MACROECONOMIC POLICY RESPONSES TO COVID-19

DISRUPTIONS IN GLOBAL SUPPLY CHAINS AND THEIR EFFECTS IN MEXICO'S REGIONAL GROSS OUTPUT IN THE CONTEXT OF THE COVID-19 PANDEMIC

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Disruptions in Global Supply Chains and their Effects in Mexico's Regional Gross Output in the Context of the COVID-19 Pandemic*

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Abstract

The paper analyzes how the initial disruption in the supply of imported inputs associated due to the COVID-19 pandemic may have induced heterogeneous responses in regional and sectoral output in Mexico. For this objective, we estimate, using Input-Output techniques, the effects on Mexican gross output associated to the supply-side shock that ensued from the lack of imported inputs from China, the European Union, and the United States at the onset of the pandemic. Our estimates suggest that the contraction in imports of intermediate inputs reduced national gross output by 1.11% in 2020, most of it accounted for the contraction in imported inputs from the U.S., followed by those from the European Union, and China. The Northern region experienced the strongest effect, while simultaneously contributing the most to the impact on national gross output. At the sectoral level, the manufacturing sector was the most affected by the shock.

JEL Codes: R11, R12, R15.

Keywords: Input-Output Matrix, Ghosh Supply Model, Mexico, COVID-19.

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1 Introduction

The first case of COVID-19 in Mexico was registered on February 27 of 2020, more than two months after it was first identified in China (November 17, 2019), and about a month after the first case was detected in the United States (January 21, 2020). As the virus spread around the world, there was an increasing number of countries implementing, at different times, temporary closures of economic activity, which in turned caused disruptions in global supply chains (Yu et al. (2021); Verschuur et al. (2021); Kejzar & Velic (2020); Ferreira et al. (2021); CEPAL (2020)). These disruptions could have affected, in turn, imports of intermediate goods in Mexico even before restrictions on non-essential activities in the country were erected on April 1st, 2020.[1,2,3]

Recognizing this possibility, this work analyzes how the initial disruption in the supply of imported inputs may have induced heterogeneous responses in regional and sectoral production in Mexico. The potential of the sanitary shock to induce such heterogeneous responses in output is suggested by the different ratios of manufacturing GDP to national manufacturing GDP, or the ratio of regional to national automotive GDP, at the regional level (Table 1). In particular, it is likely that given the lower shares of regional manufacturing and automobile GDP in the Southern region, the sanitary shock may have translated into a relatively weaker output response than those experienced in the Northern and Central regions.

The possibility that the COVID-19 pandemic, by disrupting the provision of intermediate goods imports in Mexico, had heterogeneous regional and sectoral effects, is also suggested in Figure 1. This graph shows that the value of accumulated national imports of intermediate goods from China during February-March 2020 contracted by 12.4% relative to the value of imports registered in the same period of 2019; while the value of imports from the United States and the European Union in April, 2020 decreased 43.1% and 19.3% against their reported April 2019 values, respectively. The contractions in national imports of Motor vehicle parts were even greater, arguing further for a possible effect of global supply disruptions in Mexican regional production. In this regard, Figure 2 shows, for the periods indicated above, that intermediate imports from China fell 58%, while those from the United States contracted 88%, and those from the European Union by 44%.

[1]The Federal Government published a list of "essential activities" in the Diario Oficial de la Federación, March 21, 2020. All other economic activities not considered in that list were deemed as "non-essential" and forced to close from April 1st up to April 30th.

[2]Banco de México (2020), p.26, shows that between March and June 2020, up to 52% of manufacturing firms, and up to 60% of non-manufacturing firms registered partial or total shutdowns.

[3]CEPAL (2020).

Table 1: Regional Manufacturing Production, 2019
(Percentage)

Region	Share of regional Manufacturing GDP in Total GDP of the region	Share of regional Manufacturing GDP in National Manufacturing GDP	Share of Regional Automotive Industry GDP in the National Automotive Industry GDP[1]
Northern	26.2	37.6	39.2
Central North	16.9	19.3	18.9
Central	14.4	34.3	41.8
Southern*	8.5	8.8	0.08*/
National	**16.7**	**100**	**100**

Notes: [1]The estimated data for the automotive industry is based on INEGI's 2018 Economic Census. The other estimates use the 2019 National Accounts data.
(*) The Southern region has some Motor Vehicle Parts Manufacturing.
Source: INEGI.

Figure 1: Total Intermediate Goods Imports by Country of Origin
(Annual percentage change)

Source: Banco de México.

Figure 2: Motor Vehicle Parts Imports of Mexico by Country of Origin
(Annual percentage change)

Source: Banco de México.

Considering the information above, in this paper we estimate, using Input-Output techniques, the effects on Mexican gross output associated to the supply-side shock that ensued from the lack of imported inputs from China, the United States and the European Union at the onset of the COVID-19 pandemic. The supply-side shock considers, in particular, the change in the value of intermediate goods imported from China during February and March 2020, against the value of intermediate goods imported from that country during February and March 2019; plus the contractions in the value of intermediate goods imports from the European Union and the United States in April 2020, against their respective values registered in April 2019. A key element of our work will be to derive shocks in imports of intermediate goods at the regional level since these imports are not available for the case of Mexico.

Our estimates suggest that the contraction in imports of intermediate inputs reduced national gross output by 1.11% in 2020 relative to a scenario where imports would have remained constant, most of it accounted for the contraction in imported inputs from the U.S., followed by those from the European Union, and China. The Northern region, in turn, experienced the strongest effect, while simultaneously contributing the most to the national impact in gross output. Finally, it is obtained that, at the sectoral level, the manufacturing sector was the most affected by the shock.

The paper is organized as follows. Section 2 reviews the Ghosh Model and the multiplier effects associated to the exogenous shocks in regional imports of intermediate goods; Section 3 presents the methodology employed to measure the exogenous shocks in regional imports of intermediate goods, while Section 4 presents the results. Final comments are

presented in Section 5.

2 Methodology

The theoretical framework used to derive the effects on output at the sectoral and regional level resulting from changes in the availability of imported inputs is a traditional Ghosh Supply Model. This model starts by assuming that sectoral gross output of a region R is equal to regional consumption of intermediate goods plus the sum of regional value-added, taxes, purchases of intermediate goods from other regions of the country, and imports of intermediate goods.[4] This relationship, for an economy with "n" goods, can be expressed in matrix notation as follows:

$$x^R = x^R B^R + v^R \tag{1}$$

where:
x^R: Vector (1xn) of gross output by sector of region R, where "n" refers to the number of sectors.
v^R: Vector (1xn) of the sum of regional value-added, taxes, purchases of intermediate goods from other regions of the country, and imports of intermediate goods by sector of region R.
B^R: Matrix (nxn) of distribution coefficients of region R given by

$$\delta_{ij}^R = \frac{z_{ij}^R}{x_i^R} \tag{2}$$

where these coefficients indicate the proportion of sales of sector i to sector j, (z_{ij}^R), and total sales of sector i in region R, (x_i^R). Both coefficients are assumed to be constant. Solving for x^R in Equation (1), we obtain:

$$x^R = v^R(1 - B^R)^{-1} \tag{3}$$

where the matrix $(I - B^R)^{-1}$ is the Inverse Supply Matrix (nxn), or Ghosh Inverse Matrix, whose elements δ_{ij}^R indicate the change in the value of gross output of sector j of region R, which is registered in the event of a change of one unit in the value of any of the variables of sector i contained in v^R. Since the main interest of this paper is to analyze changes in sectoral and regional gross output as a result of a reduction in imports of intermediate goods by sector, the shock is captured in the vector v_i^R. The elements δ_{ij}^R of the Inverse

[4]This representation of the Ghosh Supply Model corresponds to Chraki (2017). This model assumes that the Leontief coefficients may vary arbitrarily; value added is fixed; and every change in final demand leads to changes in gross output, which in turn modifies the allocation matrix. Finally, it is being assumed that the Mexican economy still retains the 2013 regional economic structure, as captured in the Regional Input-Output Matrices estimated by Banco de México. See also Torre Cepeda et al. (2020).

Supply Matrix represent the input multipliers, which capture the change in gross output of sector j as a result of a unit change in the supply of intermediate goods imported from sector i.[5]

For the calculations of this paper, three main data sources are employed: (i) the 2013 National Input-Output Matrix of Imports from INEGI; (ii) Banco de México's monthly database of intermediate goods imports by product and country of origin, and (iii) the 2013 Input-Output Regional Matrices estimated by Banco de México.[6]

3 Identification and Allocation of Supply Shocks in Intermediate Goods Imports and Estimation of their Impact on Regional Gross Output

In this paper, the supply shock in the Mexican regions will be defined as the contraction in imports of intermediate goods observed during the first months of the COVID-19 pandemic, considering that these imports could have responded to the disruption in supply chains even before imports were also affected negatively due to demand shocks.[7] Thus, the supply shock is calculated as the sum of: (i) the change in the level of imports of intermediate goods from China in February and March 2020 against that level of the same period of 2019; (ii) the change in the value of imports of intermediate goods from the United States in April 2020 compared to the value of such imports in same month of 2019; and (iii) the change in imports of intermediate goods from the European Union during April 2020 against to those imports during the same month of 2019.[8]

In our estimates, we assume that the reduced availability of intermediate goods imports from China is likely to be capturing a supply-side shock as producers in Mexico were already experiencing shortages of Chinese imports of inputs during February-March 2020, this is, even before Mexican sanitary authorities ordered closures of economic activities. Those from the European Union and the United States, on the other hand, are more likely to be capturing both supply and demand shocks, particularly during April. In that month, the supply shock component may be catching the effect of closures of economic activities in a variety of countries which may have reduced the availability of intermediate goods in Mexico. The demand side component, on the other hand, may be connected to the fact that imports of intermediate goods decreased, as there were not

[5]These effects would be present to the extent that there are no inputs of national origin that can substitute, in the very short term, to the imported inputs.

[6]Chiquiar et al. (2017) presents the methodology employed to obtain the regional matrices for Mexico.

[7]Demand shocks would have resulted, for instance, from lower consumption by national and international households as their income fell due to the sanitary crisis.

[8]It should be noted that in 2019, Mexican imports of intermediate goods from the United States, China, and the European Union accounted for 73.5% of Mexican total imports of these goods.

only closures of some nonessential economic activities (supply shock) in Mexico, but also because Mexican consumers may have attempted to reduce their exposure to the virus, or increase their savings in order to prepare for more difficult times. While we recognize the possibility that in April 2020, the reductions in imports of intermediate goods could have derived from a combination of supply and demand shocks, we will treat them as if they had been only the result of supply side shocks, and leave for further work the possibility of disentangling more meticulously such reductions in their potential demand and supply components. The supply shocks defined in this way will be the ones to be distributed at the regional and sectoral level.

Given the lack of information on imports of intermediate goods by country of origin at the state level, and impossibility to identify, for the same level of disaggregation, the imports of intermediate goods that each sector acquires from other sectors, it was necessary to assume that:

1. The structure of imports of intermediate goods *by sector* and country of origin at the regional level is the same as at the national level.[9]
2. The proportion of imported inputs purchased by sector j from sector i at the regional level is the same at the national level.
3. The percentage changes in regional intermediate imports are equal to the percentage changes in imports of intermediate goods at the national level *for each sector*.[10]

The second assumption is quite relevant since the available data on imports of intermediate goods, which is the basis for assumptions (1) and (3), only records the type of inputs entering Mexico from other countries, but it does not identify the sector to which the imported input is allocated.[11] Therefore, using the national input-output matrix of imports, it is possible to obtain the proportion that each sector acquires directly of intermediate goods from international sources, as well as the proportion that it purchases of these inputs to other sectors. In this way, the magnitude of the shock that each sector within each region will receive, can be more precisely assigned according to how intensive it is in the use of imported inputs for its production. For instance, assume that the textile inputs that the apparel manufacturing sector imports from the United States, China, and the European Union registered hypothetical contractions of 10%, 5%, and 3%, respectively, in the periods analyzed. However, this sector not only imports textile inputs for its production, but also other intermediate goods. Thus, the 10%, 5%, and 3% reductions will only alter the proportion that textile inputs from each country represents

[9]The structure of imports used was that of 2019. That year Mexico obtained 46.4% of its total imports of intermediate goods from the United States, 17.3% from China, and 9.7% from the European Union.

[10]The National Input-Output Matrix of imported intermediate goods from INEGI was used to obtain the proportion of imported inputs purchased by sector j that are provided by sector i.

[11]It is very likely that the structure of imports of intermediate inputs across regions differ as a result, for instance, of trade orientation or technological issues. Hence, assumptions 1 through 3 represent a limitation, and therefore our results should be taken with caution.

in total imported inputs required by the apparel manufacturing sector. In other words, the estimated supply shock will not only be a function of the magnitude of the usage of the imported input, but also of the proportion that imports from the United States, China, and the European Union represent in the total of intermediate goods imports of each sector.

In order to distribute the estimated shock among the different sectors and regions, and subsequently calculate its effects on sectoral gross output, we first proceed to estimate the proportion that the imported inputs of sector i represent of the total purchases of imported intermediate goods performed by sector j based on the national input-product import matrix (assumption 2):

$$\gamma_{ij}^{N} = \frac{m_{ij}^{N}}{M_{ij}^{N}} = \gamma_{ij}^{R} \tag{4}$$

where:

γ_{ij}^{N}: nxn matrix whose elements capture the proportion of imported inputs that sector j acquires from sector i at the national level.
$\frac{m_{ij}^{N}}{M_{j}^{N}}$: Inputs of imported origin from sector i going to sector j at the national level, divided by the total purchases that sector j makes of imported intermediate goods.
γ_{ij}^{R}: nxn matrix whose elements capture the proportion of imported inputs that sector j acquires from sector i at the regional level.

In this way, using γ_{ij}^{R} we approximate, in monetary terms, a nxn matrix that contains the value of imported inputs that sector j acquires from sector i in region R (θ_{ij}^{R}) :

$$\theta_{ij}^{R} = \gamma_{ij}^{R} * \beta_{j}^{R} \tag{5}$$

where:

β_{j}^{R}: is a 1xn vector that contains the total value of purchases made by sector j of imported inputs. These values are taken directly from the 2013 Regional Input-Output Matrices estimated by Banco de México.

Once a matrix containing the inter-sectoral transactions of intermediate goods imported in the region R (θ_{ij}^{R}) has been obtained, it is important to approximate the value of inputs imported from each of the countries analyzed, as the magnitude of the shock that arises from each country is different at the sectoral level. In this way, using (θ_{ij}^{R}), three sub-matrices of order nxn are obtained, each containing, respectively, the intermediate demand for imported inputs from the United States, China, and the European

Union ($\rho_{ij}^{R,C}$):

$$\rho_{ij}^{R,C} = \theta_{ij}^{R} * \alpha_{i}^{R,C} \tag{6}$$

where:

$\alpha_{i}^{R,C}$: Vector of nx1 that indicates the percentage share that each country C has in total imports of intermediate goods at the national level by sector. That is: $\alpha_{i}^{N,C} = \frac{k_{i}^{C}}{K_{i}^{N}}$ where k_{i}^{C} are the imports of sector i that come from country C and K_{i}^{N} are the total imports of intermediate goods made by the same sector i. Likewise, it is important to remember that in this work we assume that the structure of intermediate goods imports by sector and country of origin at the regional level is the same as at the national level, that is: $\alpha_{i}^{R,C} = \alpha_{i}^{N,C}$.

Obtaining the sub-matrices of imports of intermediate goods from the United States, China, and the European Union for each region, a nxn matrix is calculated for each of them that contains the change in the value of imports of intermediate goods ($\Delta v_{ij}^{R,C}$), that is the estimated supply shock in monetary terms:

$$\Delta v_{ij}^{R,C} = \rho_{ij}^{R,C} * \Delta\%k_{i}^{R,C} \tag{7}$$

where:

$\Delta\%k_{i}^{R,C}$ represents the percentage change in imports of intermediate goods from United States, the European Union, and China. As mentioned above, for the first two economies, the difference between the value of imports in April 2020 and the April 2019 value is considered; while for China, the difference between the accumulated value of imports in January and February 2020, and the accumulated value of imports in January and February 2019 is considered. Also, according to assumption (3) described above, the percentage changes in regional input imports are equal to the respective percentage change in imports of intermediate goods at the national level, that is, $\Delta\%k_{i}^{R,C} = \Delta\%k_{i}^{N,C}$.[12]

[12]The data on the value of intermediate goods imports by country of origin was originally obtained with the 6-digit classification of the Tariff of the General Import and Export Tax Law (TIGIE, by its acronym in Spanish). However, given that the 2013 Regional Input-Output Matrices estimated by Banco de México use the classification of the North American Industry Classification System (NAICS), a reclassification was necessary. For this, the information with a 6-digit TIGIE classification was converted to the NAICS classification using the 6-digit TIGIE to NAICS 2019 Correlation Table. Then, 3-digit groupings were integrated since this is the breakdown of the 2013 Regional Input-Output Matrices; only the automotive industry and the auto-part industry were kept at the 6 and 4-digit levels, respectively, for analytical purposes. Likewise, given that the data of the Regional Input-Product Matrices is at 2013 prices, the values in current dollars of monthly 2019 and 2020 imports of intermediate goods were converted to constant 2013 pesos. This transformation required, first, to express the values in current USD to current pesos by multiplying the former by the monthly average of the FIX exchange rate reported by Banco de México. These figures were finally transformed to constant 2013 pesos using the

Once the shock in intermediate goods imports in monetary terms has been identified, the Inverse Ghosh Matrix is applied. The δ_{ij}^{R} elements of this matrix, referred as the input multipliers, will be the ones used to calculate the effects on gross output across regions and sectors of the shocks in intermediate goods imports.

The assumptions made and the usage of the Regional Input-Output Matrices would suggest, for instance, that a contraction in imports of auto parts components, could have an important effect in regions in which the automotive activity is concentrated (such as the Northern, North-Central, and Central regions in Mexico); while the impact would be slight in regions where such activity does not have a relevant weight in their total output (as it would be the case of the Southern region). Further, since the productive structure of each region is different, the input multipliers may differ across sectors and regions and, therefore, they will indicate the degree of differentiated impact on regional and sectoral gross production associated with the disruption in the supply chains.

The above allows to obtain, by region, three square matrices of order nxn containing the sub-effects on gross output of sector j associated with a change in intermediate goods imports from sector i originating from country C:

$$\Delta x_{ij}^{R,C} = \Delta\ v_{ij}^{R,C} * \delta_{ij}^{R} \tag{8}$$

Hence, the total change in gross output of sector j as a result of the initial supply shock in intermediate goods imports from all sectors of region R that come from the United States, the European Union and China, is given by the sum per column of the effects on sector j:

$$O_{j}^{R} = \sum_{C=1}^{3} \sum_{i=1}^{n} \Delta x_{ij}^{R,C} \tag{9}$$

Thus, O_{j}^{R} captures the overall effect on the gross production of sector j as a result of the initial disruption in the supply chain of all sectors from which sector j buys intermediate inputs for its production.

4 Results

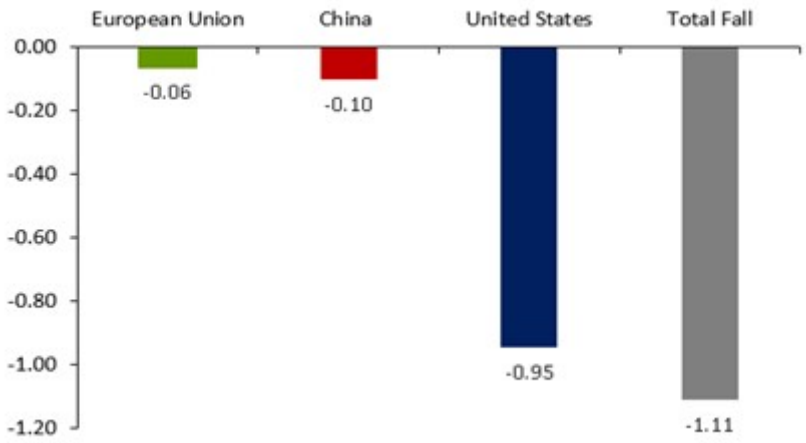
Table 2 presents the percentage declines observed in imports of intermediate goods, which are the basis for calculating the initial shock associated with the disruption of supply chains (Equation (7)), and the effect that this initial shock has on gross output

implicit price deflators of INEGI for each activity, which were the ones used in the different estimates of this work.

by sector and region (Equation (9)).[13]

The results indicate that supply chains disruptions at the onset of the pandemic could have reduced national gross output by 1.11% relative to a scenario where imports would have remained constant. As a reference, in the second quarter of 2020, national gross output dropped 19.9% relative to the previous quarter using seasonally adjusted data, therefore the estimated effect of the disruptions in the supply chain looks significant. Of the 1.11% contraction in national gross production, 0.10 percentage points correspond to the impact of China during the February-March 2020 period, when the closure of non-essential activities in Mexico had not yet been decreed. In turn, the subsequent shocks from the United States and the European Union, both from April 2020, would have contributed 0.95 and 0.06 percentage points, respectively (Figure 3).

Figure 3: Contributions of Supply Chains Disruptions from the European Union, China, and the United States to Mexico's Gross Output Contraction at the Onset of the Pandemic
(Percentage points)



Source: Own estimates using Banco de México's data.

At the regional level, the North was the one that could have registered the greatest impact, with a reduction of 2.02% in its gross output due to the reduction in inputs. This is explained in terms of its greater dependence on imported inputs in that region, as well as by the greater multiplier effects that this region has in the sectors that experienced a greater fall in the import of intermediate goods, for instance, in the auto parts manufacturing subsector.[14] This region was followed by the estimated effects of the central

[13] In this section, the percentages presented take as a basis of comparison gross output values corresponding to the Regional Input-Output Matrices, except for those presented in Table 1, which refer to the percentage variation observed in the value of imports of intermediate goods between 2019 and 2020, with figures in dollars.

[14] According to the 2013 Regional Input-Product Matrices, the North is the one with the highest share of total imports of intermediate goods with 40.6%, followed by the Central region with 32.9%, the North-Central with 15.6%, and the South with 10.9%.

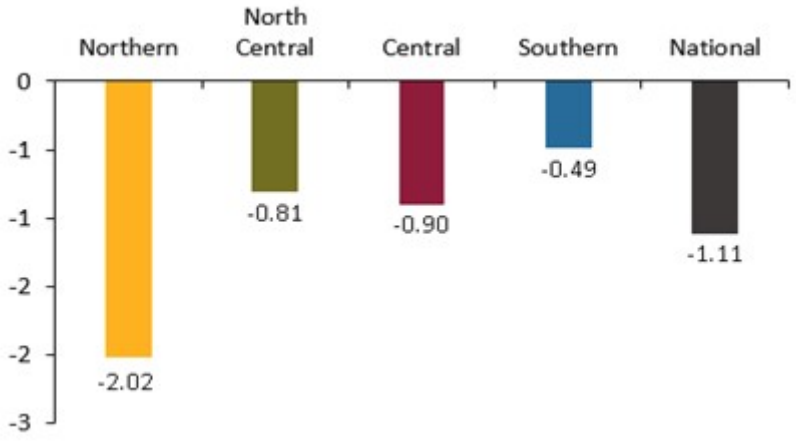
Table 2: Intermediate Goods Imports by Sector and Country of Origin
(Annual percentage change)[1]

Sector	April 2020 vs. April 2019		Feb-Mar 2020 vs. Feb-Mar 2019
	United States	European Union	China
Mining (except Oil and Gas)	-	-	-27.9
Electric Power Generation, Transmission and Distribution	-53.2	-	-
Textile Mills and Textile Product Mills	-46.2	-26.3	-30.7
Apparel and Leather and Allied Product Manufacturing	-73.8	-41.7	-
Wood Produc Manufacturing	-33.6	-26.6	-28.0
Paper Manufacturing / Printing and Related Support Activities	-18.7	-2.0	-5.0
Petroleum and Coal Products, Chemicals, and Plastic and Rubber Products Manufacturing	-39.8	-7.9	-19.0
Nonmetallic Mineral Product Manufacturing	-43.9	-16.5	-18.4
Primary Metal and Metal Product Manufacturing	-39.7	-22.2	-14.9
Machinery, Electronic, Electric Products, and Transportation Equipment Manufacturing (except Motor Vehicle Parts)	-56.6	-26.8	-8.9
Motor Vehicle Parts Manufacturing	-87.8	-48.4	-58.4
Furniture and Related Product Manufacturing	-55.5	-28.8	-26.0
Miscellaneous Manufacturing	-27.5	-15.8	-42.1

Notes: [1] The percentage changes presented in this table correspond to the value of imports of intermediate goods measured in current dollars. However, for analysis purposes, the percentage variations used to estimate the supply shock are calculated based on the value of these imports in constant 2013 pesos. The spaces without values indicate that the sector did not have any impact or had an increase in the import of intermediate goods in the period analyzed. To classify by SCIAN sector, the TIGIE-SCIAN 2019 Correlation Table from INEGI was used.
Source: Prepared by Banco de México with data from SAT, SE, Banco de México, INEGI. Commercial Balance of Goods of Mexico. SNIEG. Information of National Interest.

and north-central, each with a contraction of 0.90 and 0.81%, respectively, in its gross output; while the southern region could have been the least affected, with a reduction of 0.49% in the same indicator (Figure 4). These differences in the estimated effects show the value of the Regional Input-Output Matrices 2013, as they reveal that the heterogeneity in productive structures and inter-sectoral technical relationships in each region capture differentiated effects in gross output. These effects are not captured in a national input-output matrix.

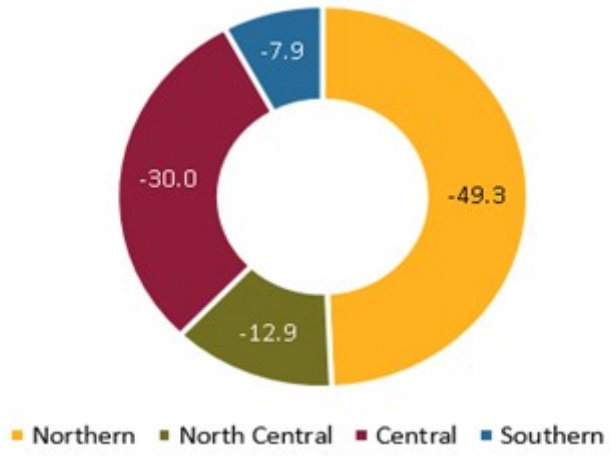
Figure 4: Estimated Contraction in Regional's Gross Output due to the Contraction in the Intermediate Goods Imports at the Onset of the Pandemic
(Percentage)



Source: Own estimates using Banco de México's data.

Of the contraction in national gross output that could be attributed to the initial supply shock caused by the pandemic of COVID-19 in the face of the decrease in imports of intermediate goods, the Northern region registered the highest contribution, with 49.3%; followed by the Central, North-Central, and Southern regions, with contributions estimated at 30.0%, 12.9% and 7.9%, respectively (Figure 5).

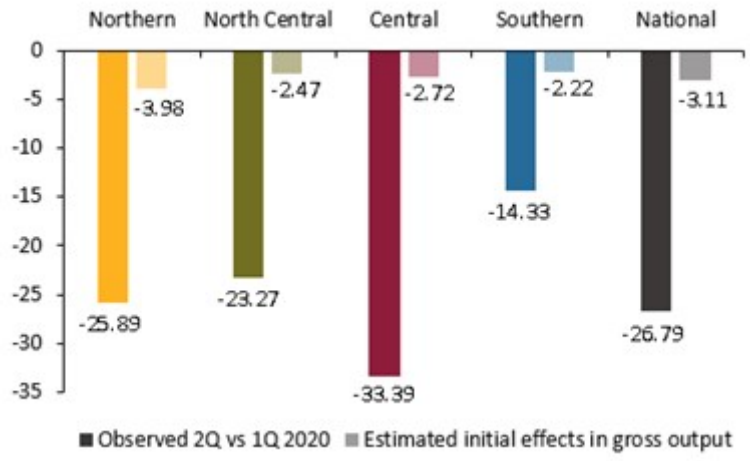
Figure 5: Regional Contribution to the Estimated Decrease in Domestic Gross Production Due to the Contraction in Intermediate Goods Imports at the Onset of the Pandemic
(Percentage)



Source: Own estimates using Banco de México's data.

On the other hand, when analyzing the national contraction of gross production at the sectoral level, manufacturing activity was the most affected by the initial supply shock in imports of intermediate goods, as expected. However, there are also effects in the secondary sector excluding manufacturing, and in the services sector, although to a much lesser degree. Thus, the decrease in manufacturing production associated with the shock being analyzed here was the one that contributed the most to the reduction in national gross output, explaining 1.10 of the 1.11 percentage points of the latter (Table 3a). Within the regions, the manufacturing sector had the greatest relative decrease in the North, where a contraction in its gross output of 3.98% is estimated due to the simulated shock. This result can be attributed to the greater integration of this region into global supply chains, as well as to the larger share of the affected sectors in their total gross manufacturing output. In contrast, the lowest relative fall of all regions is estimated for the South, with a variation of -2.22% (Table 3b). As a reference, the observed contractions in manufacturing output in the second quarter of 2020 compared to the previous quarter were 25.9% in the North, 23.3% in the North-Central, 33.4% in the Central, and 14.3% in the Southern region (Figure 6).[15] Thus, the disruptions in imports of intermediate goods in the North have been a more relevant factor in explaining the reduction in manufacturing production than in the other regions.

Figure 6: Observed Contraction in Manufacturing Production and Estimated Contraction in Manufacturing Gross Output due to the Decrease in Intermediate Goods Imports at the Onset of the Pandemic
(Percentage)



Source: Estimated by Banco de México. The observed decrease reported is based on the INEGI's Monthly Indicator of Manufacturing Activity by state, seasonally adjusted.

[15]Banco de México estimates based on INEGI's Monthly Indicator of Manufacturing Activity by state, seasonally adjusted.

Table 3: Estimated Effects on Gross Output due to the Contraction in Imports of Intermediate Goods at the Onset of the Pandemic

(a) Sectoral Contribution to the Estimated Reduction in Regional Gross Output (Percentage points)[1]

Sector	**Northern**	**North Central**	**Central**	**Southern**	**National**
Secondary, excluding manufacturing	-0.01	-0.01	-0.01	-0.01	-0.01
Manufacturing	-2.01	-0.79	-0.88	-0.47	-1.10
Services	-0.01	-0.01	-0.01	-0.01	-0.01
Estimated Contraction in Gross Output (%)[2]	**-2.02**	**-0.81**	**-0.90**	**-0.49**	**-1.11**

(b) Estimated Relative Contraction in Sector Gross Output by Region (Percent)

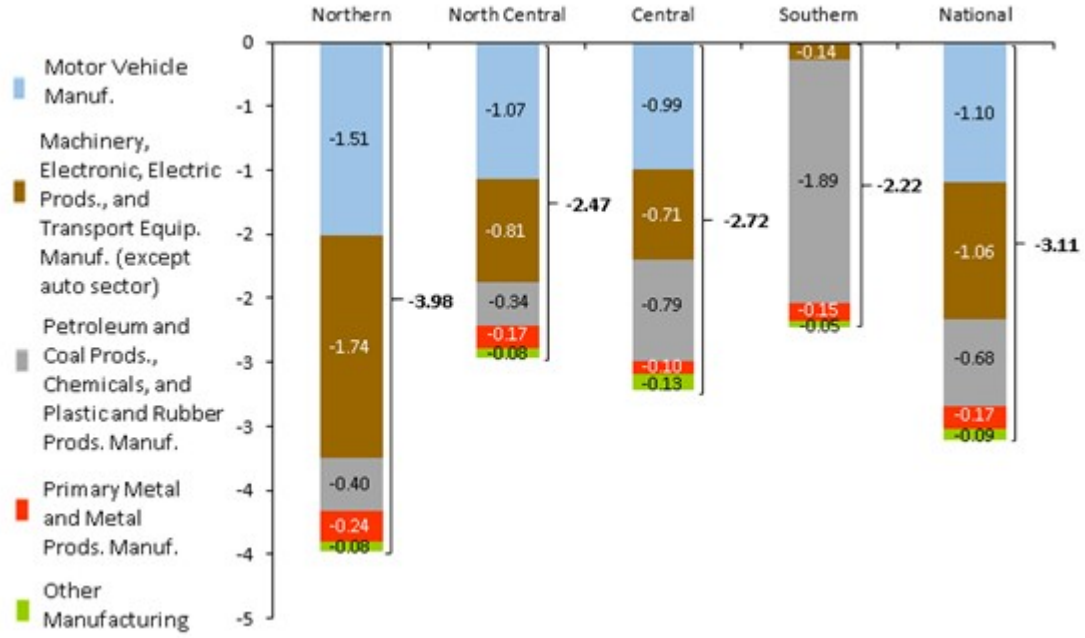
Sector	**Northern**	**North Central**	**Central**	**Southern**	**National**
Secondary, excluding manufacturing	-0.06	-0.06	-0.08	-0.03	**-0.05**
Manufacturing	-3.98	-2.47	-2.72	-2.22	**-3.11**
Services	-0.02	-0.01	-0.02	-0.01	**-0.02**

Notes: [1]Figures may not add up to the total due to rounding.
[2]Due to the contraction in imported inputs.
Source: Own estimates using Banco de México's data.

Within the manufacturing sector, the contributions to the contraction in national manufacturing gross output stand out due to the simulated initial supply shock in (i) the auto vehicle manufacturing, and (ii) in the group made up of the machinery and equipment manufacturing, electrical industry, industrial electronics, and manufacturing of transportation equipment except for cars and trucks (Figure 7). In total, these activities account for 2.16 percentage points of the 3.11% contraction in manufacturing gross output at the national level resulting from the simulated initial supply shock. Figure 7 also shows the implications of the heterogeneity of the initial shock and of the different productive structures in regional gross output. It is observed, for example, that the North was mostly affected in the group of sectors made up of machinery and equipment, electrical industry, electronics, and transport equipment (excluding automotive industry), followed by the effect in the automotive industry; while the North-Central and Central regions were mostly affected in the automotive sector. In the South, the manufacturing of petroleum products, the chemical industry, and the plastics and rubber industry, were the ones with the largest reductions within regional gross manufacturing production. These results are relevant since, even though the automotive and non automotive sectors did not stop their

operations as they were designated essential economic activities, the shortage of imported inputs would seem to have had a significant negative impact on their productive activity.

Figure 7: Sectoral Contribution to the Estimated Contraction in Gross Manufacturing Production due to the Initial Shock Associated with the Contraction in Imports of Intermediate Goods at the Onset of the Pandemic
(Percentage)



Source: Own estimates using Banco de México's data.

5 Concluding Remarks

In this paper we identify heterogeneous regional effects of shocks in imports of intermediate goods on gross output due to the disruptions in global supply chains at the onset of the sanitary crisis. It is shown that the Northern region was the most affected, with the Southern being the least. The manufacturing sector is estimated to have suffered, in turn, the largest effect, particularly, the Motor vehicle manufacturing. In the South, the largest relative effect was estimated in the Oil and carbon derivatives, chemistry, and plastic and rubber. These results also suggest that current global supply chains disruptions, such as international logistic problems and microchips shortages, in the context of the COVID-19 pandemic, may be inducing heterogeneous responses in regional economic activity.

It should be stressed, however, that when defining the shocks to capture disruptions in the supply chains, we assumed that they emerged from supply effects, and not from demand side effects. More precisely, the shocks from the European Union and the United States are more likely to be capturing not only supply, but also demand shocks, as they

are estimated using information for April 2020, when demand effects could already be playing a role. Hence, the effects obtained here should be viewed as an estimate of a shock on economic activity that may have emerged from a strong contraction in imports of intermediate goods, beyond those that may have played a preponderant role on output. As a result, there is an opportunity for future research to refine the contributions of demand and supply factors to gross regional and sectoral gross output at the outset of the COVID-19 pandemic.

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