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The economic impact of the closure of non-essential activities due to Covid-19 in Mexico: An evaluation using the hypothetical extraction method

Impacto económico del cierre de las actividades no esenciales a causa del Covid-19 en México: una evaluación por el método de extracción hipotética

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Abstract

In the event of the Covid-19 pandemic, the Mexican government ordered the suspension of the non-essential economic activities for an approximate period of 60 days in order to contain the virus transmission. This paper pretends to evaluate the economic impact of this measure using the hypothetical extraction method to analyze several scenarios that allow to know the magnitude of the fall in gross production and value added of México in 2020. The results show that when intermediate and final demand fall around 40 and 50% over a 60-day period, production and value added contract between 3.94 and 4.84%, and 2.86 and 3.52%, respectively. Furthermore, the sectors which extraction cause a significant fall in value added are identified.

JEL Code: C67, O41, O47, O54
Keywords: covid-19; economic impact; hypothetical extraction method; México

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Resumen

Ante la pandemia por Covid-19 el gobierno mexicano ordenó la suspensión de las actividades económicas no esenciales por un periodo aproximado de 60 días para contener la transmisión del virus. Este trabajo evalúa el impacto económico de esta medida utilizando el método de extracción hipotética para analizar una serie de escenarios que permitan conocer la magnitud de la caída en la producción bruta y el valor agregado de México en 2020. Los resultados muestran que cuando la demanda intermedia y final caen entre 40 y 50% por un periodo de 60 días, la producción y el valor agregado se contraen entre 3.94 y 4.84%, y 2.86 y 3.52%, respectivamente. Además, se identificaron los sectores cuya extracción ocasionaría una caída significativa en el valor agregado.

Código JEL: C67, O41, O47, O54
Palabras clave: covid-19; impacto económico; método de extracción hipotética; México

Introduction

The Covid-19 pandemic has spread throughout the world since the beginning of 2020. The ease with which the virus is transmitted has put the world population at risk of contagion. The exponential growth in the number of positive cases led to the imposition of measures to contain the spread of the virus, such as social distancing and restriction of international transit of passengers, among others, forcing a significant part of the world population to remain in isolation for periods that have exceeded 120 days.

In Mexico, the lockdown due to Covid-19 has stopped some significant economic activities such as manufacturing production and the provision of personal services, which has caused a drop in the procurement of production inputs, employment, production, and household income. These activities have been identified by the Mexican government as non-essential and were forced to suspend their on-site activities for 60 days. Undoubtedly, this measure has significantly affected production in 2020.

Accordingly, this paper aims to evaluate the economic impact of the 60-day stoppage in non-essential activities due to the Covid-19 pandemic in Mexico. It uses the partial Hypothetical Extraction Method (HEM) based on the input-output model and matrix. Recently, the input-output model has been used to analyze the economic impact of various phenomena such as natural disasters (see Xia et al., 2019; Mendoza-Tinoco et al., 2017; Schulte in den Bäumen et al., 2015; Steenge & Bockarjova, 2007), pollution and CO2 emissions (Lin and Nakamura, 2019), and violence against women (Ciaschini & Chelli, 2020), among others. The diversity of these works demonstrates the versatility of the input-output model to analyze economic, social, natural, and biological events. The economic effect of the Covid-19 pandemic is no exception.

The HEM was constructed for daily economic activity, considering that the cessation of non-essential activities and its effect on the Mexican economy can be analyzed assuming the hypothetical

partial extraction of the sectors representing non-essential activities for 60 days.

The document is divided into four sections in addition to this introduction and conclusions. The first section reviews data on the evolution of the pandemic in Mexico. Section Two lists the non-essential activities based on the North American Industrial Classification System. Section Three describes the methodology used to determine the economic impact of the suspension of non-essential activities due to the Covid-19 pandemic. Finally, Section Four discusses the results obtained.

The context of the covid-19 pandemic

The presence of the SARS-CoV-2 virus, specifically the disease known as COVID-19, marked 2020 as a year that abruptly changed the growth expectations for economies and their various sectors. The possibility of recovery for many of these sectors will extend beyond 2020. There is extensive literature addressing the impacts of this pandemic on the various economic sectors and the expectations for recovery.

International organizations such as the World Health Organization (WHO), the International Monetary Fund (IMF), the World Bank (WB), and the United Nations (UN), among others, have continuously monitored the effects that Covid-19 is having not only in terms of health but also on the economy.

In this context, the growth forecast for the world economy for 2020 is between -4.9% (IMF, 2020) and -5.2% (WB, 2020); furthermore, the World Bank has forecasted that economic activity in advanced economies will contract by -7%, and emerging markets and developing economies will contract by -2.5%. Growth expectations for 2021 are 4.2% for the world economy, 3.9% for developed economies, and 4.6% for developing economies.

On the other hand, the UN (2020) has indicated that the coronavirus pandemic may cause around 176 million people to fall into poverty, a situation that would translate into an increase of 2.3 percentage points compared to a scenario without coronavirus. Meanwhile, the WHO (2020) reports that by July 8, 2020, more than two hundred nations and territories had been affected by the pandemic.

For the specific case of the Mexican economy, the Bank of Mexico (Banxico, 2020) forecasts two possible scenarios: a) one associated with the reopening, in June, of various sectors and the relaxation of various social distancing measures that would generate a GDP variation for 2020 between -4.6% to -8.8% and between 4.0% and 5.6% for 2021; b) one that assumes that the weakness of activity extends throughout the year, generating a GDP variation of -8.3 to -12.8% during 2020 and between -0.5 and 1.3% for 2021.

Accordingly, the effects of the pandemic worldwide are slowing down labor supply and

production, causing the most violent economic shock that the world economy has suffered in recent decades (Navarrete, 2020). In this regard, the efforts of specialists have been significant in trying to measure the economic impact that the Covid-19 health crisis will generate. In the case of the United States, Alberro (2020) highlights the loss of 21 million jobs between March and April, affecting practically all sectors and, specifically, people with the lowest salaries. By June, more than 22 million people had been infected, and by the end of September, a little over 210,000 deaths had been recorded.

For Latin America, Jaramillo and Ñopo (2020) analyze the case of Peru by measuring the potential impacts of the crisis on household labor income. They highlight that only a limited portion of households have some regulatory protection, which leaves salaried workers without contracts and the informal self-employed, who will be the sector of the population potentially most affected by the Covid-19 crisis, in very vulnerable conditions. For Central America, they note that the crisis affects the region in different ways due to the levels of poverty, inequality, and labor informality prevailing in the region and the signs of economic slowdown and stagnation. For example, there is the expectation of a fall in exports to the United States and a reduction in the volume of international trade between Asia and the Americas. In addition, the slump in tourism will represent an adverse shock for the economies of Guatemala, Honduras, Costa Rica, and Panama (Morales, 2020).

In the case of Spain, Ruesga (2020) notes that in the first weeks, economic activity could have fallen by 40 percent, especially due to the reduction of tourism, which represents 14.3 percent of its gross domestic product. They argue that territorial asymmetries in the impact of the crisis are linked to the economic characteristics of each territory and geographical differences.

In the case of Mexico, Esquivel (2020) provides a brief account of the multiple economic impacts of the pandemic: a -19.9% contraction of economic activity during April and May, as a result of the suspension of non-essential activities, which affected several manufacturing and service sectors. Among the most affected sectors, they single out tourism, transportation, and restaurants or consumption of fast food services. They also argue that due to the pandemic and its aftermath, it is highly likely that poverty will increase, particularly an increase in extreme poverty levels from 6 to 16.6 million people. In the case of employment, they note that in the period from March to June 2020, just over 1.1 million formal jobs were lost, a reduction of 5.4% of all formal jobs registered with the Mexican Social Security Institute. The loss of formal jobs has been disproportionately concentrated in low-income workers, as 83.7% (933 thousand) of all jobs lost correspond to workers earning between 1 and 2 minimum wages (Esquivel, 2020).

In the same vein, Samaniego (2020) highlights that more than 12 million workers left the labor force in April. More than 90% correspond to the informal economy due to the temporary suspension of their work without pay. In formal salaried employment, most layoffs were of young people between 15

and 29. The most affected branches of activity were temporary accommodation services, construction, and food and beverage preparation services. Tourist centers were among the municipalities and cities with significant losses, especially the Riviera Maya, Cancun, Playa del Carmen, and Tulum.

Non-essential economic activities

Given the evolution of the Covid-19 pandemic in Mexico, the Mexican government ordered the suspension of non-essential economic activities to mitigate the spread of the virus, and its complications, in the Official Gazette of March 31, 2020. The statement defines non-essential activities as all those not included in the list of essential activities.

In short, the latter are those related to the health sector, pharmaceuticals, hazardous waste disposal, security and public safety, procurement and administration of justice and legislative activities, activities related to social programs, the financial sector, tax collection; generation, distribution and sale of energy, gas, and drinking water; the food and non-alcoholic beverage industry, markets, supermarkets, self-service stores, groceries, and the sale of prepared foods; passenger and freight transportation services; agricultural, fishing and livestock production, agribusiness, chemical industry, cleaning products, and hardware stores; courier services, private security; daycare and childcare centers, nursing homes, and shelters; telecommunications and information media; private emergency services, funeral and burial services, storage and logistics, airports, ports, and railroads; and conservation, maintenance, and repair of critical infrastructure[1].

The suspension of the remaining non-essential activities lasted approximately 60 days. The return to the "new normal" made it possible, between May 25 and June 1, 2020, for most industries to resume their activities following the health safety protocols in the work environment of the Secretariat of Economy (2020).

To better identify the essential and non-essential activities, the North American Industrial Classification System (NAICS), which at the subsector level disaggregates economic activity into 79 subsectors, is considered. However, it was necessary to disaggregate eight subsectors at the branch level to separate essential and non-essential activities in greater detail. The central idea of this disaggregation is to identify the sectors of activity that had to suspend their activities, which was useful for the application of the HEM. Table 1 presents the total economic activities grouped into 87 subsectors indicating whether they are essential or not. The subsectors that should have been disaggregated at the branch level are identified with an asterisk in the NAICS code.

[1]For further details, see the press release published in the Official Gazette of the Federation on March 31, 2020.

Table 1
Essential and Non-Essential Activities in the Face of the Covid-19 Pandemic

No	NAICS	Description	Type of activity
1	111	Agriculture	Essential
2	112	Animal breeding and husbandry	Essential
3	113	Forest harvesting	Non-essential
4	114	Fishing, hunting, and trapping	Essential
5	115*	Services related to agricultural activities	Essential
6	1153*	Services related to forest harvesting	Non-essential
7	211	Oil and gas extraction	Essential
8	212	Mining of metallic and non-metallic minerals, except oil and gas	Non-essential
9	213	Mining-related services	Non-essential
10	221	Generation, transmission, and distribution of electric power	Essential
11	222	Water supply and piped gas supply to the end consumer	Essential
12	236	Construction	Non-essential
13	2371, 2373*	Construction of works to supply water, oil, gas, electricity, etc.	Essential
14	2372, 2379*	Land division, construction works, urbanization, civil engineering	Non-essential
15	238	Specialized works for construction	Non-essential
16	311	Food industry	Essential
17	3121*	Beverage industry	Essential
18	3122*	Tobacco industry	Non-essential
19	313	Textile input manufacturing and textile finishing	Non-essential
20	314	Manufacture of textile products, except garments	Non-essential
21	315	Garment manufacturing	Non-essential
22	316	Tanning and finishing of leather and fur, leather and fur products, and leather substitutes	Non-essential
23	321	Wood industry	Non-essential
24	322	Paper industry	Non-essential
25	323	Printing and related industries	Non-essential
26	324	Manufacture of petroleum and coal products	Essential
27	3251, 32524, 3256*	Basic chemicals, pharmaceuticals, soaps, cleansers, and toilet preparations	Essential
28	3252, 3253, 3255, 3259*	Other chemical products	Non-essential
29	326	Plastic and rubber industry	Non-essential
30	327	Manufacture of products based on non-metallic minerals	Non-essential
31	331	Basic metal industries	Non-essential
32	332	Manufacture of metal products	Non-essential
33	333	Machinery and equipment manufacturing	Non-essential
34	334*	Computers, communications equipment, and electronic accessories	Non-essential
35	3345*	Measuring instruments	Essential
36	335	Accessories, electrical devices, and electrical power generation equipment	Non-essential
37	336	Manufacture of transportation equipment	Non-essential
38	337	Manufacture of furniture, mattresses, and blinds	Non-essential
39	3391*	Non-electronic equipment, disposable medical and laboratory supplies	Essential
40	3399*	Other manufacturing industries	Non-essential
41	431	Wholesale trade in groceries, food, beverages, ice, and tobacco	Essential
42	461	Retail trade in groceries, food, beverages, ice, and tobacco	Essential
43	481	Transportation by air	Essential
44	482	Transportation by rail	Essential
45	483	Transportation by water	Essential
46	484	Freight transportation	Essential
47	485	Passenger land transportation, except by rail	Essential
48	486	Transportation by pipeline	Essential

No	NAICS	Description	Type of activity
49	487	Tourist transportation	Non-essential
50	488	Transportation-related services	Essential
51	491	Postal services	Essential
52	492	Courier and package services	Essential
53	493	Storage services	Essential
54	511	Publishing of newspapers, magazines, books, software, and other materials.	Essential
55	512	Film and video industry and sound industry	Non-essential
56	515	Radio and television	Essential
57	517	Other telecommunications	Essential
58	518	Information processing, hosting, and related services	Non-essential
59	519	Other information services	Non-essential
60	521	Central Banking	Essential
61	522	Non-stock financial and credit intermediation institutions	Essential
62	523	Stock exchange, foreign exchange, and financial investment activities	Essential
63	524	Bonding, insurance, and pension companies	Essential
64	531	Real estate services	Non-essential
65	532	Rental services of movable property	Non-essential
66	533	Trademark, patent, and franchise leasing services	Non-essential
67	541	Professional, scientific, and technical services	Non-essential
68	551	Corporate	Non-essential
69	561	Business support services	Non-essential
70	562	Waste management and remediation services	Essential
71	611	Educational services	Non-essential
72	621	Outpatient medical and related services	Essential
73	622	Hospitals	Essential
74	623	Social assistance and health care residences	Essential
75	624	Other social assistance services	Essential
76	711	Artistic, cultural, sporting, and other related services	Non-essential
77	712	Museums, historical sites, zoos, and other related services	Non-essential
78	713	On-site entertainment services and other recreational services	Non-essential
79	721	Temporary lodging services	Non-essential
80	7223, 7225*	Food and beverage preparation services	Essential
81	7224*	Nightclubs, bars, cantinas, and other similar services	Non-essential
82	811	Repair and maintenance services	Non-essential
83	812*	Personal services, except funeral services and cemetery management	Non-essential
84	8123*	Funeral services and cemetery management	Essential
85	813	Associations and organizations	Non-essential
86	814	Households with domestic employees	Non-essential
87	931	Government activities and international organizations	Essential

Source: created by the authors with information from the Official Gazette of the Federation (DOF, 2020)

The hypothetical extraction method for assessing the economic impact of Covid-19 in Mexico

The hypothetical extraction method (HEM) is a technique based on the input-output model, originally developed to assess the relative importance of an industry in the total economy by assuming its extraction and estimating the level of output that would be reached after its elimination (see Strassert, 1968; Cella, 1984). The total reduction in the level of output after extraction defines the importance of the industry and can also be used to estimate the effects on other industries.

The original HEM assumes the total extraction of an industry and consists of eliminating the row and column corresponding to it by changing all its entries to zeros, including its entry in the final demand vector. This indicates that the sector eliminates any economic relationship with the rest of the industries and institutional sectors. The extraction of an industry that is strongly interconnected with the productive fabric will cause a considerable drop in many sectors and, therefore, in total national production.

In the last decade, the HEM has been reformulated (Termushoev & Oosterhaven, 2014; Dietzenbacher & Lahr, 2013) to identify cases in which full hypothetical extraction is valid and those in which it is better to consider partial extraction. The application of some HEMs requires considering two important aspects.

First, it is necessary to specify the variant of the HEM to be used since there are several. Following Miller and Blair (2009), the column of an industry can be replaced by zeros in an input-output matrix when the industry cannot buy intermediate inputs from the other sectors, i.e., when the backward linkages of the industry disappear. Similarly, an industry row can be replaced by zeros when it has no sales to other industries and its forward linkages disappear. On the other hand, the column and row may be replaced by zeros when both linkages cease.

However, in a recent critique of the use of the HEM, Oosterhaven (2017) argues that the extraction of an industry should be interpreted only with a view of backward linkages, i.e., when the coefficients of a column are changed to zero, it is equivalent to removing the backward dependence of the eliminated industry with other sectors, while replacing the coefficients of a row by zeros means removing the backward dependence of the rest of the sectors with the particular industry. This is because if any sector stops producing, it will not be able to supply the intermediate demand of other industries or the final demand, causing the output to fall.

Second, it is crucial to define how much the linkages of the industry with the productive fabric will be reduced. According to Dietzenbacher and Lahr (2013), it is useful and novel to pose scenarios in which the relationships of an industry are reduced by a certain percentage. This makes it possible to have more realistic and less drastic scenarios, especially when the HEM is used to analyze the economic impact of some real event instead of the relative importance of some sector in total production. Accordingly, the entries in the row or column of an industry, instead of being replaced by zeros, can be multiplied by a scalar, whose value is between zero and one, representing the percentage reduction in the production capacity of the industry in question. This procedure is known as partial extraction.

The basic input-output model is based on the concept that each sector produces a different good used to supply intermediate and final demand. It is described by Equation 1, where matrix A

represents the matrix of technical coefficients $\left(a_{ij} = \frac{z_{ij}}{x_j}\right)$, which, when multiplied by the vector of production x, results in a vector of intermediate demands. The vector f demonstrates the final demand of each sector.

$$x = Ax + f \tag{1}$$

Solving Equation 1 for x indicates that the gross production value is defined by the Leontief inverse matrix L and the final demand vector (see Equation 2). The elements l_{ij} of matrix L represent the direct and indirect requirements of industry i to satisfy one unit of final demand of industry j.

$$x = (I - A)^{-1}f = Lf \tag{2}$$

The original HEM is based on the idea that some industry, for example, Industry 1, is eliminated from the economic system; the consequences of this change can be analyzed by conducting the complete extraction of that industry. On the one hand, this implies the elimination of the intermediate transactions of Industry 1 with the rest of the industries, achieved by replacing all the row and column entries corresponding to Industry 1 with zero; consequently, the new matrix nxn of technical coefficients that considers the extraction of Industry 1 is denoted by $\overline{A}$ and is defined by Equation 3.

$$\overline{A} = \begin{pmatrix} 0 & 0 & \dots & 0 \\ 0 & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 0 & a_{n2} & \dots & a_{nn} \end{pmatrix} \tag{3}$$

On the other hand, the complete extraction of Industry 1 also considers changes in the final demand of the industry. In this case, if all intermediate transactions of the industry disappear, it is evident that its level of output and final demand will also be zero. Therefore, the input-output model that estimates the output resulting from the hypothetical extraction of Industry 1 is depicted in equations 4 and 5.

$$\begin{pmatrix} \overline{x}_1 \\ \vdots \\ \overline{x}_n \end{pmatrix} = \begin{pmatrix} 0 & 0 & \dots & 0 \\ 0 & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 0 & a_{n2} & \dots & a_{nn} \end{pmatrix} \begin{pmatrix} \overline{x}_1 \\ \vdots \\ \overline{x}_n \end{pmatrix} + \begin{pmatrix} 0 \\ \vdots \\ \overline{f}_n \end{pmatrix} \tag{4}$$

$$\bar{x} = (I - \bar{A})^{-1}\bar{f} = \bar{L}\bar{f} \tag{5}$$

Where $\bar{x}$ is the new vector of total gross output, $\bar{A}$ the new matrix of technical coefficients, and $\bar{f}$ is the new vector of final demand considering the hypothetical extraction of Industry 1. In matrix notation, the fall in total gross output resulting from the complete extraction of Industry 1 is written as in Equation 6.

$$\bar{x} - x = \bar{L}\bar{f} - Lf \tag{6}$$

According to Dietzenbacher and Lahr (2013), it is surprising that exercises based on full extraction still predominate today, especially from an economic and economic policy point of view, since several phenomena require the positing of more realistic scenarios, which can be analyzed through the partial HEM. The latter is used when part of an industry, for example, Industry 1, ceases to exist, causing its productive capacity to be reduced. If its production falls, then its intermediate requirements and sales will decrease by a percentage α, and, in matrix A, the elements of row and column 1 will decrease by α. α represents the percentage reduction in the productive capacity of Industry 1 and takes values between zero and one ($0 \leq \alpha \leq 1$), where zero indicates no reduction in productive capacity, and one reflects the complete disappearance of the intersectoral relationships of the sector as in full extraction. Consequently, $(1 - \alpha)$ presents the percentage of productive capacity with which the industry will operate after partial extraction.

The elements of row 1, except for the main diagonal element, will be expressed by $\bar{a}_{1j} = \frac{\bar{z}_{1j}}{\bar{x}_j} = \frac{(1-\alpha)z_{i1}}{x_j} = (1 - \alpha)a_{1j}\ \forall\, j = 1, \ldots, n\ (j \neq 1)$. In contrast, the entries in column 1, including that of the main diagonal, will remain unchanged because $\bar{a}_{i1} = \frac{\bar{z}_{i1}}{\bar{x}_1} = \frac{(1-\alpha)z_{i1}}{(1-\alpha)x_j} = a_{i1}$.

On the other hand, in partial hypothetical extraction, final demand can be treated in two ways. The first considers that final demand can remain constant as long as the final demand of Sector 1 is satisfied by the rest of the establishments that comprise Sector 1. The second option considers that the reduction in the production capacity of Sector 1 translates into a reduction in final demand in a magnitude equal to α. In this case, the final demand of Sector 1 would be: $\bar{f}_1 = (1 - \alpha)f_1$. Tybout (2003) finds that high-exporting sectors are less prone to stop their activities than those that supply the domestic market.

In the first case, the total gross output is obtained by multiplying the new matrix of technical coefficients by the output vector and adding to it the original final demand vector as in Equation 7.

Solving for x, the reduction in total gross production is obtained by Equation 8.

$$\begin{pmatrix} \bar{x}_1 \\ \vdots \\ \vdots \\ \bar{x}_n \end{pmatrix} = \begin{pmatrix} a_{11} & (1-\alpha)a_{12} & \dots & (1-\alpha)a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{pmatrix} \begin{pmatrix} \bar{x}_1 \\ \vdots \\ \vdots \\ \bar{x}_n \end{pmatrix} + \begin{pmatrix} f_1 \\ \vdots \\ \vdots \\ f_n \end{pmatrix} \tag{7}$$

$$\bar{x} - x = \bar{L}f - Lf = (\bar{L} - L)f \tag{8}$$

For the second option, these results are expressed through equations 9 and 10.

$$\begin{pmatrix} \bar{x}_1 \\ \vdots \\ \vdots \\ \bar{x}_n \end{pmatrix} = \begin{pmatrix} a_{11} & (1-\alpha)a_{12} & \dots & (1-\alpha)a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{pmatrix} \begin{pmatrix} \bar{x}_1 \\ \vdots \\ \vdots \\ \bar{x}_n \end{pmatrix} + \begin{pmatrix} (1-\alpha)f_1 \\ \vdots \\ f_n \end{pmatrix} \tag{9}$$

$$\bar{x} - x = \bar{L}\bar{f} - Lf \tag{10}$$

The drop in total gross production that considers variations in the final demand vector (Equation 10) is greater than that from considering the original final demand (Equation 8). Accordingly, to evaluate the economic impact of the suspension of non-essential activities in Mexico for 60 days, it was necessary to use the partial HEM, which corresponds to the reduction in a percentage α of the elements of the rows, except for the main diagonal, of the sectors of non-essential activities. The Covid-19 pandemic forced companies to temporarily reduce their production capacity, causing their intermediate and final sales to be reduced. The elements of the columns of the non-essential activities remain constant because $\bar{a}_{i1} = \frac{\bar{z}_{i1}}{\bar{x}_1} = \frac{(1-\alpha)z_{i1}}{(1-\alpha)x_j} = a_{i1}$. This suggests that the sectoral production technique is not altered in scenarios of lower production, except when some industries stop supplying their products because of the suspension of activities due to the pandemic. This situation will be common in our exercises as the scenarios analyzed consider the simultaneous partial extraction of all non-essential activities. Different hypothetical partial extraction scenarios starting from equations 7 and 9 considering different values for α were considered. These exercises were performed using the 2019 input-output matrix obtained by updating the 2013 matrix using the RAS method[2].

[2]For more details on the update of the 2013 matrix using the RAS method and the data vectors used, see the annex, respectively.

Finally, it is of great interest to measure the impact of the Covid-19 pandemic on a variable related to the population's welfare, such as value added. Equation 11 defines its reduction as a consequence of the temporary suspension of non-essential activities, where $\hat{v}$ is the diagonalized vector of the coefficients of value added $\left(v_j = \frac{VA_j}{X_j}\right)$.

$$\overline{VA} - VA = \hat{v}(\overline{x} - x) \tag{11}$$

It is worth mentioning that the main limitation of the input-output model for the analysis of expected or forecast effects lies in the static and deterministic nature of the model. However, the information contained in the input-output matrices, which reflect the productive structure of a country, offers unparalleled detail for the intersectoral analysis of the effects of the pandemic, especially if the input-output matrix of the immediately preceding year is used.

Economic impact of the covid-19 pandemic in Mexico

The effect of the suspension of non-essential activities on production and value added in Mexico due to the Covid-19 pandemic was estimated through different partial hypothetical extraction exercises using the updated 2019 input-output matrix for daily national production. The latter was calculated assuming that intermediate and final demand for non-essential activities contracted by percentage α. Furthermore, since the stoppage of non-essential activities lasted approximately 60 days, the result was multiplied by 60 and added to the value of production under normal conditions for the remaining 305 days of the year. Finally, this amount was compared with the total annual production of the economy under normal conditions, and the same for the value added.

Figure 1 presents the percentage drop that Mexico's domestic production would experience due to a 60-day stoppage in non-essential activities. The horizontal axis represents the percentage reduction in intermediate demand for non-essential activities (α), and the vertical axis presents the percentage drop in annual production. In total, 30 exercises were performed resulting from 10 different values of α (0.1, 0.2, 0.3, ..., 1) and three different treatments of final demand. The blue line indicates the percentage drop in output, assuming that intermediate demand is reduced by a percentage α and that final demand remains constant. The red line indicates the results of the exercises in which a percentage $\boldsymbol{\alpha}$ reduces both intermediate and final demand, and the green line assumes that intermediate demand is reduced by a percentage α while final demand is fully extracted.

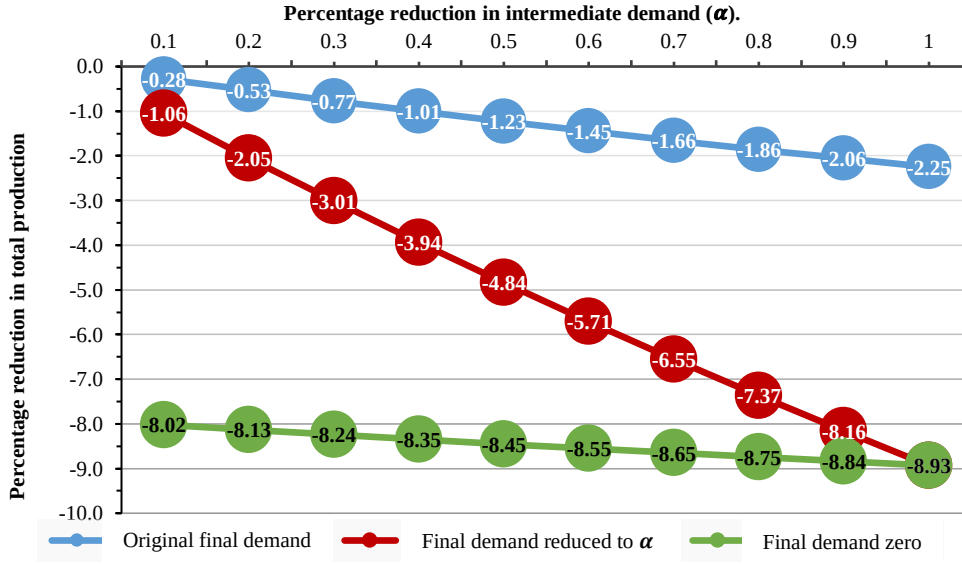

Figure 1. Percentage reduction in the total gross production of 2020 due to the partial closure of non-essential activities for 60 days
Source: created by the authors

Overall, the results demonstrate that the drop in output is smaller in the scenarios using the original final demand (blue line). On the one hand, this is due to the demand-driven nature of the model; on the other hand, it is due to the weight of final demand in the total output of most sectors. For example, when the intermediate sales of the 46 sub-sectors of non-essential activities are extracted by 10% ($\alpha = 0.1$), and final demand remains constant, in the sense that it is fully satisfied by other firms in the same sectors, total production would only contract 0.28%. In contrast, with the same value of α for intermediate sales and a value equal to zero for final demand, domestic production would contract by 8.02%. This example reveals the importance of economic growth of demand from households, firms, government, and the external sector. Without demand, sectoral production falls sharply and total production with it.

The results indicate that, in the most optimistic scenario, total production in 2020 would suffer a contraction of 0.28% with respect to 2019. This figure results from a scenario in which intermediate demand for non-essential activities contracts by 10% and final demand remains constant. At the opposite extreme, the most pessimistic scenario predicts that if intermediate sales of non-essential activities are fully extracted, as well as their final demand, total production would experience a drop of 8.93%. It is worth noting that this figure assumes that after 60 days, non-essential activities return to normal.

On the other hand, when intermediate demand is completely extracted ($\alpha = 1$), the difference

between the original and zero final demand scenarios, although reduced, is still large. In the first case, production contracts by 2.25%, and in the second by 8.93%. It is clear that the scenarios represented in the blue and green lines summarize the extreme cases but highlight the importance of final demand in determining production.

The red line presents the economic impact of the Covid-19 lockdown in more realistic scenarios, in which both intermediate and final demand are reduced by percentage α. For example, when intermediate and final demand contract for 60 days by 50% from their original value, total annual gross production would contract by 4.84%. This figure differs significantly from scenarios with the same value of α for intermediate demand but with original or zero final demand, which result in -1.23 and -8.45%, respectively.

Moreover, considering recent statistics on the performance of the manufacturing industry (EMIM, 2020), it is possible to anticipate the magnitude of the fall in total production, especially because just over 40% of the non-essential activity sectors belong to the manufacturing industry and because there is evidence suggesting that domestic production has similar behavior to manufacturing production (De Jesús-Almonte, 2019).

Table 2
Manufacturing sales growth by subsector, 2020.01- 2020.05

Subsector	2020.01	2020.02	2020.03	2020.04	2020.05
Manufacturing	-0.18	0.25	-1.34	-41.31	-44.42
311 Food	5.82	4.53	10.99	7.30	-0.74
312 Beverage and tobacco	-0.99	6.28	3.27	-22.98	-27.81
313 Textile inputs	-14.42	-8.96	-11.52	-65.85	-65.83
314 Textile products	-6.93	-6.51	4.18	-55.41	-46.28
315 Garments	-1.38	-0.44	-9.41	-76.90	-78.26
316 Leather and fur products	1.15	-2.98	-8.04	-86.04	-85.59
321 Wood	-6.64	-0.56	-3.17	-23.93	-35.51
322 Paper	-3.15	-0.46	4.65	-10.60	-20.11
323 Printing and related	-1.21	2.13	-0.31	-36.31	-29.20
324 Petroleum derivatives	16.91	-25.01	-27.83	-51.66	-38.36
325 Chemical	-7.46	-3.86	-2.07	-12.36	-17.90
326 Plastic and rubber	-2.35	-1.48	-2.58	-41.07	-44.34
327 Mineral products	0.06	2.44	-0.69	-25.53	-26.50
331 Basic metals	-8.69	-8.25	-1.36	-22.55	-23.57
332 Metal products	-8.88	-6.65	-0.19	-29.06	-35.44
333 Machinery and equipment	-15.10	-8.31	-9.76	-25.01	-35.67
334 Computers and communication	0.18	-3.33	-7.44	-24.78	-28.34
335 Electrical accessories and appliances	0.02	-0.44	5.44	-5.68	-27.06
336 Transportation equipment	2.76	4.55	-4.54	-85.68	-83.21
337 Furniture and mattresses	-3.55	-3.63	-5.10	-62.47	-64.99
339 Other manufacturing	6.45	2.82	4.52	-32.86	-26.13

Source: created by the authors based on the Monthly Survey of the Manufacturing Industry (2020)

Table 2 presents the growth in total sales (intermediate and final) during the first five months of 2020 compared to the same five months of 2019 for the 21 manufacturing subsectors. Early statistics indicate a large drop in intermediate and final demand for manufacturing, especially in April and May, months covering the 60 days of restriction on non-essential activities. Total sales fell 41.31% and 44.42%, respectively.

Furthermore, some sectors have been much more affected than others. For example, in the textile inputs (313) and furniture and mattresses (337) sectors, total sales have fallen around 65% during April and May 2020. In the leather and fur products (316) and transportation equipment (336) sectors, the drop in their sales has reached over 85% during the same months. The only manufacturing subsector in which sales did not fall, or fell by a better percentage, is the food industry, which is considered essential and was not forced to stop its economic activities.

However, considering the reduction in total manufacturing sales (-41.31 and -44.42%) in April and May to evaluate the economic impact of the Covid-19 pandemic, the total gross production in 2020 would be reduced by a percentage between 3.94% and 4.84%, figures that correspond to the red line scenarios with α values equal to 0.4 and 0.5 (see Figure 1). It is important to mention that these exercises assume that, as of June, economic activity in the non-essential sectors will return to normal, which is unlikely, especially because recovery from such an abrupt drop is gradual. Accordingly, the fall in total production in 2020 could be even larger and represented in the second half of the red line in Figure 1.

The percentage reduction in total value added due to the Covid-19 pandemic is presented in Figure 2. The exercises performed followed the same methodology as those in Figure 1, with the difference that they consider the value added coefficients (see Equation 11). In this case, when intermediate demand is reduced by 10% ($\alpha = 0.1$) and the original final demand is used, value added would fall 0.15% with respect to its 2019 value. With the same value of α for intermediate deliveries, accompanied by a value equal to zero for final demand, value added would contract by 4.20%.

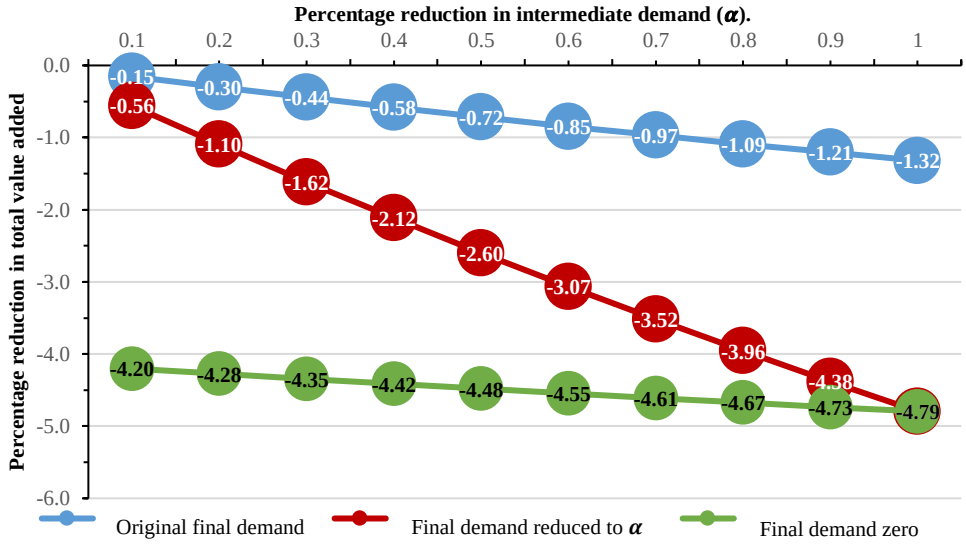

Figure 2. Percentage reduction in total value added in 2020 due to partial closure of non-essential activities for 60 days
Source: created by the authors

In the pessimistic scenario, i.e., full extraction of non-essential activities, value added would fall by 4.79%. These results indicate that the fall in value added represents approximately 50% of the fall in total gross production, which is explained by the share of value added in the latter.

Table 3
Percentage reduction in domestic value added in 2020 due to a 50% drop in sectoral intermediate demand

No	NAICS	Description	(1) Original final demand	(2) Reduced final demand $\alpha = 0.5$	(3) Zero final demand
3	113	Forest harvesting	-0.01	-0.01	-0.01
6	1153*	Services for forest harvesting	0.00	0.00	0.00
8	212	Mining, except oil and gas	-0.09	-0.11	-0.13
9	213	Mining-related services	0.00	-0.05	-0.10
12	236	Construction	0.00	-0.59	-1.18
14	2372, 2379*	Construction of works, urbanization	0.00	-0.05	-0.09
15	238	Specialized works for construction	-0.08	-0.09	-0.11
18	3122*	Tobacco industry	0.00	-0.01	-0.03
19	313	Manufacture of textile inputs	-0.01	-0.02	-0.03
20	314	Manufacture of textile products	0.00	-0.01	-0.02
21	315	Garment manufacturing	0.00	-0.05	-0.09
22	316	Leather and fur, leather, and fur products	0.00	-0.02	-0.04
23	321	Wood industry	-0.02	-0.02	-0.03
24	322	Paper industry	-0.03	-0.05	-0.07

No	NAICS	Description	(1) Original final demand	(2) Reduced final demand $\alpha = 0.5$	(3) Zero final demand
25	323	Printing and related industries	-0.01	-0.02	-0.03
28	3252, 3253, 3255, 3259*	Other chemical products	-0.03	-0.06	-0.10
29	326	Plastic and rubber industry	-0.04	-0.08	-0.13
30	327	Non-metallic mineral-based products	-0.06	-0.09	-0.11
31	331	Basic metal industries	-0.09	-0.19	-0.28
32	332	Manufacture of metal products	-0.04	-0.10	-0.16
33	333	Machinery and equipment manufacturing	-0.01	-0.09	-0.18
34	334*	Computer and communication equipment	0.00	-0.15	-0.30
36	335	Accessories, electrical appliances, etc.	-0.01	-0.09	-0.17
37	336	Manufacture of transportation equipment	-0.02	-0.57	-1.12
38	337	Manufacture of furniture, mattresses, and blinds	0.00	-0.03	-0.06
40	3399*	Other manufacturing industries	0.00	-0.03	-0.06
49	487	Tourist transportation	0.00	0.00	0.00
55	512	Video and sound film industry	-0.01	-0.02	-0.04
58	518	Lodging and related services	0.00	0.00	0.00
59	519	Other information services	0.00	0.00	0.00
64	531	Real estate services	-0.10	-0.96	-1.82
65	532	Rental services of movable property	-0.02	-0.02	-0.02
66	533	Trademarks, patents, and franchises	-0.01	-0.02	-0.03
67	541	Professional, scientific, and technical services	-0.17	-0.21	-0.24
68	551	Corporate	-0.07	-0.07	-0.07
69	561	Business support services	-0.33	-0.35	-0.37
71	611	Educational services	0.00	-0.35	-0.70
76	711	Artistic, cultural, and sporting services	0.00	-0.02	-0.04
77	712	Museums, historical sites, zoos, and other related services	0.00	0.00	-0.01
78	713	Entertainment and recreational services	0.00	-0.03	-0.06
79	721	Temporary lodging services	-0.02	-0.13	-0.24
81	7224*	Nightclubs, bars, cantinas, and other similar services	0.00	-0.01	-0.01
82	811	Repair and maintenance services	-0.04	-0.06	-0.08
83	812*	Personal services except for funeral services	0.00	-0.09	-0.17
85	813	Associations and organizations	0.00	-0.03	-0.05
86	814	Households with domestic employees	0.00	0.00	0.00

Source: created by the authors

The hypothetical extraction exercises also provide insight into the effect of individual sectoral extraction on total value added. Table 3 presents the results for a 50% reduction in intermediate sales ($\alpha = 0.5$) of the non-essential activity sectors. These results indicate the percentage drop that the total national value added would experience due to the individual and single extraction of each non-essential

activity sector.

Column 1 presents the fall in total value added caused by a 50% reduction in the intermediate demand of the sector in question with the original final demand. Column 2 presents the fall in total value added when the intermediate and total demand of the sector are reduced by 50%, whereas column 3 presents the respective fall when the final demand is zero. These exercises are representative because they reveal the relative importance of each sub-sector of non-essential activity in national value added.

The results suggest two types of sectors: those strongly linked to the productive fabric (column 1) and those significant on the final demand side (columns 2 and 3). In the first group of sectors, mining (212); basic metal industry (331); real estate services (531); professional, scientific, and technical services (541); and business support services (561) stand out because their partial extraction causes the sharpest drops in national value added. These five sectors are key for the rest of the industries to maintain their value added generation. The most significant case is that of business support services (561) because if their intermediate sales were to fall 50% for 60 days due to the Covid-19 lockdown, national value added would fall by 0.33%. If those of the professional, scientific, and technical services sector (541) are reduced by the same magnitude, total value added would fall 0.17% or 0.10% in the case of real estate services (531) and so on.

In the second group, the sectors that stand out for their final demand in that the reduction in their final sales causes a relatively larger drop in total value added are, in order of importance, real estate services (531), construction (236), and transportation equipment (336); a 50% reduction in intermediate and final demand in these sectors individually causes a drop in total value added of 0.96%, 0.59%, and 0.57%, respectively (see column 2). Moreover, when the intermediate demand of these sectors contracts by 50%, and the final demand takes a value of zero, the total value added is reduced in all cases by almost double (see column 3), highlighting the relative importance of the individual final demand of these sectors.

These results are important because they help identify the non-essential activities with the greatest impact on national value added and the most significant transmission channels. It is essential to formulate some type of economic policy that encourages final demand or supports the real estate services (531), construction (236), and transportation equipment manufacturing (336) sectors to mitigate the negative effects of pandemic lockdown on national value added. Because these are employment-intensive sectors, they have an important impact on the national economy's performance. For their part, the mining (212); basic metal industry (331); real estate services (531); professional, scientific, and technical services (541); and business support services (561) sectors are indispensable for the functioning of the productive fabric in Mexico. Therefore, it is appropriate to formulate a protocol of sanitary measures that make it possible for these industries to work partially in the scenario of a future

call for the closure of activities.

No similar works were found for the Mexican economy in the literature review. The efforts of specialists to measure the potential impacts of Covid-19 in Mexico have focused on macroeconomic effects. Among them is the work of Mendoza et al. (2020), who, based on econometric simulations, evaluate the different impacts that the epidemic may present due to the various transmission channels, including foreign trade, shocks in oil prices, and the slowdown of the world economy.

Conclusions

Due to the Covid-19 pandemic in Mexico and the world, the lockdown forced many sectors to suspend their economic activities totally or partially. In Mexico, the federal government distinguished between essential and non-essential activities; the latter had to respect the lockdown imposed for approximately 60 days and included most manufacturing and personal services sectors.

This paper offers an evaluation of the possible economic impact of the suspension of non-essential activities for 60 days, using the partial hypothetical extraction method to simulate different scenarios of contraction of intermediate and total sales. The results indicate different ranges of declines in total gross production and value added, which, together with recent statistics on total manufacturing sales, help understand the magnitude of the economic impact. Assuming that non-essential activities see their total sales fall between 40% and 50% for only 60 days, the total gross output would fall between 3.94% and 4.84% compared to 2019, and value added would fall between 2.12% and 2.60%.

The results of the partial hypothetical extraction of each non-essential activity sector also provide valuable information on the sectors of relative importance for value added growth. A 50% drop in intermediate demand for business support services (561), professional, scientific, and technical services (541), and real estate services (531) was found to cause the largest reduction in total value added, ranging from 0.17% to 0.10%. Meanwhile, a 50% drop in intermediate demand accompanied by the same percentage reduction in final demand in real estate services (531), construction (236), and transportation equipment (336) sectors led to a contraction in value added of 0.96%, 0.59%, and 0.57%, respectively.

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Annex

The RAS method for updating input-output matrices

The RAS method is a bi-proportional adjustment procedure introduced by Stone (1961) and Stone and Brown (1962). Based on census or survey information, it is possible to update input-output matrices using only 3n data.

Let $a_{ij} \in A$ be the technical coefficients of the known input-output matrix and $q_{ij} \in Q$ the coefficients of the matrix to be found. The 3n required data are a) the column vector of intermediate demand of the target year $\left(dn_i^{obj}\right)$, b) the row vector of intermediate consumption of the target year $\left(cn_j^{obj}\right)$ and c) the column vector of the VBP of the target year $\left(x_i^{obj}\right)$.

The method consists of obtaining successive estimates of the diagonalized vectors (r and s) that account for the difference or distance between the target and observed values of dn and cn. It is necessary to begin from the observed and initial value of intermediate demand: $dn^1 = Ax$ and obtain the first estimate, r_1, of what matrix A should change so that $dn^1 = dn^{obj}$ and multiply it by A to obtain the new input-output structure Q^1 as follows:

$$r_1 = \widehat{dn}^{obj}(\widehat{dn}^1)^{-1}, \text{ entonces } Q^1 = r_1 A \tag{i}$$

Q^1 of Equation (i) is the first estimate of the new input-output structure. The row sums of $Q^1 x$ now equal the known values of dn^{obj} but the column sums will not equal the target values of intermediate consumption (cn_j^{obj}). Therefore, it is necessary to calculate $cn^1 = i' Q^1 \hat{x}$ where $i' = (1, \ldots, 1)$ is the sum vector. That is:

$$s_1 = \widehat{cn}^{obj}(\widehat{cn}^1)^{-1}, \text{ then } Q^2 = Q^1 s_1 \tag{ii}$$

where Q^2 is the matrix for which the column sums of $Q^2 x$ equal to cn_j^{obj}, but the row sums differ from dn_i^{obj}. The objective of the RAS is to obtain successive estimates of r_i and s_i, until the difference between dn_i^{obj} and cn_j^{obj} with their respective estimates is the smallest possible. This happens when the sum per column equals the sum per row. In general, the procedure converges to a stable estimate of Q after a few iterations.

For the update of the 2013 to 2019 matrix, the 2013 input-output matrix (INEGI, 2013) and INEGI (2020) data on intermediate consumption, value added, imports, and gross value of 2019 production in 2013 basic prices disaggregated at the branch level (261 industries) were used to aggregate into a total of 87 subsectors that help distinguish between essential and non-essential activities (information available in Annex 1). Based on the RAS method, the 2019 matrix was obtained as follows:

i. The amount of the sum of the intermediate and final demand was obtained using the accounting identities:

$$\text{Gross value of production} = \text{Intermediate consumption} + \text{Value added} + \text{Imports}$$
$$= \text{Intermediate demand} + \text{Final demand}$$

ii. From the 2013 matrix, the share of intermediate and final demand in total GVP was obtained. The shares were multiplied by the amount obtained in the previous subsection, and the intermediate and final demand for 2019 at constant 2013 prices was found (information available in Annex 1).

With the 2019 target vectors of intermediate demand and consumption (dn_i^{obj} and cn_j^{obj}), and with matrix A of 2013 technical coefficients, matrix Q of 2019 technical coefficients was estimated.

Table A1
Data on intermediate consumption (CI), imports (M), value added (VA), gross value of production (X), intermediate (DI) and final demand (DF) for 2019 at 2013 basic prices

NAICS	CI	M	VA	X	DI	DF	NAICS	CI	M	VA	X	DI	DF
111	82668	40159	373298	496125	257322	238803	483	6938	2697	12085	21720	3829	17891
112	177825	24870	183032	385727	273271	112456	484	180372	120013	619229	919613	250455	669159
113	4101	1294	20047	25442	22516	2926	485	210444	46813	377322	634579	31044	603535
114	9139	445	15160	24744	6472	18271	486	3013	301	5169	8483	8483	0
115*	1149	516	1646	3311	1163	2148	487	1130	268	998	2395	29	2366
1153*	354	167	625	1146	1146	0	488	41380	15791	81476	138647	58063	80584
211	67578	26244	598926	692747	331484	361263	491	491	81	3403	3975	3646	329
212	75859	18354	177410	271622	217201	54422	492	18274	2418	23390	44082	29239	14842
213	56325	14111	81232	151668	7141	144527	493	15415	9499	13271	38185	38143	41
221	146597	28300	227071	401969	312869	89100	511	11058	2123	17531	30711	14176	16536
222	34052	7268	58812	100132	57560	42572	512	21209	3899	32103	57211	18386	38825
236	463108	124506	864306	1451920	24415	1427505	515	34362	7870	23789	66022	26657	39365
2371, 2373*	99944	30598	140190	270731	12806	257925	517	83697	48691	499888	632276	260003	372273
2372, 2379*	53591	14053	56107	123751	3813	119938	518	2571	448	1798	4817	4671	146
238	54370	10997	162874	228241	196157	32084	519	729	74	903	1706	1207	499
311	988688	192854	690813	1872355	326094	1546261	521	2236	70	20539	22845	17789	5057
3121*	159367	49335	149016	357718	22031	335687	522	183390	7885	713195	904470	194825	709645
3122*	5276	2925	26147	34347	274	34074	523	11350	390	18578	30318	29862	456
313	38350	17227	25619	81195	50746	30449	524	158920	43461	148303	350684	72519	278165
314	12550	5707	13650	31907	8277	23630	531	138392	15691	1992200	2146283	257193	1889090
315	58688	33065	58916	150669	17001	133669	532	16092	5513	29116	50721	41602	9119
316	30785	11975	22036	64797	9901	54895	533	501	48	42762	43311	31617	11694
321	34021	6136	24724	64880	53374	11507	541	113838	15344	348490	477672	399407	78265
322	97539	56958	54312	208810	125270	83539	551	58436	17143	108525	184104	183793	311
323	32791	10818	18383	61992	38635	23357	561	88728	17025	688342	794095	746711	47383
324	263518	155804	39480	458801	274892	183909	562	4274	1505	7222	13001	7265	5735
3251, 32524, 3256*	247569	112169	171704	531441	245832	285610	611	84397	18264	688385	791047	6150	784897
3252, 3253, 3255, 3259*	99898	81208	57983	239089	122427	116661	621	69781	12852	183413	266047	3189	262857
326	118955	109724	82841	311519	149488	162032	622	110422	24096	203791	338309	850	337459
327	157218	28424	75129	260771	201187	59584	623	881	183	1740	2804	6	2799
331	318564	98057	175899	592521	328968	263553	624	13445	1127	9699	24270	2477	21794
332	163919	82516	96111	342546	155759	186786	711	7901	2335	38284	48520	8711	39809
333	100777	112081	117878	330736	23277	307459	712	2873	314	3804	6991	29	6962
334*	116853	842714	226894	1186460	22292	1164168	713	25371	4589	35308	65268	221	65047
3345*	8617	32507	17473	58598	1141	57457	721	74534	19042	215598	309175	56714	252460
335	128997	171715	88266	388978	38017	350961	7223, 7225*	98364	12972	185236	296572	45746	250825
336	944404	1052322	619053	2615779	294782	2320997	7224*	3670	704	9435	13810	365	13445
337	44060	12023	30693	86776	7475	79301	811	58485	21499	82121	162106	106201	55905
3391*	22427	99995	30675	153097	18804	134293	812*	36245	7215	151701	195161	11158	184003
3399*	33403	55025	36795	125224	20602	104622	8123*	2931	301	2569	5801	8	5794
431	331867	58961	1565500	1956327	1170596	785731	813	16854	2209	46344	65407	10125	55282
461	343976	50752	1667084	2061811	247164	1814648	814	0	0	0	0	0	0
481	135513	18626	43234	197373	32742	164631	931	328050	40597	711225	1079871	1705	1078166
482	19988	3076	22397	45460	10030	35431							

Source: national accounts base 2013. Economic Information Bank, INEGI (2020)