevo León, Oaxaca, Puebla, Querétaro, Quintana Roo, Tabasco, and Yucatán. Mobility refers to driving mobility measured by Apple

for debit cards. These elasticity estimates are between four and five times the implied elasticity estimated by Andersen et al. (2020b).

Why is the elasticity of POS expenditures to mobility larger in Mexico? We conjecture that this difference is driven mainly by the strength (or lack thereof) of e-commerce, financial inclusion, and internet penetration. As mentioned in the Introduction, financial inclusion is lower in Mexico than in China, the United States, and European countries. In 2014, the proportion of individuals in Mexico with an account at a financial institution was 40 percent, while it is 80 percent in China and close to 100 percent in developed countries. If we consider that internet penetration is lower

as well, then we have a weaker market for e-commerce in Mexico than elsewhere. Indeed, results from the United Nations Conference on Trade and Development (2016) show that Mexico has an e-commerce readiness index much lower than other countries (Mexico's index is 49.1 while that for the U.S. is 82.6). POS transactions thus depend much more on mobility in Mexico than in other countries.

Finally, we cannot test the claim of Chetty et al. (2020) that the channels of the decline in POS expenditures are mainly rich individuals in fear of contagion. We attempt to compare our results, at least at the aggregate level, by computing POS expenditures by credit versus debit cards, which are highly segregated in Mexico. We calculate that approximately 77 percent of credit cards and 62 percent of debit cards are held by individuals in the top 30 percent of the wealth distribution (see figures in Supplementary Materials). The decline in POS expenditures is larger for credit cards (28.6 percent) than for debit cards (10 percent). The elasticity of POS expenditures with respect to mobility is also much larger for credit cards than for debit cards. We thus conjecture that the decline in POS expenditures is partially driven by richer individuals concerned for their health, as in Chetty et al. (2020).

5 Summary

This paper analyzes consumption patterns in Mexico using the universe of POS transactions for the period from January 2019 to September 2020. Unlike some other countries, Mexico implemented a soft lockdown as well as a moderate counter-cyclical fiscal policy. We find that POS expenditures for the April-June quarter are 23 percent less than they would have been in the absence of the pandemic and 16 percent less for the second and third quarter combined. This difference is less than that calculated for European countries using similar data, and comparable to that reported for the U.S. by Chetty et al. (2020), also using results based on live POS data.

The losses we find for Mexico are heterogeneous across economic sectors and region. As in other studies, the more severely affected sectors are those related to tourism (travel agencies and hotels), food services (such as restaurants), and transportation. States that benefit more directly from tourism (beach resorts and other tourist destinations) were also more affected.

There is a debate about whether mobility patterns affect POS expenditures and thus economic activity. Using information up to the second quarter of 2020, which is when the pandemic hit hardest in terms of mobility and POS expenditures, we find that the elasticity of POS expenditures with respect to mobility is close to 1 (0.93 using Apple's measure of mobility in one specification and 0.91 for both Google's and Apple's measures of mobility in another). These estimates are much larger than the implied elasticity estimated by Andersen et al. (2020b) for Sweden. Our estimate likely indicates that POS expenditures in developing countries with shallower financial sectors are more responsive to mobility patterns than in developed countries. It also suggests that mobility indicators, which can be observed almost in real time, could serve as a good proxy for the behavior of expenditures in some economies.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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References

- Asger, A., Emil Toft, H., Niels J., & Adam, S. (2020a). Consumer Responses to the COVID-19 Crisis: Evidence from Bank Account Transaction Data. *Centre for Economic Policy Research*. http://www.cepr.org/active/publications/discussion_papers/dp.php?dpno=14809.
- Andersen, A. L., Hansen, E. T., Johannesen, N., & Sheridan, A. (2020b). Pandemic, Shutdown and Consumer Spending: Lessons from Scandinavian Policy Responses to COVID-19. Working Paper arXiv:2005.04630v1.
- Apple Inc. (2020). "Apple Mobility Trends reports". <https://www.apple.com/covid19/mobility/> (Accessed: June 5th, 2020).
- Baker, S. R., Farrokhnia, R. A., Meyer, S., Pagel, M., & Yannelis, C. (2020). How does household spending respond to an epidemic? Consumption during the 2020 COVID-19 pandemic. *Covid Economics*, 18, 73–108.
- Bounie, D., Camara, Y., & Galbraith, J. (2020). Consumers' mobility, expenditure and online-offline substitution response to COVID-19: evidence from French transaction data. CIRANO Working Papers 2020-28.
- Carvalho, B., Peralta, S., & Pereira, J. P. d. (2020). What and how did people buy during the great lockdown? Evidence from electronic payments. *Covid Economics*, 28, 119–158.
- Carvalho, V. M., Hansen, S., Ortiz, Á., García, Juan, R., Rodrigo, T., Mora, S. R., & Ruiz, J. (2020b). Tracking the COVID-19 crisis with high-resolution transaction data. *Centre for Economic Policy Research*. https://cepr.org/active/publications/discussion_papers/dp.php?dpno=14642.
- Chen, H., Qian, W., & Wen, Q. (2020). The Impact of the COVID-19 Pandemic on Consumption: Learning from High Frequency Transaction Data. *SSRN*. <https://doi.org/10.2139/ssrn.3568574>.
- Chetty, R. J., Friedman, J. N., Hendren, N., Stepner, M., & The Opportunity Insights Team. (2020). How Did COVID-19 and Stabilization Policies Affect Spending and Employment? A New Real-Time Economic Tracker Based on Private Sector Data. National Bureau of Economic Research, NBER Working Paper 27431, <https://doi.org/10.3386/w27431>.
- Google LLC. (2020). Google COVID-19 Community Mobility Reports. <https://www.google.com/covid19/mobility/> (Accessed: June 5th, 2020).
- Guerrieri, V, G Lorenzoni, L Straub, & I Werning (2020). Macroeconomic implications of COVID-19: Can negative supply shocks cause demand shortages? National Bureau of Economic Research, NBER Working Paper 26918, <https://doi.org/10.3386/w26918>.
- Hacioglu, S., Känzig, D. R., & Surico, P. (2020). Consumption in the time of Covid 19: Evidence from UK transaction data. Centre for Economic Policy Research, CEPR Discussion Paper 14733. http://www.cepr.org/active/publications/discussion_papers/dp.php?dpno=14733.
- Instituto Nacional de Estadística y Geografía. (2018). Encuesta Nacional de Inclusión Financiera (ENIF) 2018". <https://www.inegi.org.mx/programas/enif/2018/> (Accessed: 5 Jun 2020).
- Forsythe, E., Kahn, L. B., Lange, F., & Wiczer, D. G. (2020). Labor Demand in the Time of COVID-19: Evidence from Vacancy Postings and UI Claims. National Bureau of Economic Research, NBER Working Paper 27061. <https://doi.org/10.1017/CBO9781107415324.004>.
- Lewis, D., Mertens, K., & Stock, J. H. (2020). US economic activity during the early weeks of the SARS-Cov-2 outbreak. National Bureau of Economic Research, NBER Working Paper 26954. <https://doi.org/10.3386/w26954>.

- Leatherby, L., & Gelles, D. (2020). How the Virus Transformed the Way Americans Spend Their Money *New York Times*. April 11. <https://www.nytimes.com/interactive/2020/04/11/business/economy/coronavirus-us-economy-spending.html?referringSource=articleShare>.
- Monroy-Gómez-Franco, L. (2020). ¿Quién puede trabajar desde casa? Evidencia desde México., Documento de Trabajo no. 06/2020. Espinosa Yglesias: Centro de Estudios.
- United Nations Conference on Trade and Development (2016). *UNCTAD B2B E-Commerce Index 2016* (Vol. 7). https://unctad.org/en/PublicationsLibrary/tn_unctad_ict4d07_en.pdf.
- World Bank (2020). Data indicators. Data.worldbank.org. Series. https://data.worldbank.org/indicator/FD.AST.PRVT.GD.ZS?locations=US-ES-GB-CN-DK-FR&name_desc=true, https://databank.worldbank.org/reports.aspx?source=1251&series=GPSS_4.