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Productive public investment in agriculture for economic recovery with rural well-being: an analysis of prospective scenarios for Mexico

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Productive public investment in agriculture for economic recovery with rural well-being: an analysis of prospective scenarios for Mexico

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Preface

The advancing COVID-19 pandemic and uncertainty about its duration and specific impacts on health and the economy, have generated an unprecedented global crisis, encumbering employment, the fight against poverty and efforts to reduce inequality.

While the crisis has not disrupted supply chains for agricultural production in Mexico, and food supply is assured, there is concern about a possible overall reduction in income, a fallback in economic activity and, consequently, an increase in the number of poor and food-deprived populations. Some disruption to value chains may be unavoidable, particularly with regard to certain inputs for agricultural production, and international trade has been set back temporarily by pandemic impacts on countries. In Mexico, the impact may be greater as the crisis has reduced migrant remittances and oil prices have fallen. Additionally, agricultural labour has decreased, due to impacts on workers' health and mobility restrictions; the supply of production inputs has declined; problems have arisen with the operation of distribution centres; final consumers have difficulties in purchasing products, largely because of loss of income due to unemployment; and there is the potential for instability in food prices.

The Secretariat for Agriculture and Rural Development of Mexico (SADER) is undergoing transformation. The development of the agrifood policy under the 2019–2024 Sectoral Programme on Agriculture and Rural Development must now consider the effects of the pandemic and recovery strategies for the post-COVID-19 era.

The Food and Agriculture Organization of the United Nations (FAO) is committed to supporting the Government of Mexico in addressing the potential effects and consequent impacts on the agrifood system during the pandemic and during the post-pandemic recovery. More specifically, FAO Mexico, together with the FAO Agrifood Economics Division in Rome, the Inter-American Institute for Cooperation on Agriculture (IICA) and the International Fund for Agricultural Development (IFAD), among other partners, has proposed three strategic outputs that will contribute to strengthening the Mexican Government's policies and strategies. These are comprised of up-to-date information and assessments that will ensure the success of the measures implemented to maintain food production and supply and will contribute to ensuring food security during the contingency and in the post-COVID-19 recovery period.

This study is carried out within the framework of this interagency support and responds to SADER's specific request for prospective scenarios. The study highlights how, through a series of prospective scenarios, public investments promoting agricultural productivity could drive growth in agrifood production, with favourable impacts on the economy as a whole, on well-being and on poverty, primarily rural poverty. Using a modelling tool representing the functioning of the Mexican economy, with its multiple sectors and current fiscal constraints, the study ranks the subsectors of Mexican agriculture which, through their impact on productivity, would generate the greatest socioeconomic benefits, maximizing the cost-effectiveness of public investment. This evidence may be vital for SADER's decision-making regarding agricultural investment in the post-COVID-19 era.

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The counsel of Patricia Concepción Aguilar Méndez and Santiago José Argüello Campos, both of SADER, enabled the authors to design prospective scenarios closer to Mexico's current context and policy, mainly with regard to the amounts of agricultural investment over time and alternative sources of financing.

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Acronyms

ABM	Association of Mexican Banks
CES	constant elasticity of substitution
CGE	computable general equilibrium
CGPE	General Economic Policy Criteria
CIMMYT	International Maize and Wheat Improvement Center
CONEVAL	National Council for the Evaluation of Social Development Policy
ECLAC	Economic Commission for Latin America and the Caribbean
ENIGH	National Survey of Household Income and Expenditure
ENOE	National Survey of Occupation and Employment
ETOE	Telephone Survey of Occupation and Employment
FANAR	Support Fund for Non-regularized Agricultural Nuclei
FIRA	Trusts Funds for Rural Development
FND	National Finance Institute for Agricultural, Rural, Forestry and Fisheries Development
GDP	gross domestic product
IFAD	International Fund for Agricultural Development
IGAE	global index of economic activity
IICA	Inter-American Institute for Cooperation on Agriculture
IMF	International Monetary Fund
INEGI	National Institute of Statistics and Geography
NDP	National Development Plan
NPV	net present value
PPEF	Federal Expenditure Draft Budget
SADER	Secretariat of Agriculture and Rural Development
SAGARPA	Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food
SAM	social accounting matrix
SEDATU	Secretariat of Agrarian, Land and Urban Development
Segalmex	Mexican Food Security
SHCP	Secretariat of Finance and Public Credit
SHRFSP	Historical Balance of Public-Sector Financial Requirements

SIAP	Agrifood and Fisheries Information Service
SUC	supply and utilization chart
TFP	total factor productivity
USD	United States dollar

Executive summary

Economic and social reasons suggest that, in a country like Mexico, agriculture can play a very important role in economic recovery and in improving people's well-being in the post-COVID-19 era. In response to a request from the Secretariat of Agriculture and Rural Development (SADER) of Mexico, this study by the Food and Agriculture Organization of the United Nations (FAO) develops and analyses prospective scenarios to answer the following questions:

- Can public investment that promotes productivity in agriculture drive growth in agrifood production and have a positive impact on the economy as a whole and on rural poverty reduction?
- In which sectors or subsectors of agriculture will this public investment result in the most significant socio-economic benefit, thus maximizing its cost-effectiveness?

To answer these questions, an economy-wide model of the Mexican economy, including its multisectoral diversity and current fiscal constraints, was used. A base or reference scenario was generated to reproduce the economy's past and current behaviour (2018–2021) and project it through 2030. This scenario was compared with 21 scenarios in which new public investment in productive infrastructure in sectors and subsectors of Mexican agriculture, representing 0.25 percent of the gross domestic product (GDP) (around MXN 50 billion, in 2018), is stepped up during the 2021–2023 period. This investment improves rural roads, irrigation systems, storage infrastructure, etc., which, according to empirical evidence, can increase productivity in the recipient sector by the equivalent of 0.3 cents for each peso invested. The scenarios focus on public investment because, in a context of crisis such as the current one, private investors are more risk-averse and the government must wield public policy in order to create an environment more conducive for private investment. In addition, the scenarios cover the period through 2030 to analyse medium- and long-term impacts.

When new public investment focuses on promoting the crop sector as a whole, it generates more positive effects on growth than when allocated to promoting livestock as a whole. For the crop sector, GDP is 0.045 and 0.164 percent higher in 2022 and 2030, respectively (over the base scenario); while, in the case of livestock, it is 0.026 and 0.089 percent higher, respectively. This can be explained because crops are relatively more integrated into international trade. The increase in agrifood GDP is much more significant. For the crop sector as a whole, agrifood GDP increases by 0.597 and 1.609 percent in 2022 and 2030, respectively (over the base scenario); while in the case of livestock, the increase is 0.169 and 0.578 percent, respectively. This result is explained by the production increase within the sector, plus its impact on other food industry sectors' as a result of production linkages. Gains in people's well-being, measured by private consumption and decreasing rural poverty, are also favourable in all 21 public investment scenarios. In some cases, the rural poverty rate falls by nearly 0.1 percentage point.

The changes shown in the above-mentioned variables may seem quite modest, but they should be considered in light of the proportion of the GDP that the sectors and subsectors account for. For example, when the sugar cane subsector receives new public investment, private consumption and GDP in 2030 are 0.3 and 0.5 percent higher, respectively (over the base scenario). Significantly, in the first year of simulation (2018), the added value of sugar cane accounts for only 0.2 percent of GDP. Thus, increasing GDP by 0.5 percent in 2030 is not at all negligible. In other words, the cumulative increase in GDP by 2030 equals 3.5 percent of GDP in that first simulation year. In addition, for all scenarios we find that, according to the net present value (NPV) of public investment, the discounted gains, in terms

of Mexican households' welfare, is greater than the investment of 2021–2023. A sensitivity analysis shows that, if this investment is doubled for those years, the effects would be much more favourable.

In addition, this study assessed the macroeconomic effects of financing the investment with four alternative sources: foreign borrowing, domestic borrowing, direct tax revenue and increased efficiency in public spending. Taking into account the macroeconomic intertemporal trade-offs generated from using these alternative financing sources for public investment, we found that foreign borrowing would be the most viable option in the current context if the objective is to promote economic recovery and improve well-being in the short term, with higher gains in the medium to long term.

Ranking the agricultural subsectors by the impact of the new public investment (from highest to lowest), the sugar cane sector ranks first in three of the four variables considered (private consumption, total GDP, agrifood GDP and rural poverty). Cereals, primarily maize, but also rice, sorghum, oats, barley and other cereals (excluding wheat, which is low in the ranking), are also sectors which, when promoted, would have positive effects on private consumption, GDP and rural poverty. More export-oriented crops, such as flowers and coffee, are also relatively high in the ranking. In no case are the livestock subsectors among the five top-ranking positions.

These results validate the merit of including sugar cane, cereals (mainly maize, but also others, such as rice, which falls within the "other cereals" group in our analysis), and coffee as priority subsectors of the 2019–2024 National Development Plan (NDP). On other hand, according to the analysis, other subsectors prioritized in the NDP, such as those involving livestock, are not the most cost-effective, in terms of the variables analysed under the current economic recession, although their food-industry linkages are significant. Furthermore, the flower subsector appears among the highest positions in our ranking, but is not considered in the NDP. The evidence generated by the analysis provides information for decision-making on additional sectors in the NDP that could be prioritized in order to revive agriculture and the economy with payoffs in rural well-being.

The ranking is a starting point for placing greater focus on the top-ranked subsectors. This is essential to answer more specific questions about these priority sectors. More precisely, it is necessary to identify the investments required along the value chains linked to each priority subsector. Accordingly, it is necessary to identify which component of the primary production of these subsectors should be promoted. (What should be invested in?) It is necessary to determine how much should be invested in them and to substantiate the budgets. (How much should be invested?) These questions should be answered, as an additional decision-making criteria, by identifying territories where such investments can have the greatest socio-economic impact, while being environmentally sound, due to their high potential for productivity and poverty reduction. (Where to invest?)

1 Introduction

The COVID-19 pandemic has posed new challenges, which have prompted decision-makers to react quickly and in a timely manner. Most efforts have focused on addressing the emergency that the pandemic has precipitated. Health has been the number one priority, but access to sufficient and nutritious food should also be seen as a core health response to the pandemic, as it is essential to health. This has forced FAO to ensure that pandemic response efforts keep food supply chains active, while emphasizing all people's access to healthy foods.

However, it has gradually become clearer that economies must recover from the unprecedented economic recession that COVID-19 itself, and attendant restrictive measures, have caused. This is a clear necessity, as the economic recession is impacting food security and poverty, primarily among the most vulnerable groups. In 2020, because of the severe contraction in global GDP, millions of people worldwide would have joined the ranks of the hungry (FAO, IFAD, WHO, WFP and UNICEF, 2020). In the estimate published in January 2021, in *Global Economic Prospects*, the World Bank indicated that the number of poor people in 2020 could have increased by between 119 million and 124 million as a result of the pandemic (according to the poverty line of USD 1.90 per day).[1] These are not unrealistic scenarios, considering the unprecedented economic recession we are experiencing: in January 2020, the International Monetary Fund (IMF) forecast that global GDP would grow by 3.3 percent in 2020, but the last estimate for that year (April 2021) was -3.3 percent, almost 7 percentage points lower than initially projected. Within this recession, middle-income countries are hard-hit. In Mexico, according to figures from the third quarter of 2020 published by the National Institute of Statistics and Geography (INEGI), the economy showed an 8.6 percent drop from the previous year.

The IMF's most recent forecast at this writing (April 2021) projects 5 percent growth in the Mexican economy by 2021, which raises questions about what the drivers for such a strong economic recovery could be. Broadly speaking, governments in different countries around the world are opting for unprecedented fiscal and monetary stimulus measures, but the question they all face is: What are the most cost-effective ways to invest resources that will accelerate growth for the well-being of all? Certainly, the international community must support the response capacity of lower-income countries. At the same time, these countries must exercise considerable fiscal responsibility and objectivity in reallocating their public resources to meet the most urgent needs arising from the pandemic.

It is therefore imperative to consider the options available to revive the economies and reduce poverty, making the best possible use of the limited resources available. Economic stimulus measures should focus on those sectors that are important to the economy and/or generate employment and better living conditions for large portions of the population. In a country such as Mexico, it is essential to explore options for reactivating agriculture (including crops, livestock, forestry and fisheries) as one element of economic recovery with improved well-being, post-COVID-19. Considering the more serious fiscal constraints that exist at this time, it is crucial to generate evidence regarding the options for economic recovery, so that the Mexican Government can make informed decisions about which sectors

[1] The estimate is based on the difference in projection for 2020, before the pandemic (the World Bank expected 31 million fewer poor globally between 2019 and 2020) and the current projection for 2020, with the pandemic (88 to 93 million more poor expected between 2019 and 2020, depending on the scenario). Adding this increase (88 to 93 million) to the reduction that was expected (31 million) gives the estimated increase in the number of poor people (between 119 million and 124 million).

of agriculture will be the most profitable to invest in and will generate clear socio-economic benefits, primarily in rural areas where rates of extreme poverty and hunger are highest. In addition, this evidence can facilitate the process of accessing international financing to support the necessary investments.

It is for this purpose that the present FAO study, in response to a request from the Mexican Secretariat of Agriculture and Rural Development (SADER), analyses prospective scenarios to answer the following questions:

- Can public investments that promote productivity in agriculture drive growth in agrifood production and have a positive impact on the economy as a whole and on rural poverty?
- In which sectors or branches of agriculture will public investment to boost productivity have the greatest socio-economic payoffs, thus maximizing the cost-effectiveness of the investment?

This analysis of prospective scenarios focuses on agriculture for a variety of reasons, despite the fact that the sector accounts for a low percentage of Mexico's GDP (3.3 percent in the last ten years and 4.2 percent in the second quarter of 2020). For example, overall, agriculture employs 12 percent of the country's workforce (6.5 million people). In addition, the livelihoods of a large part of the rural population depend on agriculture. Forty-seven percent of farms sell what they grow, and this totals 87.4 percent of total production volume. Production for self-consumption is significant. Specifically, 27.5, 58.0 and 75.4 percent of farms use their production to feed livestock, as seed for planting, and for family consumption, respectively; these amounts are equivalent to 7.8, 0.5 and 4.3 percent of the total production volume, respectively (INEGI, 2019). A number of Mexico's agricultural products are exported to the country's main trading partners, mainly red fruits (especially blackberries), tomato, avocado, sugarcane, tequila and malt beer (according to data from the Agrifood and Fisheries Information Service [SIAP] for 2017). It is also notable that Mexican agriculture has shown significant resilience during the pandemic. Not only is it a sector with production potential, but it is also vital for significantly reducing poverty. According to the multidimensional poverty indicator, 55 percent of the rural population is poor, versus 37.2 percent in urban areas (CONEVAL, 2018).

In order to generate the prospective scenarios to be analysed, a multisectoral computable general equilibrium (CGE) model is used to capture, over time, the macroeconomic, sectoral and distributional effects caused by new public investments with an impact on productivity, and their financing, in the short, medium and long term. In addition, this CGE model can accommodate fiscal and public financing restrictions (and the relevant policies) in effect during the current restrictive context of the Mexican economy.

More specifically, the CGE model is used to simulate two types of scenarios. First, a base or reference scenario, which reproduces the Mexican economy's past and current behaviour, including its sectoral structure, and projects it forward. Second, this base scenario is compared to scenarios for assessing the effects of government investment that increase productivity in selected agricultural sectors; for example, by improving rural roads, irrigation systems, storage infrastructure, etc. The 2019–2024 National Development Plan, or NDP, was reviewed to select priority sectors (as further shown below). Other agricultural sectors not included in the NDP were also considered, to assess their potential to generate positive economy-wide effects. The scenarios focus on public investment because, in a crisis context such as the current one, private investors are more risk-averse and the Government must intervene, through public policy, to create an environment more conducive for private investment.

The scenario analysis conducted makes it possible to determine which of Mexico's agricultural subsectors should be promoted because, when they receive the new investment,

they provide the most significant effects on sectoral and national economic growth and rural poverty reduction. In other words, it aims to identify the agriculture subsectors where public investment is most cost-effective. In addition, different sources of financing for the new productive public investment are considered when designing the scenarios, in order to determine the various macroeconomic effects and advisability of each one. While foreign and domestic public borrowing situations are scrutinized, due to the current restrictive fiscal context, two alternative sources of financing that are considered "neutral" (that is, that do not change the total budget) are also analysed: (i) the reallocation of public spending, with or without greater efficiency in providing public services,[2] and (ii) the increase of different effective tax rates, presumably as a result improved tax collection.[3]

The rest of the document is organized into five additional sections. Section 2 describes the recent context of the Mexican economy, with an emphasis on the evolution and contributions of agriculture in terms of production, employment and living conditions of the population, mainly the rural population. In addition, reference is made to public fiscal and investment policy, and the fiscal space to finance new investments. Section 3 summarizes the modelling approach for generating scenarios and the data used to apply it. Section 4 then describes the productive public investment scenarios that were eventually developed and analyses their macroeconomic, sectoral and distributional results. Finally, Section 5 presents the conclusions and policy recommendations.

[2] In this case, scenarios are designed in which the public sector can provide the same volume of services (education, health and public administration) with fewer production factors (work and capital). Alternatively, the Government could reduce its current spending without altering the quality of the services it provides.

[3] The effective tax rate is defined as the ratio between collection and the taxable base. Consequently, that rate could increase, even if the legal rate is not changed.

2 Context: economic and social performance, reforms and production aspects

KEY MESSAGES

- Over the past 20 years, Mexico has experienced three economic crises: the 2008 financial crisis, the A/H1N1 pandemic and, the most recent, the COVID-19 pandemic.
- The first two crises resulted in an average annual GDP growth rate ranging from 2 to 3 percent over the last 20 years.
- During the COVID-19 crisis, GDP has contracted to record-low figures.
- Despite the collapse in economic activity nationwide, the primary sector has been the most resilient.
- Even so, the agriculture sector lacks productive dynamism and is one of the sectors with the highest levels of informal employment and the lowest wages.
- A policy of public investment in the sector's productive infrastructure would contribute to economic recovery and improving people's well-being.

The macroeconomic stability that Mexico has enjoyed since 2010 remains, although recently the economy has undergone programme and policy changes that often come with the transition to a new government from a different political party. Moreover, in its second year, the current government has had to deal with the challenges of the COVID-19 pandemic. According to data from the Secretariat of Health, by 15 January 2021, casualties had exceeded 137 900 and 1.6 million people had tested positive. Mexico has one of the highest COVID-19 death rates in Latin America and the Caribbean.

The pandemic has shut down major economic activities, particularly in the secondary sector (manufacturing and industries), which are important sources of income and foreign exchange, especially in terms of trade with the United States of America, the country's top trading partner. In the public administration sector, government bodies have been closed, public officials have been dismissed and the salaries of senior officials have been reduced; all this as part of the savings and spending efficiency measures instituted by the Government for the present-day context. In the second quarter of 2020, GDP fell by 18.7 percent, according to INEGI. This collapse is unprecedented in Mexico's history. However, the primary sector has been relatively more resilient than the other sectors.

Currently, the Secretariat of Agrarian, Land and Urban Development (SEDATU) and SADER[4] lead agricultural policy-making. Both institutions work in coordination with other ministries to develop the country's agricultural sector, which faces a number of significant challenges. For example, credit for this sector remains a major constraint to its development and a natural explanation of setbacks in productive investment.[5] Another challenge is the need to consolidate Mexico's past two agricultural reforms. The first reform, which was completed in 1939 with the expropriation of mega-plantations and the creation of *ejidos* (areas of communal land used for agriculture), provided no financial support or training for farmers. The second, instituted in 1992, sought to privatize land without state intervention, that is, allowing *ejidal* land to be sold by its owner. Neither of the reforms included significant investment in equipment, in high-quality agriculture for export, or in meaningfully improving farmers' wages (Cárcar Irujo, 2013).

2.1 Main trends

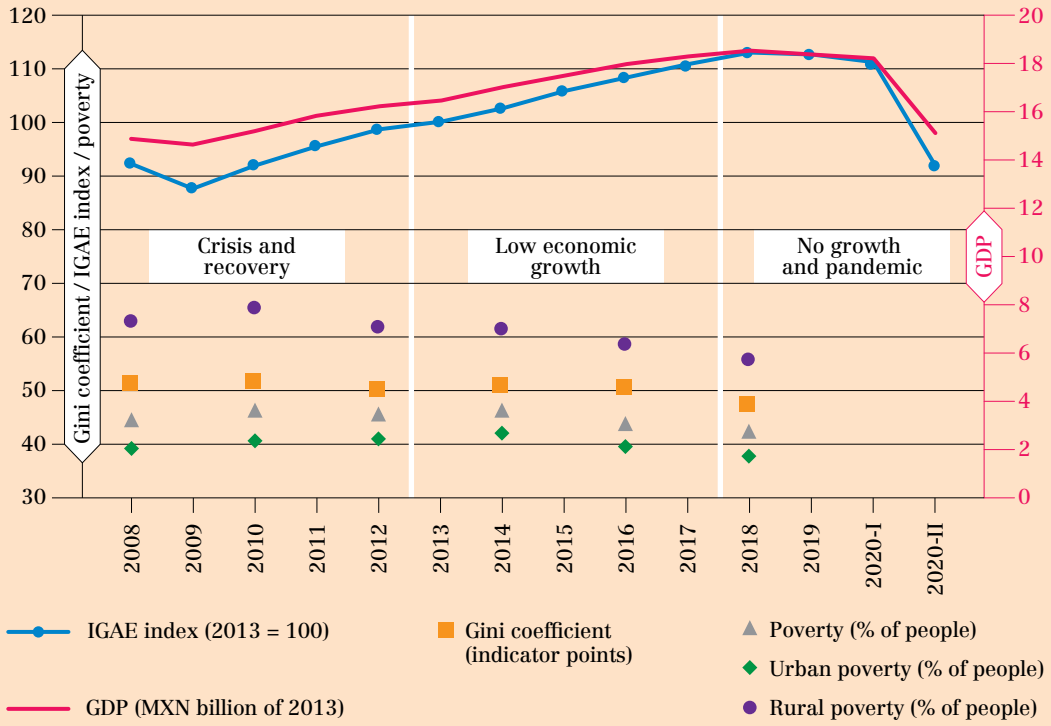
Below is a brief analysis of the evolution of Mexico's economy and how this has impacted poverty, divided into the last three six-year periods, in which Mexico has alternated between governments from different parties. During the 2006–2012 period, there was a reduction in GDP of 5.1 percent in 2008 and 2009 due to the international financial crisis, followed by a subsequent recovery. In the 2012–2018 period, reform agreements were maintained, social programmes changed only in name, and macroeconomic policy continued to give the country stability, despite low economic growth rates hovering around 2.4 percent. Between 2018 and 2020, the current administration (2018–2024) made major changes, such as ending the most prominent poverty-reduction programme, Opportunities (also known as Prospera), which had been operating since 1997 and which, in 2018, had more than 6 million beneficiary families (approximately 25 million people). The programme was replaced with new programmes whose operating rules and beneficiary standards are still being developed. Economic growth from 2018 to 2019 was -0.3 percent, which led to discussion of a possible economic recession in Mexico. However, the pandemic, which stopped non-priority economic activities, left no doubt that the economy was already in recession. This was highlighted by the GDP, which is published quarterly, and the Overall Economic Activity Index (IGAE), which is published monthly (Figure 1).

Between 2018 and 2019, GDP declined by 0.3 percent, and in the first quarter of 2020, by 2.1 percent. But the strongest drop was in the second quarter of 2020, during the pandemic: 18.7 percent (Figure 2). The secondary and tertiary sectors were affected the most, contracting by 26.7 and 16.3 percent, respectively. The primary sector, in contrast, has been more resilient, showing a relative decline of only 2.1 percent in this period.

[4] Formerly known as the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA). Again, this study has been conducted in response to a request that SADER made of FAO.

[5] Seen as a percentage of total credit in Latin American and Caribbean countries, credit for agriculture in Mexico represents only 1.9 percent, ranking among the region's lowest (the highest being Nicaragua with 14.6 percent) (ECLAC, FAO and IICA, 2019). Obviously Mexican agriculture is at a different stage of development than that of other countries in the region, but these figures still provide a perspective on the meager support that the sector receives.

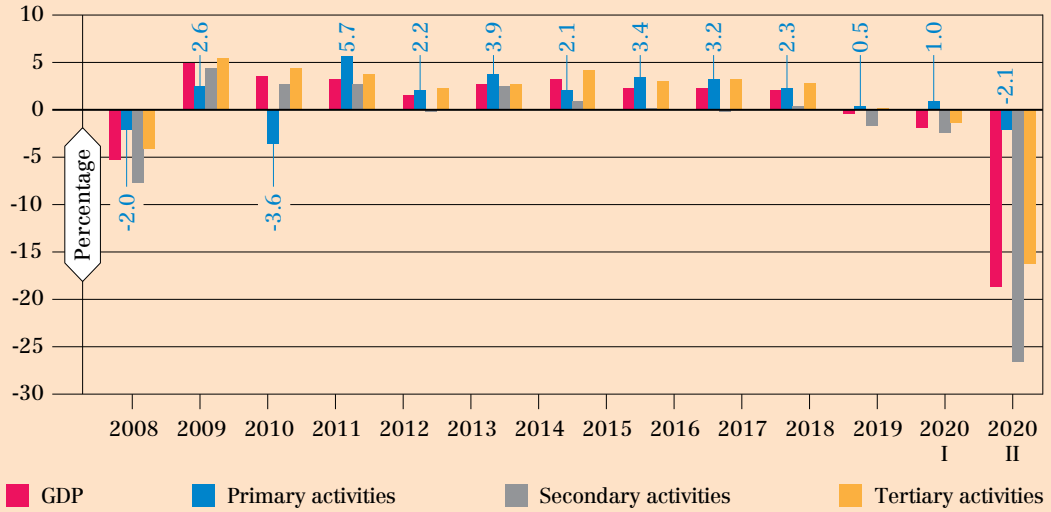
FIGURE 1 Trends in economic activity, poverty and inequality



Note: The Gini coefficient and the official poverty lines of the National Counsel for the Evaluation of Social Development Policy (CONEVAL), which take into account the total current per capita income of households, are presented for the years available from the National Survey of Household Income and Expenditure (ENIGH).

Source: Authors' own elaboration based on official INEGI data.

FIGURE 2 Average annual growth of GDP and the three sectors of economic activity



Note: Percentages are presented only for primary activities.

Source: Authors' own elaboration based on INEGI national account data.

International forecasts for Mexico's economic growth – issued by official sources such as the Secretariat of Finance and Public Credit (SHCP), the Bank of Mexico, and the IMF – waver at around 3.0 percent or more for 2021–2022. However, additional investment will be required to provide economic stimulus, accelerate growth and achieve the targets set in the NDP.

Moreover, since economic growth and its distribution have not been sufficient to significantly reduce poverty or income inequality, economic stimulus is also needed to improve these variables. The last official measurement in 2018 shows that, while poverty and income inequality (as measured by the Gini coefficient) have declined, they remain high (Figure 1). In 2018, 41.0 percent of the population (that is, 52.4 million people) continued to be identified as multidimensionally poor, experiencing deprivations in their social rights. Furthermore, income distribution in Mexico remains one of most unequal in Latin America, with a Gini coefficient of 46.8, according to CONEVAL (2018). Even more worrying is the high rate of rural poverty in 2018 (55.3 percent), still much higher than urban poverty (37.5 percent).

Because of the pandemic, the survey which provides biannual estimates of poverty and the population census were postponed. However, CONEVAL estimates for the second quarter of 2020 indicate that the greatest impact will be on income poverty and labour poverty.[6] According to CONEVAL, income poverty could increase from 48.8 to 56.7 percent, and extreme income poverty could be between 21.69 and 25.37 percent. In addition, labour poverty could have increased from 37.3 to 45.8 percent in the first two quarters of 2020. Although income poverty has not fallen below 40 percentage points in the past decade, social policies to reduce poverty have been implemented during this period.

The Government has made announcements about economic stimulus initiatives. For example, SADER announced in November 2020 that it would launch timely financing and credit schemes for basic grain farmers, arranging crop price coverage and agricultural insurance, and will later provide financing and support programmes for crop price coverage for beneficiaries of the Price Guarantee programme, through the Mexican Food Security Agency (Segalmex). Participants will include the Trusts Funds for Rural Development (FIRA); the National Finance Institute for Agricultural, Rural, Forestry and Fisheries Development (FND); and the Association of Mexican Banks (ABM). These and other stimulus initiatives to be proposed should be based on clear information pointing to where to invest so as to stimulate the economy and reduce poverty.

2.2 Macroeconomic performance

In the period from 2010 to 2019, Mexico's average annual GDP growth was 2.3 percent which, considering the size of the population, represents an average per capita growth rate of 1.4 percent per year (Table 1). This growth enabled the country to meet the targets set out in its national development plans and had established budgets, including those associated with social programmes, interest rates, inflation, and debt payments. At the macroeconomic level, indicators have shown signs of stability; however, unsurprisingly, the performance of the labour market, manufacturing and large enterprises has deteriorated as a result of the pandemic.

[6] In the Mexican context, income poverty takes account of people who cannot afford to purchase a basic food basket and basic goods and services, even if they spend their entire per capita household income. Extreme income poverty is similar, but it is based on the cost of the basic food basket. Labour poverty includes people who cannot afford to buy a basic food basket, even if they spend all their labour income (per capita for the household).

In the first six months of 2020, both open unemployment and underemployment – fewer hours worked or compulsory "leave" in the workplace – increased over the values recorded in the same period in 2019. The underemployment indicator rose from an average of almost 8.0 percent in the last decade to 25.1 percent in the second quarter of 2020 (Table 1). Inflation has not increased, but rather has tended to slow down as the economy contracted. However, the average official exchange rate against the dollar and the reserve ratio in relation to the monetary base, which had been stable, have tended to increase recently. The announcement of the health emergency in the United States of America appears to have been influential in this regard. On the other hand, remittances (which were already increasing) jumped 17.1 percent in the first quarter of 2020, in response to the announced closure of activities due to the health contingency. Subsequently, remittances declined, as expected, due to the pandemic.

TABLE 1 Main macroeconomic indicators, 2010–2020

Items	2010–2019	2019	2020	
			Quarter I	Quarter II
Economic activity and employment (%)				
GDP at constant prices of 2013 (average annual growth rates)	2.36	-0.30	-2.13	-18.68
GDP per capita (average annual growth rates)	1.40	-1.23		
Open unemployment rate* annual average	4.37	3.50	4.67	4.19
Population underemployed	7.98	7.52	8.46	25.14
Prices and exchange rate				
National cumulative annual inflation (IPC base year 2013) (%)	3.96	3.64	3.40	2.77
Average annual inflation of the rural food basket** (%)	5.08	1.91	4.18	4.22
Average annual inflation of the urban food basket** (%)	5.05	2.68	3.99	3.95
Average official exchange rate (MXP x USD)	15.62	19.26	19.86	23.36
Monetary sector				
International reserves/monetary base (number of times)	2.51	2.16	2.17	2.39
Balance of net international reserves (USD millions)	163 971.10	178 603.00	184 191.60	187 862.10

TABLE 1 (cont.) **Main macroeconomic indicators, 2010–2020**

Items	2010–2019	2019	2020	
			Quarter I	Quarter II
Gross international reserve balance (USD millions)	167 827.30	184 359.90	189 145.30	196 887.10
Annual remittance revenue (CE81) (USD millions)	26 467.98	36 438.76	9 397.71	10 399.78
Annual growth rate of remittances (%)	5.83	8.43	17.12	3.90
Non-financial public sector (% of GDP)				
Public balance before aid, subsidies or transfers***	0.70	1.30		
Public balance after aid, subsidies or transfers***	-2.40	-1.60		
External financing***	0.90	0.20		
Domestic financing***	1.50	1.40		
Public debt				
Public sector net debt balance (USD millions)	461 270.00	585 156.69	515 705.90	537 010.39
Public sector debt / GDP*** (%)	40.40	45.50		

Notes: Data correspond to the annual average, and in 2020 with respect to quarters I and II. * Monthly for 2020. ** Annual average in April 2020. *** Constant prices of 2013.

Source: Authors' own elaboration based on data from the INEGI National Accounts System, the World Bank, the SHCP and CONEVAL.

The non-financial public sector in 2019 averaged higher growth than in the previous decade. In terms of financing the budget, the trend has been towards more domestic borrowing than foreign borrowing. Public sector debt shows a 5-percentage-point increase in GDP in 2019 over the previous decade's average. According to the 2020 Annual Financing Plan of the Secretariat of Finance and Public Credit:

> *...the Historical Balance of Public Sector Financial Requirements (SHRFSP) is estimated, at the closing of 2019, at 44.7 percent of the GDP (MXN 10.9 trillion) and, by 2020, at a level close to 2019.*" In addition, "*debt policy will be geared towards covering the Federal Government deficit through domestic borrowing, and will seek to favour long-term, fixed-rate instruments. External indebtedness will be used strategically to complement domestic credit when favourable conditions are found in international markets* (SHCP, 2020b). It is estimated that "*at the end of 2020, 78.7 percent of the Federal Government's gross debt will be domestic and 21.3 percent will be external debt*".[7]

[7] By comparison, in the post crisis period from 1994 to 1998, the external debt reached 98 percent of Mexico's public debt, making it impossible to finance new investments with foreign borrowing.

Consumption, investment and international trade

Private consumption increased an average of 2.6 percent in 2010–2019, similar to the increase in GDP during the same period. However, it declined considerably in 2019, and with the pandemic, dropped to a negative rate of -20.6 percent (Table 2). Private investment behaved similarly to consumption, with average growth rates of 2.9 percent in 2010–2019, but which dropped to negative rates at the end of that period. Public investment showed a more alarming outcome, with an overall average decline since 2010. Any economic stimulus measure should consider that private investors are risk-averse amidst the economic recession, and that public investment gaps would justify taking public initiative to revive the economy. As to international trade, which had been growing faster than GDP, this fell sharply in the second quarter of 2020, with negative rates of nearly -30 percent.

TABLE 2 Gross domestic product by expenditure component (growth rate and structure)

Items	2010–2019	2019	2020*		2010–2019	2019	2020*	
			I	II			I	II
	Growth rate (%)				Percentage structure of GDP			
Gross domestic product (GDP)	2.66	-0.30	-2.13	-18.68	2.3	-0.3	-2.1	-18.6
Final consumption	2.57	0.16	-0.53	-17.22	78.0	79.8	80.1	80.6
Government consumption	1.96	-1.35	3.3	2.4	11.9	11.8	12.3	14.7
Private consumption	2.68	0.4	-1.2	-2.6	66.1	67.9	67.7	65.9
Consumption by households and non-profit institutions**	2.76							
Gross investment	1.06	-5.12	-9.5	-34.0	20.8	18.7	18.5	15.7
Public investment	-6.11	-9.68	-7.2	-10.2	3.9	2.5	2.5	2.9
Private investment	2.97	-4.35	-9.8	-37.4	16.9	16.20	16.0	12.8
Exports of goods and services	4.86	1.45	1.8	-31.1	32.8	36.4	38.0	31.8
Imports of goods and services	4.12	-0.85	-5.0	-29.7	33.5	36.2	36.0	31.9

Notes: * Constant prices of 2013. ** Information available up to 2018; also includes private consumption.
Source: INEGI National Accounts System.

2.3 Fiscal performance

Public debt exists in the face of the Government's need to finance the gap that arises when its income is exceeded by its spending. To prevent it from soaring to the point where its sustainability is threatened, without neglecting existing public investment needs, it is essential to maintain good fiscal performance. Net public spending in Mexico has fluctuated

significantly, as shown by its growth rate, which increased by an average of 2.6 percent in 2010–2019 and by 21.2 percent in the first quarter of 2020, then decreasing by 4.6 percent in the second quarter (Table 3). The largest increase in spending comes from debts incurred at the state level with the aim of financing public infrastructure works and, more recently, needs associated with the pandemic. According to INEGI, in 2019 the states with the highest percentage of debt, compared to the national total, were the State of Mexico and the State of Veracruz. Oil revenues, which are the Federal Government's foremost source of income, have also dropped as a result of falling oil prices, dropping 48.3 percent in the first quarter of 2020. As a result, the Government has increased fiscal surveillance to access non-oil resources through the tax system, increasing its tax revenues by 34.3 percent.

On the other hand, there has been a radical change in social support and assistance, compared to previous administrations. Previously, social programmes operated under guidelines governed by public service and the SHCP, and adhered strictly to operating rules. Currently, social assistance is delivered directly, without intermediation and without rosters of pre-targeted beneficiaries. Spending in this area increased by 1 036.7 percent in the first quarter of 2020, while in the second quarter it contracted by 95.0 percent.

According to SHCP figures, the public balance sheet is negative in the second quarter of 2020. However, seen as a percentage of GDP, the budget deficit in that quarter is similar to that of 2019, between 1.6 and 1.7 percent, but lower than the previous decade's average (2.4 percent). As mentioned, the budget deficit has been financed mostly from domestic borrowing, however, the economic downturn has left the Government less room to continue this policy of raising domestic resources, and foreign borrowing has predominated over domestic borrowing, which is already evident in the first two quarters of 2020 (Table 3). This appears to be a major change in the policy, or at least the structure, of government funding.

TABLE 3 Public sector financial situation, 2010–2020

Items	2010–2019	2019	2020		2010–2019	2019	2020	
			I	II			I	II
	Growth rate*(%)				Percentage of GDP (%)			
1. Budget revenue	**2.7**	**14.3**	**19.2**	**-3.8**	**22.6**	**22.0**	**6.2**	**13.2**
Oil revenue	**6.7**	**25.9**	**-48.3**	**-8.8**	**6.1**	**3.9**	**0.6**	**1.3**
Federal Government oil revenue	20.8	-30.4	-29.0	-68.3	3.6	1.8	0.4	0.6
Pemex's own income	21.0	83.6	-64.7	75.3	2.5	2.1	0.2	0.7
Non-oil income	**5.7**	**11.3**	**32.7**	**-2.8**	**16.6**	**18.1**	**5.6**	**12.0**
Federal Government non-oil revenue	5.3	15.1	38.2	-3.2	12.9	14.6	4.8	9.9
Non-oil tax revenue	8.0	-0.1	34.3	-7.0	11.2	13.1	4.3	8.9
Non-tax non-oil income	104.4	399.2	84.7	88.8	1.7	1.5	0.5	1.0

TABLE 3 (cont.) Public sector financial situation, 2010–2020

Items	2010–2019	2019	2020		2010–2019	2019	2020	
			I	II			I	II
	Growth rate*(%)				Percentage of GDP (%)			
Revenue from agencies and companies other than Pemex	19.7	-1.6	6.7	-1.6	3.6	3.5	0.9	2.1
2. Net public expenditure paid	2.6	13.7	21.2	-4.6	25.0	23.7	6.3	14.8
Programmable budget expenditure paid	**2.3**	**20.0**	**25.5**	**0.9**	**19.3**	**17.3**	**4.6**	**10.5**
Current budget expenditure	2.6	30.3	26.3	-6.0	14.8	14.3	3.7	8.5
Budget personnel services	2.9	8.2	20.6	4.6	5.6	5.0	1.3	2.9
Other budget operating expenses	3.3	53.8	-15.4	-9.4	2.8	2.7	0.4	1.2
Pensions and retirement	4.1	29.7	11.8	14.9	3.0	3.6	1.0	2.4
Aid, subsidies and budget transfers	12.9	83.1	60.1	-35.3	3.1	2.9	0.9	1.9
Aid and other expenses	42.4	119.8	1 036.7	-95.7	0.2	0.2	0.1	0.1
Budget capital expenditure	9.7	-16.2	21.6	43.5	4.6	3.0	0.8	2.0
Expenditure on fixed capital assets	0.0	13.1	38.4	15.7	3.8	2.3	0.7	1.7
Direct expenditure on fixed capital assets	0.6	2.4	107.9	1.5	2.4	1.3	0.4	0.9
Budget transfers for fixed capital assets	14.4	55.8	-6.8	32.7	1.4	1.0	0.3	0.8
Financial capital assets and others	433.1	-53.0	-47.5	-11 207.1	0.8	0.7	0.2	0.4
Non-programmable budget expenditure	**6.1**	**2.6**	**8.4**	**-12.1**	**5.7**	**6.4**	**1.7**	**4.3**
Budget financial cost	4.9	0.0	17.8	0.6	2.2	2.7	0.6	1.9

TABLE 3 (cont.) **Public sector financial situation, 2010–2020**

Items	2010–2019	2019	2020		2010–2019	2019	2020	
			I	II			I	II
	Growth rate*(%)				Percentage of GDP (%)			
Interest, commissions and budget expenditures	4.9	0.0	17.8	0.6	2.1	2.5	0.5	1.7
Federal Government interest, commissions and expenses	4.6	1.0	30.3	1.6	1.7	1.9	0.3	1.3
Interest, commissions and expenditures of agencies and companies under direct budgetary control	13.4	-9.5	0.9	-13.4	0.4	0.6	0.2	0.4
Savings and debtor support programmes	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.2
Institute for the Protection of Bank Savings	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.2
Other debtor support programmes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Participation rates	3.6	-4.0	-2.7	-36.9	3.4	3.6	1.0	2.3
Adefas (liabilities accrued in previous years) and others	-243.0	-207.1	-219.1	-3.7	0.1	0.1	0.1	0.1
3. Budget balance (1 - 2)	**26.6**	**12.0**	**198.2**	**-6.8**	**-2.4**	**-1.7**	**-0.1**	**-1.6**
4. Financial balance of entities under indirect budgetary control	**-1.8**	**133.7**	**281.9**	**-323.0**	**0.0**	**0.1**	**0.2**	**0.1**
5. Public balance sheet (3 + 4) = (6 + 7)	**23.3**	**22.1**	**417.5**	**-4.7**	**-2.4**	**-1.6**	**0.1**	**-1.5**
6. External financing	**142.0**	**2 075.4**	**576.2**	**-83.6**	**0.9**	**0.2**	**0.6**	**1.6**
7. Domestic financing	**-477.5**	**46.4**	**474.2**	**-0.8**	**1.5**	**1.4**	**-0.7**	**-0.1**

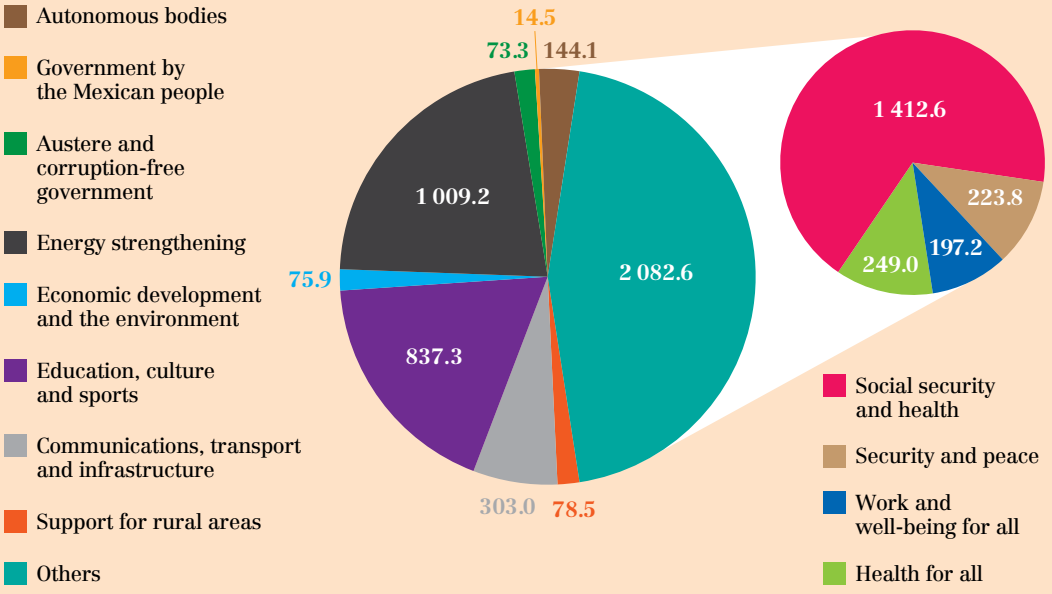
Note: * Constant prices of 2018.

Source: Secretariat of Finance and Public Credit (SHCP).

While the increase in foreign borrowing is an indicator of the Government's internal financial constraints on generating revenue, it further indicates that the Government of Mexico has access to international financial markets.[8] This, coupled with a less orthodox context, in which international financial institutions urge countries to stimulate economies less conservatively in terms of the debts they may accumulate (in view of the low prevailing interest rates), as well as the fact that public debt accounted for only 45.5 percent of GDP in 2019, is a sign that fiscal leeway can be created through foreign borrowing to stimulate the economy through public investment.

On 8 September 2020, the SHCP presented the General Economic Policy Criteria (CGPE) for fiscal year 2021 to the Congress, stressing that these *"are very different from those of previous years and are distinguished by deeper reflection on the economic and social aspects, as well as on the country's health, economy and public finances"* (SHCP, 2020a). The CGPE includes the Federal Expenditure Draft Budget (PPEF) for 12 public spending actions to be implemented by the Government of Mexico in 2021, as well as for priority government programmes (see Figure 3).

FIGURE 3 Twelve spending actions for the Government of Mexico in 2021 (MXN billion)



Source: Authors' own elaboration based on data from the PPEF 2020 from the SHCP.

The current administration's eleven priority projects, including the new airport and the Maya train, add up to a total of MXN 103 037.20 million, representing 2.2 percent of the programmable expenditure and 0.6 percent of GDP (PPEF-2020 by SHCP). The 18 priority social programmes are allocated a budget of MXN 336 631.90 million, representing 7.3 percent of programmable expenditure and 2.0 percent of GDP, with the older adult programme comprising 40.1 percent of the social programmes budget. These social programmes appear in the 2019–2024 NDP and are expected to have an impact on poverty because of their direct influence on the food basket, both rural and urban. It is important to generate additional evidence on how to invest more cost-effectively in these programmes, to boost economic recovery and increase the well-being of the Mexican people.

[8] According to Fitch, as of February 2021, Mexico had a BBB risk rating.

2.4 Sectoral productive performance

In the 2010–2019 period, primary activities, including agriculture (crops), livestock farming operations, forestry, fishing and hunting, report an average annual growth rate of 2.2 percent (Table 4). Of these activities, crop agriculture grew the most (2.7 percent); followed by the fisheries, hunting and gathering sector (2.5 percent); and by forestry (2.4 percent). However, the pattern from the previous decade is unlike 2019, when the entire primary sector contracted, except for livestock farming. In the previous decade, starting in 2006, the increase in the price of the family food basket, with its large component of rice and beans, led to an increase in the costs of production inputs (Ortega-Díaz and Székely, 2014). Subsequently, in the first half of 2020, during the pandemic, crop production sectors managed to recover insofar as (as was the case with some other economic sectors such as transport and courier services), they benefited from the designation as "priority sectors" for food, the food manufacturing industry and deliveries. Still, the food industry as a whole contracted 1.1 percent in the second quarter of 2020.

TABLE 4 **Value added in primary, secondary and tertiary sectors, with disaggregation for the agrifood sectors, 2010–2020 (average annual growth rates)**

Items	2010–2019	2019	2020*	
			Quarter I	Quarter II
Primary sector (%)	**2.2**	**0.4**	**0.9**	**-0.5**
Crop agriculture	2.7	-0.5	0.4	-0.1
Livestock farming	1.3	3.3	2.8	1.8
Forestry	1.2	-2.0	-5.1	-35.6
Fishing, hunting and gathering	2.5	-4.9	-2.0	-0.4
Services related to agricultural and forestry activities	2.4	-31.2	8.7	-15.8
Secondary sector (%)	**0.9**	**-1.7**	**-2.6**	**-29.7**
Total food industry	2.1	1.6	3.2	-1.1
Animal feed production	2.1	1.5	7.1	6.1
Grinding of grains and seeds and production of oils and fats	2.5	2.3	2.9	0.7
Making of sugars, chocolates, sweets and the like	0.0	-8.8	-2.8	-25.3
Preservation of fruits, vegetables and prepared foods	2.7	2.6	0.6	-6.6
Dairy processing	1.4	1.0	2.5	-0.7

TABLE 4 (cont.) **Value added in primary, secondary and tertiary sectors, with disaggregation for the agrifood sectors, 2010–2020 (average annual growth rates)**

Items	2010–2019	2019	2020*	
			Quarter I	Quarter II
Butchering, packaging and processing meat from cattle, poultry and other edible animals	2.9	5.0	8.2	4.9
Preparation and packaging of seafood	1.0	-3.2	-7.5	-0.4
Preparation of bakery products and tortillas	1.5	0.5	2.0	-0.1
Other food industries	3.2	1.9	1.2	-5.9
Tertiary sector (%)	**3.0**	**0.2**	**-0.7**	**-17.7**

Note: * Constant prices of 2013, preliminary figures for 2020.

Source: INEGI National Accounts System.

2.5 Employment and poverty

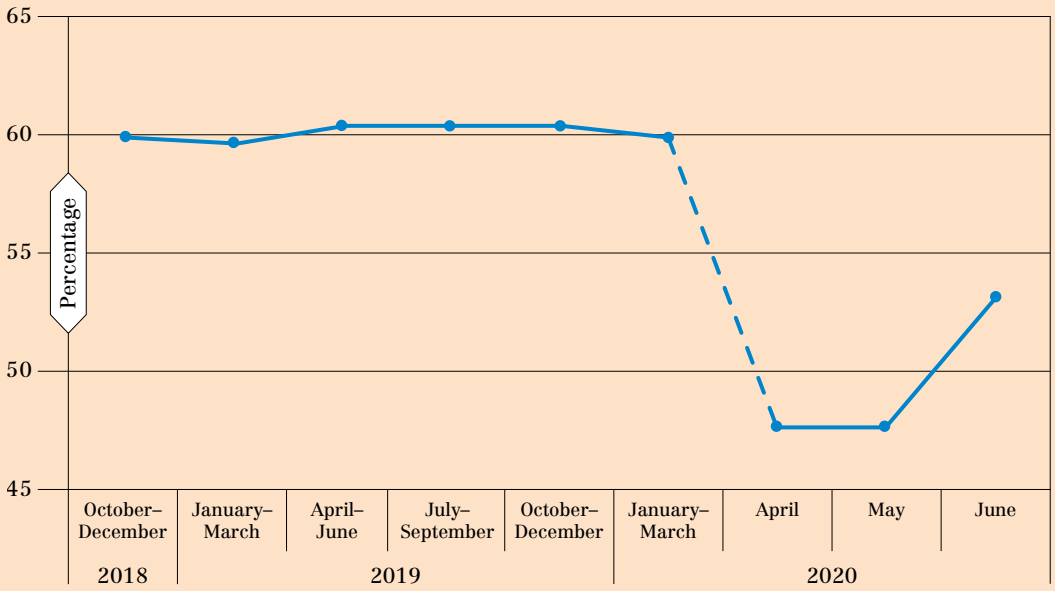
Employment and informal work

The economic performance described above translates into changes in employment and poverty. As of the first quarter of 2020, the employed population began to decline, and at the beginning of the second quarter, the shutdown of economic activities caused a 20.7 percent drop in the employed population (according to our calculations, based on data from INEGI's National Survey of Occupation and Employment [ENOE] and the INEGI Telephone Survey of Occupation and Employment [ETOE]). To understand the evolution of employment indicators during the pandemic, INEGI implemented the ETOE, which is conducted monthly, and while it is not exactly comparable with the ENOE, its design is the same, and the weighting factors expand to the representative population. The ETOE reflects 12 million fewer people employed, reporting 43.2 million employed, with a slight recovery in May of 300 000 employed, and a further recovery in June of around 5 million people employed (Figure 4). The falling participation rate clearly reflects that a large part of the working-age population ceased to be economically active as a result of the economic downturn.

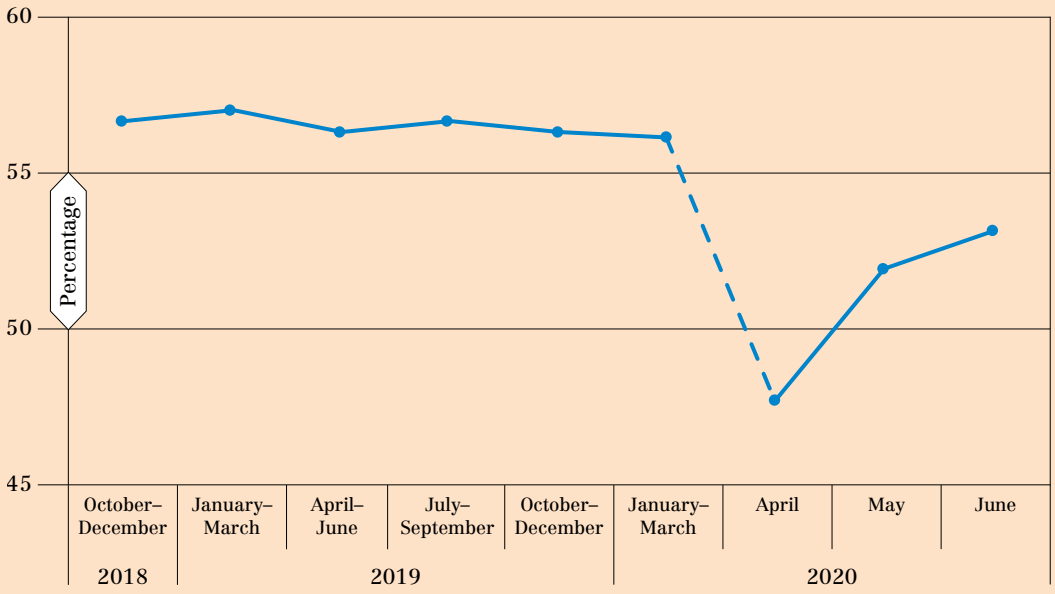
One of Mexico's most serious problems is the degree of informality in the labour market, which means that a significant number of workers do not have social security, many do not pay taxes, and many work under precarious conditions. The rate of informality had stabilized somewhat before the pandemic at around 56.0 percent, and, as could be expected, informal jobs decreased markedly with the economic shock that resulted from the pandemic (Figure 4). After April 2020, the secondary sector of economic activity lost 3 million workers (26.6 percent). Meanwhile, the tertiary sector lost 20.4 percent and the primary sector lost 17.5 percent.

FIGURE 4 Labour market participation and informality rates

A. PARTICIPATION RATE



B. EMPLOYMENT INFORMALITY RATE (TIL 1)



Source: Authors' own elaboration based on ENOE and ETOE data from INEGI.

The employment quality situation is alarming, because the number of workers who are now underemployed (that is, working fewer hours than they are willing to work) or who are being furloughed, and, as a result, receive less income, increased by 67.6 percent, by 85.1 percent and by 170.9 percent in the primary, secondary and tertiary sectors, respectively.

According to the National Agricultural Survey, in 2017 only 63.9 percent of agricultural workers were paid labourers (7.8 percent with a permanent contract, 12.6 percent as occasional hires, and 79.5 percent day labourers), and this percentage decreased to

57.1 percent in 2019 (6.4 percent with a permanent contract, 10.3 percent occasional hires, and 83.3 percent day labourers). This reveals that agriculture is a fairly unprotected sector in terms of social benefits and that its informality has been increasing. There are 11.8 million jobs (contracts) as day labourers in the farm production units included in the survey, and the most widely used contract mode is precisely as day labourers. Permanent posts are fewer, regardless of the size of the cultivated area. Moreover, 95.9 percent of the labour force is hired by small and medium-sized farms, and 4.1 percent by large farms.

Poverty

The various poverty indicators available for Mexico show two very interesting patterns. On the one hand, indicators of the most extreme poverty levels show a fairly sustained reduction between 2008 and 2018 (Table 5). By contrast, indicators reflecting multidimensional[9] and moderate poverty levels show an increase between 2008 and 2014 (due to the financial crisis between 2008 and 2010, and then, in 2014, due to the sharp rise in food prices), which reversed in the following years (as a result of greater macroeconomic stability), until the start of the pandemic. With the employment trends and economic downturn described above, these indicators of moderate and extreme poverty are expected to have deteriorated significantly in 2020. As noted in the main trends at the beginning of this second section, it is distressing that rural poverty remains high (55.3 percent in 2018, measured by income) and well above urban poverty (37.5 percent) (Table 5).

Table 5 shows that the population experiencing multidimensional poverty has been above 40.0 percent, following the pattern described above. According to the latest measurement in 2018, nearly 42.0 percent of the population suffered from multidimensional poverty. One of the most common deficiencies among the population is access to health and social security. Although the lack of social security has declined from 65.0 percent in 2008 to 57.3 percent in 2018, precariousness remains very high as social security is obtained through formal employment, and, as previously indicated, Mexico's labour market informality is very high. On the other hand, access to public health care is also obtained through formal employment, but this improved with the Popular Insurance programme that provided access to public health care for people who would not otherwise have been able to access it. This is reflected in the drop in the percentage of persons not covered from 38.4 percent in 2008 to 16.2 percent in 2018. It is important to note that, as of 2019, the new presidential administration shut down the Popular Insurance programme, replacing it with the Institute of Health for Welfare, which is in the process of incorporating beneficiaries. Such a change in the midst of a pandemic will likely result in an increase in lack of health-care coverage in the 2020 measurement.

[9] Since 2008, Mexico has officially measured multidimensional poverty taking account eight dimensions, which are the rights defined in the General Law on Social Development (DOF, 2004). This measure considers a person to be multidimensionally poor if he or she has an income below the line of well-being and have one unmet social right. Well-being means the person can afford to buy a complete food basket comprised of basic goods and services while, on the other hand, the social rights in which a person can be considered unserved are inadequacy or lack of basic housing services (water, electricity and gas) and materials for housing (ceiling, walls and enclosures), educational shortfall, food insecurity, no access to health services, and no social security (pension or employment benefits). In addition, the country measures income inequality within the federal territory where people live, considering this measurement as a proxy for social cohesion.

TABLE 5 Percentage of people in poverty according to various forms of measurement, 2008–2018

Indicators (%)	2008	2010	2012	2014	2016	2018
Population in multidimensional poverty	**44.3**	**46.1**	**45.4**	**46.1**	**43.5**	**41.9**
Population in moderate poverty	33.3	34.7	35.6	36.6	35.9	34.4
Population in extreme poverty	11.0	11.3	9.8	9.5	7.6	7.4
Population vulnerable to social deficiencies	32.2	28.0	28.5	26.2	26.8	29.3
Vulnerable population by income	4.6	5.8	6.1	7.0	7.0	6.9
Non-poor and non-vulnerable population	18.7	19.9	19.7	20.5	22.6	21.8
Deprivation of social rights						
Population deprived of at least one social right	76.6	74.1	74.0	72.4	70.3	71.2
Population deprived of at least three social rights	31.7	28.2	23.9	22.1	18.7	18.7
Indicators of social rights deprivation						
Educational shortfall	21.9	20.6	19.2	18.6	17.3	16.8
Lack of access to health services	38.4	29.2	21.5	18.1	15.5	16.1
Lack of access to social security	65.0	60.7	61.2	58.4	55.8	57.2
Lack of housing quality and space	17.7	15.1	13.5	12.3	12.0	11.0
Lack of access to basic housing services	22.8	22.9	21.2	21.2	19.3	19.7
Lack of access to food	21.7	24.8	23.3	23.3	20.0	20.4
Welfare						
Population with income below the extreme income poverty line	16.7	19.4	20.0	20.5	17.4	16.8
Population with income below the extreme income poverty line (rural)	32.8	34.9	32.7	31.9	29.2	27.3
Population with income below the extreme income poverty line (urban)	11.9	14.7	16.2	17.1	13.9	13.4
Population with income below the income poverty line	49.0	52.0	51.6	53.2	50.5	48.8
Population with income below the income poverty line (rural)	63.1	65.9	62.8	62.4	59.7	56.7
Population with income below the income poverty line (urban)	44.8	47.8	48.3	50.5	47.8	46.3

Source: Authors' own elaboration based on data from CONEVAL.

2.6 Primary sector and agribusiness

Agricultural reforms

As previously indicated, Mexico has undertaken two agricultural reforms. The first reform was implemented in 1939 and expropriated large estates, creating *ejidos*. The second, implemented in 1992, allowed for the privatization of *ejidal* property. According to official data from the National Agrarian Registry (2015):

> *…under the two programmes, more than 10 million agricultural land registration documents have been issued in Mexico from 1993 to date, for the benefit of around 5 million agricultural stakeholders and more than 30 thousand ejidal nuclei, of the country's existing 31 thousand* (RAN, 2015).

In recent years, there has been little progress in agricultural reform, but the Support Fund for Non-regularized Agricultural Nuclei (FANAR), established in 2007, helps farmers obtain land titles, which is essential to provide collateral guarantee when applying for production loans, which helps to support planting and agricultural production. Even so, it is believed that the reforms have not resulted in a significant socio-economic improvement for farmers (Cárcar Irujo, 2013), who also still have significant productivity gaps.

Another reform was the amendment of the National Water Law. Currently, however, the regulation of irrigation water use is in conflict in the State of Chihuahua. Some northern Mexican states, such as Sonora, have been documented as pioneers in the use of water and cutting-edge technology in planting and harvesting. The issue of irrigation, however, does not appear to have been a priority in public policy since 1980, and has rather been addressed by the private sector through better water management, along with fertilizer use, crop diversification, and planting systems, among other measures (McCullough and Matson, 2016).

In November 2012, the United States of America and Mexico signed a bilateral agreement, referred to as Minute 319 (Schlatter, Grabau and Waters, 2015), to allocate the Colorado River's environmental water flows in Mexico and expand restoration efforts to repair the water corridor. Under five-year agreements, both countries would provide 105 392 acre-feet of water to mimic natural flows to recover the Colorado River. These agreements are currently under review. They are important because they supply water to much of the country's Lagunera region. Water is a resource that is used throughout all three sectors of the economy, and will be important to expand Mexican agricultural production. In most cases, the output of irrigated agriculture is higher than that of rainfed agriculture. It is therefore essential to have new investment in irrigation, as this would increase water savings and agricultural production. Unsurprisingly, this has already been recommended by the Economic Commission for Latin America and the Caribbean (ECLAC), FAO and the Inter-American Institute for Cooperation on Agriculture (IICA) (2019) for agricultural and rural transformation.

Productive structure and intrasectoral growth

The primary sector has stabilised in the last 12 years at around 3.4 percent of GDP, while the secondary sector has reduced its share of the economy from 35.3 to 27.6 percent, and the tertiary sector has increased from 61.3 to 68.3 percent. The move to a service economy has been at the expense of the secondary sector, not the primary sector. However, there have been significant fluctuations in the GDP share of primary and secondary activities related to the agricultural and agribusiness sectors. For example, the primary sector's share of GDP has ranged from 2.7 to 4.2 percent between 2010 and 2019, mostly involving crop agriculture (1.4 to 2.7 percent), and livestock farming (0.95 to 1.3 percent), with quarterly cyclical behaviour. White maize seed production has increased since 2012, and yellow maize

production has declined from 2017 to 2019. As a whole, maize production accounted for 2.7 percent of GDP in 2020. In addition, cattle, pig and poultry production has increased to 1.2 percent of GDP in 2020.

It is apparent that, although primary-sector activities account for no more than 4.0 percent of GDP, their subsectors have very different growth rates. For example, within oilseeds, canola grew by 43.3 percent in 2019, while the rest of the oilseeds decreased. Within legumes, chickpea production decreased by 57.5 percent, while peas increased by 4.4 percent. Priority products in the NDP, such as maize, have moved in opposite directions and at significantly different rates. For example, forage maize grew over the past decade at a rate of 8.4 percent per annum, but decreased by 8.0 percent over the past year. Production of cattle, pigs, sheep and poultry, on average, achieved positive growth rates; while beekeeping and turkeys have had negative rates. The widely divergent growth rates of Mexico's agriculture subsectors reflects a number of factors ranging from markets to factors directly related to production and climate.

In 2017, the cultivation of sugar cane and white maize accounted for 35.5 and 4.6 percent, respectively, of the total number of hectares harvested in the country. Both sugar cane and maize are priority crops in the NDP, which is not surprising since the two commodities cover over 70 percent of production tonnage. On the other hand, in 2017 and 2019, 87.4 and 82.8 percent, respectively, of the volume of all agricultural production was produced for the markets, the rest being for household self-consumption.

There are also important production linkages between primary production and the food industry. As the number of cattle has increased, so has the production of milk. The food manufacturing subsector, within the secondary sector (32 percent of GDP), has fluctuated between 3.6 and 4.7 percent of GDP between 2010 and 2019, averaging 3.9 percent over the past 12 years. Within this sector, the main subsectors are "butchering, packing and processing of meat from cattle, poultry and other edible animals" and "making of bakery products and tortillas", each representing 1 percent, or a bit more, of GDP. The next section presents more in-depth analysis of productive linkages between primary production activities and the food industry.

Productive infrastructure gaps

In addition to the previously mentioned gaps in irrigation infrastructure, there are also significant technological lags in Mexican agriculture. For example, according to the National Agricultural Survey, regarding farmers' technology and/or machinery, only 19.5 percent in 2017, and 20.5 percent in 2019, of farming units declared that they had their own machinery, primarily tractors, followed by precision sowers (Table 6). A study looking at approximately 43.0 percent of Mexico's rural population (25 million people) indicates that agricultural households provide an average of 31 more employment days than non-agricultural households (Manning and Taylor, 2015). This reflects their lack of agricultural technology for harvesting crops, which forces small farmers to spend most of their time harvesting. According to the same study, increased agricultural efficiency would raise the value of rural households' time, reducing their farm work and likely expanding their opportunities to sell their produce on the market (Manning and Taylor, 2015). Clearly, investment in productive infrastructure is greatly needed in Mexican agriculture in order to boost productivity.

Purchasing inputs or raw materials and paying salaries or wages, continue to be the main uses of credit in the agricultural sector. In addition, for years, two of the farmers' greatest problems have been the high costs of inputs and climate-related crop loss. However, less than 11.0 percent of farms have obtained credit, according to data from the 2019 National Agricultural Survey.

SADER's priority objectives based on the 2019–2024 NDP, related to agricultural efficiency, include Objective 3.1 which refers to "Increasing sustainable production practices in the agricultural and aquaculture–fishing sector to address agroclimatic risks". Obviously, these are more achievable targets if there are new investments in productive infrastructure. The methodology and data used to evaluate prospective scenarios for new public investments in productive infrastructure for Mexican agriculture are explained below.

TABLE 6 Main problems facing farming units

Problem and trend	ENA 2012	ENA 2014	ENA 2017	ENA 2019
	Percentage			
High input and service cost ↓	81.4	83.4	75.7	73.8
Climate-related loss of crops or animals ↑↓	74.0	78.2	74.7	
Loss of crops or animals from biological causes			44.2	
Lack of training and technical assistance ↓	51.9	45.5	33.1	30.8
Difficulty in sales due to low prices ↓↑		37.2	31.7	33.1
Soil fertility loss ↓	48.6	39.4	28.4	27.9
Difficulty selling to another country			28.2	
Difficulty exporting due to strict technical and phytosanitary requirements			9.2	10.4
Insufficient infrastructure for production ↓	45.0	34.9	24.0	20.8
Difficulty in sales due to the existence of intermediaries ↑↓	26.5	37.2	22.8	24.3
Difficulty transporting and storing ↓		25.7	19.7	12.2
Elderly or ailing farmer ↑↓↑	23.3	24.6	18.9	19.5
Lack of safety ↓↑		25.3	17.0	19.6
Low incentive to export due to a better price in the local market ↑			9.6	12.6
Lack of product price information ↓↑		21.9	9.5	10.9

Notes: The partial figures do not add up to 100 percent because there are farming units that stated more than one problem. ENA = National Agricultural Survey

Source: Authors' own elaboration based on ENA data for the years 2012 to 2019.

3 Data and data analysis method

KEY MESSAGES

- Policy decisions regarding public investment in productive infrastructure for agriculture should be informed by prospective scenarios.
- An economy-wide model that considers the multisectoral diversity and current fiscal constraints of Mexico's economy is fundamental to developing such scenarios.
- Such tool is found in a computable general equilibrium model that, using information from a social accounting matrix, records macroeconomic, sectors' supply-demand, and institutions' income-expenditure balances.
- The model captures the interrelationships among 58 production sectors, 18 types of households (rural and urban, disaggregated according to their main income source), the Government (both its fiscal policies and its budget) and the rest of the world (represented through the balance of payments).
- The computable general equilibrium model needs to be combined with a microsimulation model to more adequately estimate distributional effects.

3.1 Scenarios with a general equilibrium model

It is obviously expected that public investment to promote agriculture will have effects on agriculture's production, directly but also indirectly (for example through input-output relationships between subsectors of agriculture and other sectors of the economy such as, undoubtedly, the food industry). Furthermore, the predominance of international agricultural trade can mean that some agricultural commodities account for a significant share of exports and imports. As a result, analysing policy shocks that affect agriculture, including a push for public investment in its subsectors, requires capturing the interrelationships among several economic agents, while paying particular attention to the direct and indirect effects that may be generated. In other words, an analysis of alternative scenarios that affect agricultural subsectors should take an approach that contemplates the economy as a whole and its entire multisectoral diversity.

The analysis of scenarios derived from a CGE model can help evaluate the short- and long-term macro and mesoeconomic effects of different shocks in a framework of analytical consistency that alternative methods do not offer. As will be apparent, consistency is ensured by simultaneous consideration of macroeconomic equilibrium, sectoral supply and demand balances, and the equalization of income and expenditure within each institutional sector (households, enterprises, government, and the rest of the world being among the most important). Recently, FAO has applied models such as the one used in this study to evaluate different public investment projects (see, among other articles, Sánchez, Cicowiez and Ramírez, 2020 and FAO, 2020). In this analysis, the CGE model

is complemented by a microsimulation model to more accurately estimate the effects on poverty and inequality.

In this study we apply a recursive dynamic CGE model, which had initially been developed as a generic model that can be applied in different contexts (Cicowiez and Lofgren, 2017). In essence, this CGE model has some relatively standard characteristics (see, for example, Lofgren, Lee Harris and Robinson, 2002 and Robinson, 1989), as well as others that make it particularly useful for assessing the effects of a shock such as that triggered by stepping up public investment in Mexican agriculture sectors. The remainder of this section discusses the general structure of the CGE model used in the study.[10]

Technically, a CGE model is a system of simultaneous equations, both linear and nonlinear. The CGE approach encompasses the entire economy, ensuring consistency among its components. In particular, it includes relationships among production sectors (and the income they generate), households, enterprises, government (including both fiscal policies and budgets) and the rest of the world (represented through the balance of payments). This is a useful, appropriate tool to analyse increases in public investment because it captures, holistically, household welfare; tax issues; differences among production sectors in terms of household preferences regarding what to produce, and from the supply side, their labour intensity, capital accumulation, and technological change; and, links with domestic and external markets (exports and imports).

Each year, the model is solved with official data from Mexico. For this purpose, the different agents (producers, households, government and rest of the world) must respect their budget constraints: income and expenditure are captured in full and balanced by design, as is the case in reality. Each agent's decisions pursue an objective that they must achieve, while respecting their budget constraints. More precisely, for producers and households, the aim is to maximize benefits and well-being (or profits), respectively. For example, households spend a share of their income on direct taxes and savings; another part is spent on their consumption basket, the composition of which they determine by maximizing their utility. The rest of the world, seen as an institution, also has its budget constraint: foreign exchange inflows and outflows are matched by an adjustment of the real exchange rate resulting from the model's solution. That is, the real exchange rate is the variable that is modified to balance transactions between Mexico and the rest of the world. Wages, rents and prices play a crucial role in balancing the supply and demand in the markets for factors of production and products (goods and services). The world price is taken for those products that are traded internationally, be they exported or imported (assuming that, being a "small" country, Mexico takes world prices as given). Domestically, however, the price for those products is also influenced by taxes, subsidies and the exchange rate.

The dynamic in the model is recursive because solutions for each year are linked to what happened in previous years, never in subsequent years.[11] Over time, production is determined by the growth in the use of production factors (labour, capital, land and natural resources) and the productivity of these factors. Capital stock growth is endogenous and depends on investment and depreciation.[12] On the other hand, for labour and natural resources (land for crops and livestock, fish stock for fishing, and subsoil assets for mining), the projected supply levels for each period are exogenous. In the case

10 Because of its detailed technical content, a supplementary document containing the model's mathematical statement is available upon request from the authors.

11 In other words, producers and consumers are myopic and make decisions year-to-year, assuming that the conditions of each year will hold for future years.

12 The values of endogenous variables are calculated by solving the model's system of simultaneous equations. By contrast, the values of exogenous variables are imputed and determined outside the CGE model.

of natural resources, those projected levels are linked to production forecasts. For labour, the projections reflect the evolution of the working-age population and labour participation rates. The unemployment rate is endogenous. The growth of total factor productivity (TFP) depends on the volume of public investment.

3.2 Social accounting matrix

The main source of information for applying a CGE model is a social accounting matrix (SAM) – a table with the same number of rows and columns which records the value of transactions between activities, products, households, enterprises, government and the rest of the world. For example, a SAM shows the amount that each productive activity allocated to purchasing intermediate inputs from other productive activities and to paying for production factors (labour, capital, land and other natural resources).

This study uses a 2018 SAM for Mexico that was built combining the following sources of information: supply and use tables (SUTs), prepared by the INEGI Experimental Statistics group; integrated economic accounts, also prepared by INEGI; and information on government financing from SHCP. In addition, it uses INEGI's 2013 input-output matrix to disaggregate agriculture activities and products identified by the supply and use table of 2018. Based on these inputs, the 11 activities and agricultural products identified in the supply and use table of 2018 were disaggregated to have 16 activities and agricultural products in order to generate better results for this study.[13] Payments to the labour factor (or remuneration) were disaggregated according to the highest level of education achieved using the ENOE, and households were disaggregated according to their main source of income, using the ENIGH.

Table 7 shows the dimensions of the SAM that were used to calibrate the CGE model for Mexico. In general, production sectors that in one way or another appear as priorities in the NDP are identified individually.[14] The disaggregation of the model also pays special attention to sectors of the food industry that use agricultural products as intermediate inputs for their production. For example, the meat and dairy sectors are closely linked to livestock farming. The milk sector, in particular, is also a priority in the NDP. The model assumes that aquaculture and fisheries produce similar but not identical products (fish); that is, the production of one activity or the other are imperfect substitutes for both intermediate and final consumption.

The figures that follow in this section help described the structure of Mexico's economy on the basis of the data from the 2018 SAM. Specifically, the figures cover information on the production structure, including production linkages, international trade and income from institutional sectors. The information is also useful for interpreting the results of public investment scenarios generated through the CGE model. To facilitate the description, the 58 production sectors included in the SAM were aggregated into 14.[15] However, the activities and products mentioned as priorities in the NDP are maintained as individual elements in the figures below.

[13] For example, in the supply and use table for 2018, beans, wheat, corn, and rice fall within the group of "oilseeds, legumes and cereals" but we needed to have these separately as much as possible.

[14] The sectors explicitly identified in the NDP are as follows: beans, wheat, corn, rice, coffee, sugar cane, beef cattle, dairy cattle and combined-use cattle.

[15] However, the simulation exercises described in the next section were conducted with the disaggregated version of the CGE model database.

TABLE 7 Accounts in Mexico's social accounting matrix

Category	Item
Sectors (activities and products)	Agriculture, forestry and fisheries (20):* oilseeds; bean; other legumes; wheat; maize; rice; other cereals; vegetables; coffee; other fruits; sugar cane; other crops; flowers; cattle; pigs; birds; aquaculture; other animals; forestry; fishing
	Mining (2): oil and gas; other mining
	Manufacturing (23): balanced animal feed; grinding; sugar; vegetable preserves; dairy products; meat; fish; bakery; other foods; beverages; tobacco; textiles; leather; wood and paper; refined petroleum products; fertilizers; other chemicals; rubber and plastic; non-metal mineral products; metals and metal products; machinery and equipment; vehicles; other manufactured goods
	Other industries (2): electricity, gas and water; construction
	Services (11): trade; transport; financial services; professional services; support services; education; health care; hotels and restaurants; domestic service; public administration; other services
Distribution margins	Domestic products
	Imports
	Exports
Production factors	Workers, whose education is: less than primary; primary; lower secondary; upper secondary, higher
	Private capital
	Government capital
	Natural resources: land (crops and livestock), forestry, fishing, extractive activities (2)
Institutions**	Households: rural (9); urban areas (9)
	Enterprises
	Government
	Rest of the world
Taxes and subsidies	Social security contributions (3)
	Taxes on production
	Import taxes
	Commodity taxes: value-added and consumer-selective tax
	Income taxes

TABLE 7 (cont.) Accounts in Mexico's social accounting matrix

Category	Item
Investment	Private investment
	Government investment
	Changes in inventories

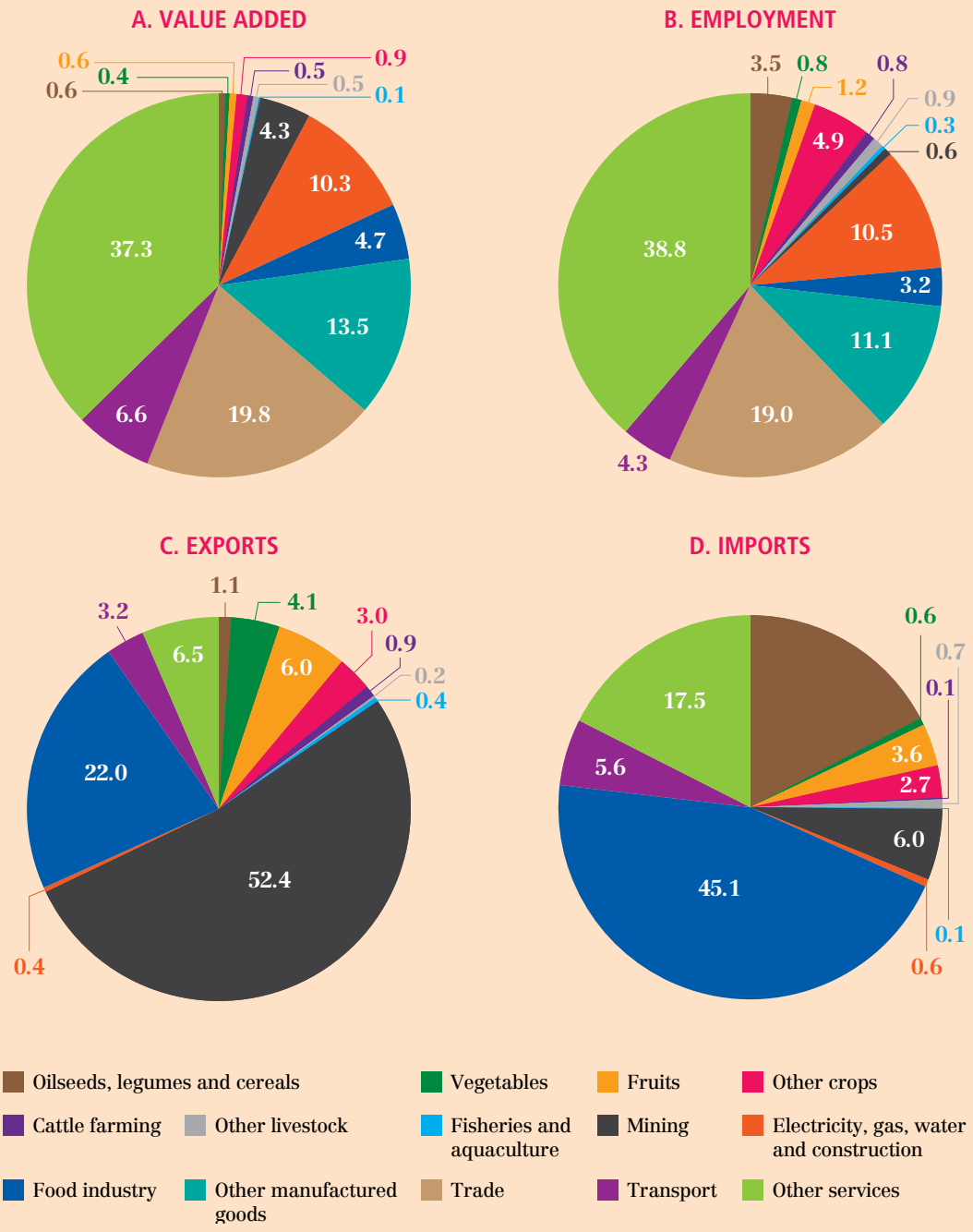
Notes: * The following sectors are grouped because their production individually represents a very small proportion of Mexican GDP: other legumes, which includes chickpeas and other legumes; other cereals, which includes rice, sorghum, oats, barley and other cereals; other fruits, which includes orange, lemon, other citrus, banana, mango, avocado, grape, apple, cocoa, coconut and other fruits; and other crops, which includes tobacco, cotton, alfalfa, pastures, agave, peanuts and other crops. ** For each of these institutions, a capital account is also identified that makes it possible to model the domestic borrowing of the Government and the foreign borrowing of households, enterprises and the Government.

Source: Authors' own elaboration.

Figure 5 summarizes Mexico's sectoral structure of both production (panels a and b) and foreign trade (panels c and d). Panels (a) and (b) show sectoral participation in the country's value-added and employment, respectively. The agricultural sector altogether accounts for 3.2 and 12.4 percent of value added and employment, respectively. That is, the sector features relatively low values for the ratio of value added to employment. Specifically, the value added per worker in agriculture and the other sectors is 0.3 and 1.1, respectively. For international trade, agriculture accounts for 2.6 percent of Mexico's total exports and imports. In 2018, oilseed crops accounted for less than half a percentage point of agricultural value added, such that the SAM considers them together as a group. Cereals – wheat (2.1 percent), maize (14.4 percent), rice (0.1 percent) and sorghum (3.3 percent) – account for almost 20.0 percent of agricultural value added when considered together. Beans stands out among the legumes. The other sectors analysed in detail in this study are vegetables, fruits, cattle farming, pig farming, forestry, and fishing and aquaculture, which are considered together.

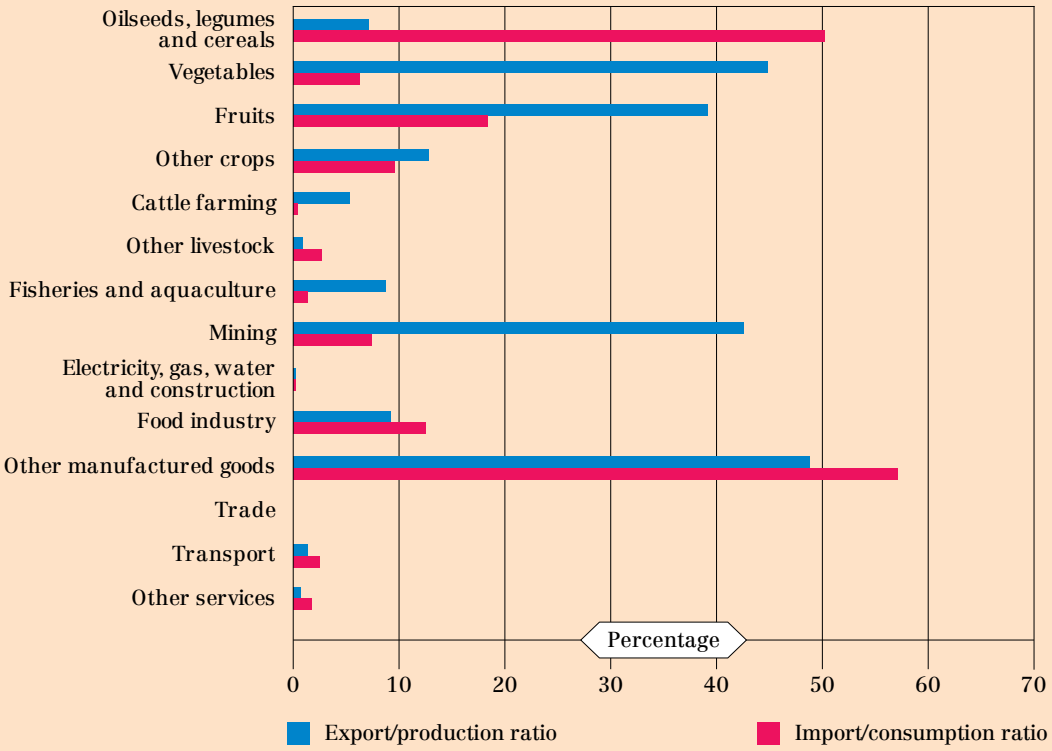
Figure 6 shows the export and import orientation of Mexico's different production sectors. Generally speaking, although with some exceptions, agricultural products identified in Mexico's SAM are not very export-oriented when compared to industrial-based manufacturing. However, there are some crops that contribute considerably to the external market. For example, 67.8 percent of coffee bean production goes to the export market; however, the sector represents a relatively small portion of Mexico's agricultural exports. Sugar cane is an interesting case because it is not traded with the rest of the world directly, but 19.1 percent of sugar cane by-products, such as sugars, chocolates and sweets, are exported. This highlights the importance of considering production linkages or input-output relationships in analysing agriculture and food (see also Figure 8).

FIGURE 5 Sector structure, 2018 (%)



Note: Exports and imports exclude other manufactured goods, which together account for 83.3 and 89.6 percent of exports and imports, respectively.
Source: Authors' own elaboration.

FIGURE 6 Export and import orientation of production sectors, 2018

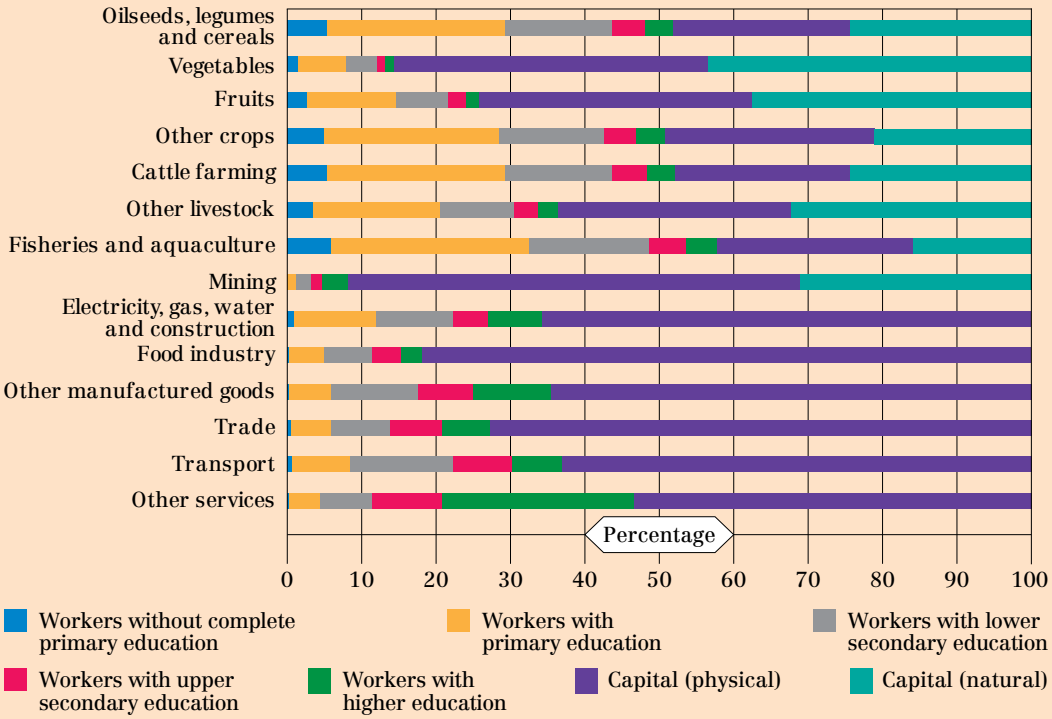


Source: Authors' own elaboration.

On the other hand, imports play a significant role in the total supply of several agricultural products in Mexico. For example, in oilseeds, wheat and rice, 96.2, 73.6 and 89.0 percent of domestic demand, respectively, were covered by imports in 2018. Taken together, the information presented in Figure 6 suggests that the Mexican agricultural sectors promoted in the NDP are limited in terms of expansion by the size of the domestic market. That is, all other things being equal, increased production could be absorbed if prices are reduced. Incidentally, internal demand is less of a constraint to increasing production in more export-oriented sectors. Food industry sectors are also geared towards the domestic market, except for sugar (as previously indicated) and fish products, exporting 19.1 and 72.8 percent of their production, respectively.

Figure 7 shows production factor use intensity in different production sectors. Agriculture tends to be relatively intensive in employing workers with an educational level below the full secondary level. This is consistent with the observation made above, that relatively low technical development means agricultural households spend much of their time on farm activities. In turn, land is the most intensively used natural resource in agricultural production. Sectoral value-added composition is a fundamental element in explaining the distributional results of each of the scenarios considered in the next section. For example, promoting agricultural activities will have relatively more significant positive effects on the welfare of households who earn most of their income from the work of members who have less than a secondary education.

FIGURE 7 Intensity of production factor use, 2018

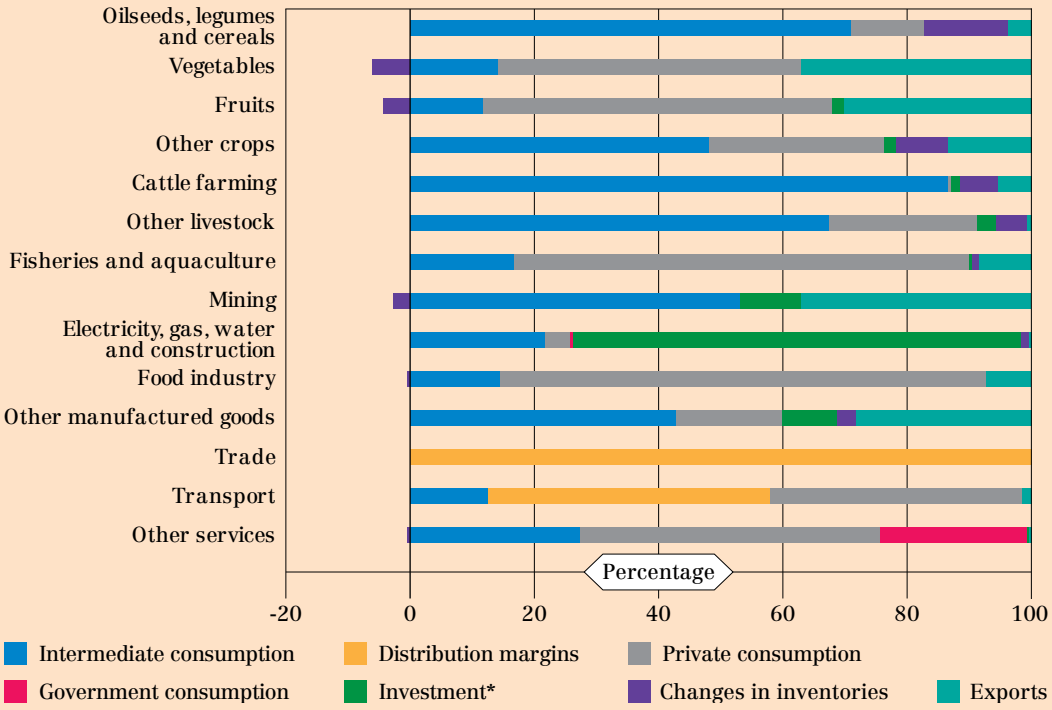


Source: Authors' own elaboration.

Figure 8 shows the destinations of sectoral production and, although aggregated, it shows production linkages between sectors. For example, vegetable and fruit produce is directly consumed in a relatively large proportion by households, 48.7 and 56.0 percent, respectively. By contrast, 71.0 percent of the production of oilseeds, legumes and cereals is used as inputs in other productive sectors; that is, most of the production is intended for intermediate consumption. Other input-output relationships that are relevant to this study at a more disaggregated level (not shown in the graph), can also be highlighted. For example, maize production is used as an input, mainly in livestock and farm production (10.8 percent), animal feed production (11.8 percent), milling (26.2 percent) and in bakeries (17.2 percent). In total, 71.4 percent of maize production is used as an intermediate input in other production activities. Similarly, cattle farming sells 28.1 percent and 56.8 percent of its production to the dairy and meat sectors, respectively; pig farming sells 96.9 percent of its production to the meat sector; and poultry sells only 55.4 percent to the meat sector and 31.7 percent directly to households that eat chicken.

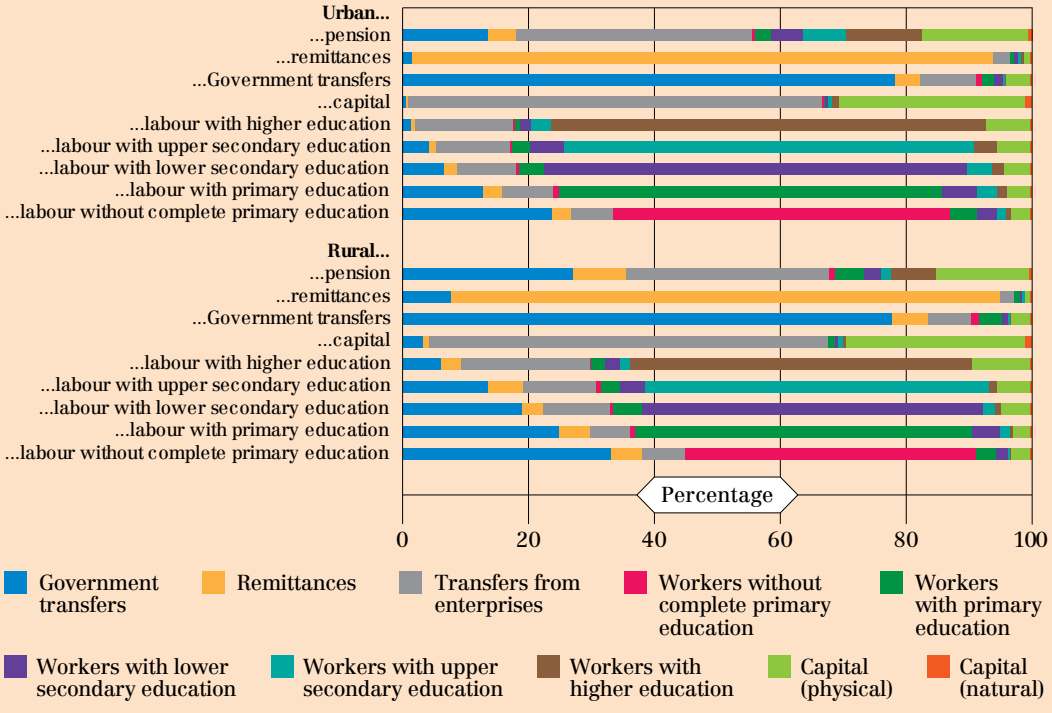
Finally, Figure 9 shows the source composition of the representative households identified in the SAM and CGE model by source of income. The name of each representative household indicates its main source of income. For example, rural households specialized in working at jobs requiring a primary school education earn 53.9 percent of their income with this level of schooling and represent 6.2 percent of the total population. Rural and urban households that earn most of their income from jobs requiring higher education account for 2.9 and 32.0 percent of the total population, respectively. In other words, skilled employment is concentrated in urban areas of Mexico.

FIGURE 8 Sector demand structure, 2018



Note: * Investment refers to gross fixed-capital formation.
Source: Authors' own elaboration.

FIGURE 9 Sources of household income, 2018



Source: Authors' own elaboration.

3.3 Additional data

In addition to the SAM, the CGE model uses several parameters to determine how producers and consumers respond to price and income changes. In technical terms, these are production and consumption elasticities. In particular, the CGE model requires, for each production sector or commodity depending on the case, the following elasticities: substitution between different production factors, substitution between imports and domestic purchases, transformation between exports and domestic sales, income (or expenditure) for each product consumed by households, and elasticity of wages with respect to unemployment. The value of these elasticities is the result of an exhaustive review of the literature. Table A1 shows the elasticities used. The ranges of each elasticity are discussed below.

The elasticity of substitution between production factors ranges from 0.20 for extractive sectors, to 0.95 for manufacturing and services (see Aguiar *et al.*, 2019). In agricultural sectors, a substitution elasticity of 0.25 is used to capture the difficulty of replacing natural resources such as land. As a result, agricultural and mining sectors cannot easily increase their production without increasing land and subsoil assets, respectively. Trade-related elasticities (between imports and domestic purchases, and between exports and domestic sales) take the following values: 2.0 for primary products, 1.5 for manufactured goods, and 0.9 for other industries and services (see Sadoulet and Janvry, 1995). In the last category, from the perspective of consumers, the value of less than 1 implies that domestic and imported products complement each other. Further, the elasticities that define the substitution between destinations for Mexican products, between exports and domestic sales, also known as transformation elasticities, are assumed to be equal to the substitution elasticities between imports and domestic purchases. The model assumes that household preferences are of the "Stone-Geary" type, deriving a linear expenditure system. Expenditure elasticities define how much households change their consumption of each good or service depending on changes in total expenditure on goods and services. In Mexico, expenditure elasticities were obtained from the econometric work of Muhammad *et al.* (2011), with relatively low estimates for food and textiles products.[16] The elasticity of wages with respect to unemployment, which appears in the wage curve described above, was set at -0.1 for the labour categories under consideration, which is consistent with the estimates reported in Blanchflower and Oswald (2005) for a wide variety of countries. That is, if the unemployment rate changes by 1.0 percent, wages will change 0.1 percent.

In any event, given the uncertainty of supply and demand elasticities in our model, Annex B assesses the sensitivity of the results to changes in their values.

[16] Calibration of the linear expenditure system also requires the Frisch parameter (Dervis, de Melo and Robinson, 1982), which is defined as the quotient of discretionary spending over total expenses. Discretionary expenditure is money spent after satisfying the minimum consumption of each good and service. In this case, the Frisch parameter ranges from -4.1 to -1.3, depending on the per capita income level of the representative household.

3.4 Microsimulation model

The CGE model is combined with a microsimulation model to estimate the distributional effects of the different scenarios considered. The CGE model and the SAM for Mexico identify 18 representative households according to their main source of income (see Figure 9). Therefore, a significant part of the distributional effects generated by changes in factor remuneration are captured within the CGE model. In particular, changes in income/consumption distribution among representative households are determined in the CGE model. However, income distribution within each representative household is assumed to be constant. In a second stage, the microsimulation model distributes, among individual households identified in the ENIGH, the changes in income/consumption of each representative household. To do this, each individual ENIGH household is linked to one of the representative households in the CGE model. For example, if the CGE model results show that income from unskilled labour increases, households earning part of their income from unskilled work will experience, all other things being equal, an increase in income/consumption. The microsimulation model reports standard indicators of monetary poverty and the Gini coefficient as an indicator ofinequality.

4 Investment scenarios: definition and analysis of results

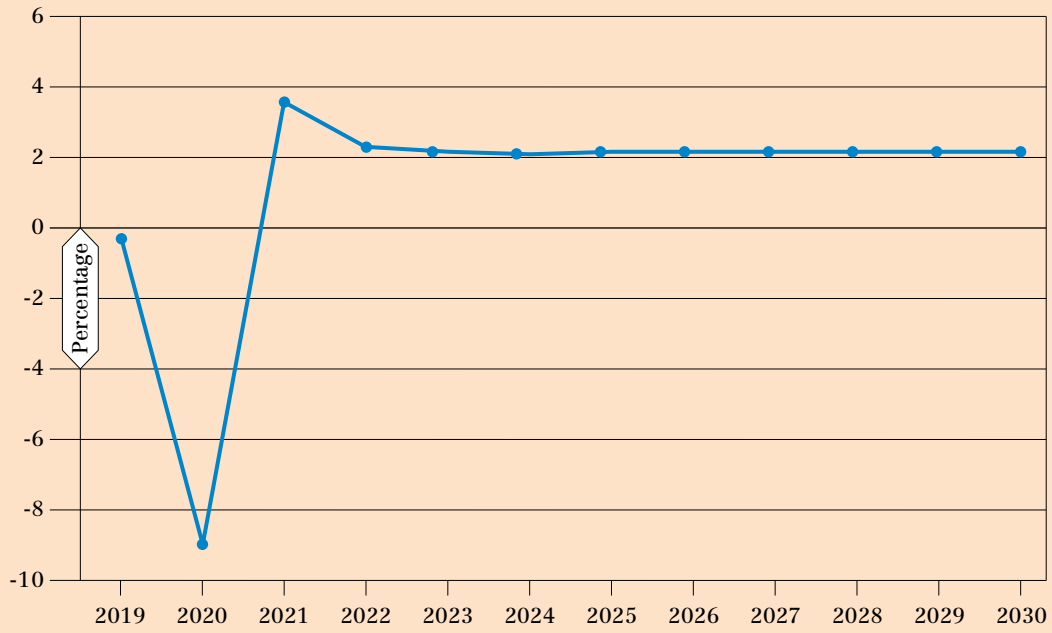
KEY MESSAGES

- Public investment scenarios need to be evaluated by comparing them to a base scenario that reproduces the economy's behaviour in the 2018–2021 period and projects it to 2030.
- In 21 scenarios, new public investment in productive infrastructure in agriculture subsectors accounted for 0.25 percent of GDP (around MXN 50 billion, in 2018) between 2021 and 2023 – a reasonable amount to evaluate according to SADER.
- These public investments, which improve rural roads, irrigation systems, storage infrastructure, etc., increase productivity by 0.3 cents for each peso invested.
- When the new public investment is allocated to crop subsectors, economic growth is more significantly impacted than when such investment is allocated to the livestock subsector, because of the linkages with international trade.
- In all scenarios, there is a positive impact on agrifood GDP and the results for people's welfare (as measured by private consumption) and rural poverty reduction are all favourable.
- According to the net present value of the new public investment, the discounted gain in terms of Mexican households' welfare outweighs the cost of the investment.
- Among the various options considered for financing the new investment (foreign borrowing, domestic borrowing, direct taxes and efficiency gains in the public sector), foreign borrowing is the option that enables the investment to generate the greatest short-term economic recovery.
- According to the ranking, the sugar cane sector comes first in three of the four variables considered (private consumption, total GDP, agrifood GDP and rural poverty reduction) as a result of the investment that it receives.
- Cereals, mainly maize, but also rice, sorghum, oats, barley and other cereals, and more export-oriented crops, such as flowers and coffee, also score high in the ranking.

4.1 Base scenario: the point of departure

Before describing the scenarios for new public investment in infrastructure aimed at generating a productivity shock in Mexican agriculture, it is important to explain the base or reference scenario to which those scenarios are compared. The base scenario starts from 2018, the year for which the SAM used in the study was developed. In order to project the base scenario, the GDP growth rate for the 2019–2030 period is inputted into the model.[17] The base scenario reflects the growth observed in 2019–2020, including the recession caused by the pandemic, and imposes a recovery according to IMF projections released in October 2020 for the period through 2025, assuming no policy changes or external shocks.[18] Then, for the 2026–2030 period, the 2025 growth rate is maintained (see Figure 10). The projected fall in GDP for 2020 is 9.0 percent, but the recovery a year later is around 3.5 percent GDP growth. For the 2021–2030 period, an average annual growth rate of 2.3 percent is imposed. The economically active population grows at the same rate as the working-age population. The supply of agricultural land remains constant. Extraction of natural fishery and mining resources grows at the same rate as GDP. Government revenues and spending, as a share of GDP, evolve smoothly, reflecting policy stability in these major variables.

FIGURE 10 GDP growth rate in the base scenario



Source: IMF, 2020.

17 That is, the growth rate is considered exogenous in order to generate the base scenario, making TFP endogenous. Thus, the recession generated by the COVID-19 pandemic is interpreted as a negative TFP shock.

18 In January 2020, the IMF published new growth projections covering only 2021 and 2022. In the case of Mexico, growth projections improved over those used here, by 0.8 and 0.2 percentage points, respectively. In any event, because the findings of this study were obtained by comparing public investment scenarios in agriculture with the base scenario, changes in the growth projections used to generate the base scenario do not substantially affect the findings discussed below.

In addition, in order to generate a base scenario that replicates what was observed in 2018–2020, in order to subsequently converge to stable growth rate, the following assumptions are made: tax rates remain unchanged; other government revenues (such as domestic and foreign borrowing) as well as all government spending evolve proportionally to the GDP, which is observed and kept constant; and, except for exports and imports, balance-of-payments components also evolve as an exogenous proportion of GDP.

The base scenario is not a forecast of how we expect Mexico's economy to evolve until 2030. Rather, it is a projection, assuming that external conditions (mainly international prices) and domestic conditions (mainly economic policies) do not change during the 2021–2030 period.

Figures 11 through 14 show the evolution of macroeconomic, sectoral and distributive variables in the base scenario. The base scenario is constructed to assume, once the drop in GDP from the COVID-19 pandemic has been overcome (see Figure 11), that the economy will grow in a balanced fashion; that is, all macroeconomic aggregates grow at a similar average annual rate for the 2021–2030 period. Thus, based on these assumptions, the macroeconomic aggregates grow in a balanced manner, with average annual growth rates for the 2021–2030 period of around 2.3 percent (Figure 12). In terms of the agriculture sectors, and because they use agricultural land, assumed to be in virtually constant supply, their growth rate is lower than that of other sectors, usually less than 2.0 percent, except, of course, for fishing, which is not land-intensive (see Figure 13).[19] The other productive sectors have average annual growth rates ranging from 1.7 to 2.6 percent. Interestingly, the oil sector has a relatively high growth rate, due to its significant export orientation.[20]

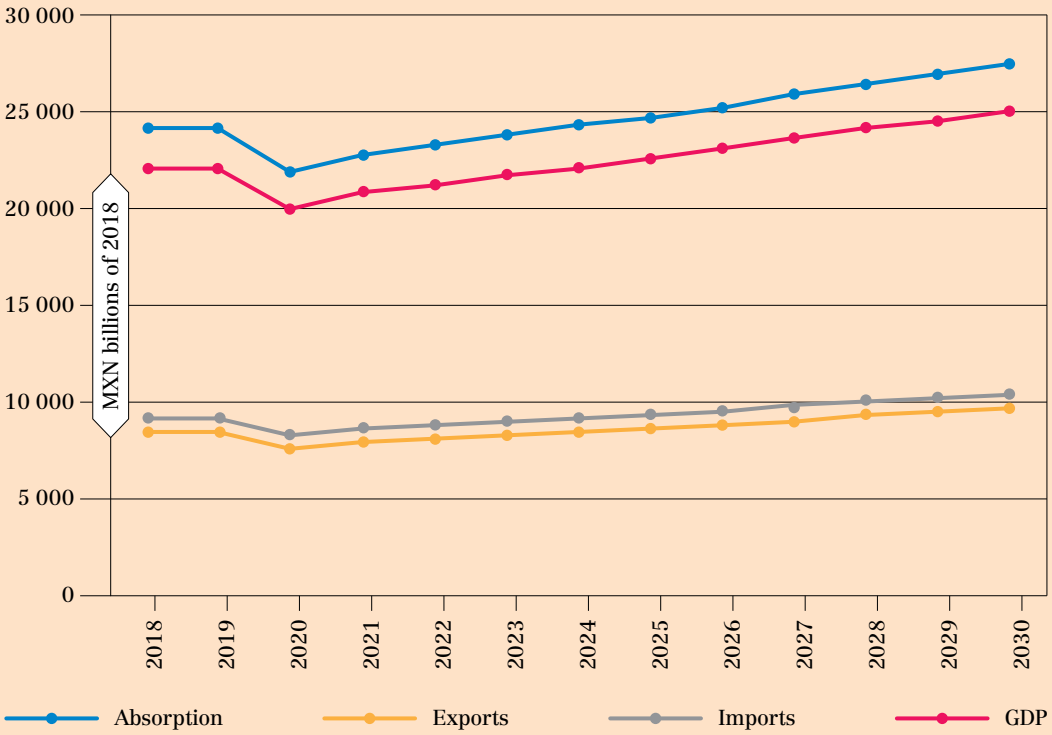
In terms of poverty, the base scenario shows a significant increase in 2020, as a result of the falling GDP due to the economic recession caused by the pandemic. Measured by consumption, rural and urban poverty rates are projected (rather than predicted) to increase, for example, to 60.0 and 41.8 percent, respectively, in 2022, maintaining the rural-urban gap. With the recovery of private consumption in the base scenario, poverty rates will drop and are projected to be 54.3 and 36.7 percent, respectively, by 2030 (see Figure 14). This fall in poverty by 2030 in the base scenario is explained by the projected per capita GDP growth (see Figure 10).

[19] In the other sectors, the growth rate is determined as a function of the amounts of capital and labour they employ. They are not restricted by the use of natural resources such as land or mining resources.

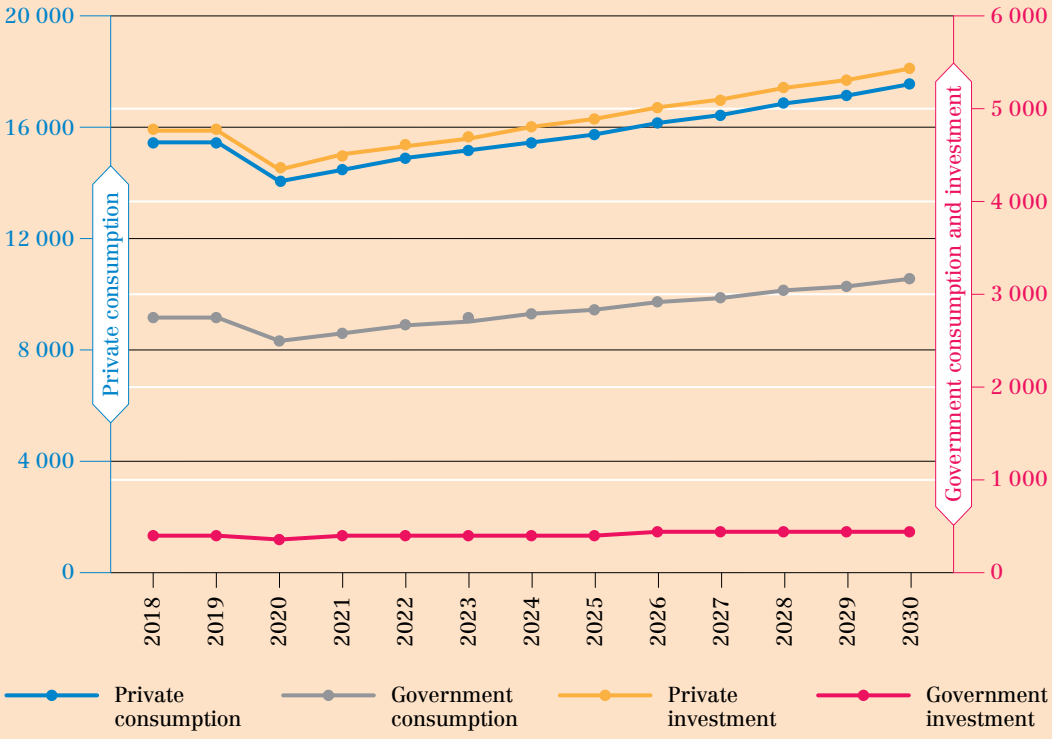
[20] Just over 57 percent of Mexico's mining production is exported to the rest of the world.

FIGURE 11 Selected macroeconomic indicators in the base scenario

A. ABSORPTION, FOREIGN TRADE AND GDP (MXN BILLION OF 2018)

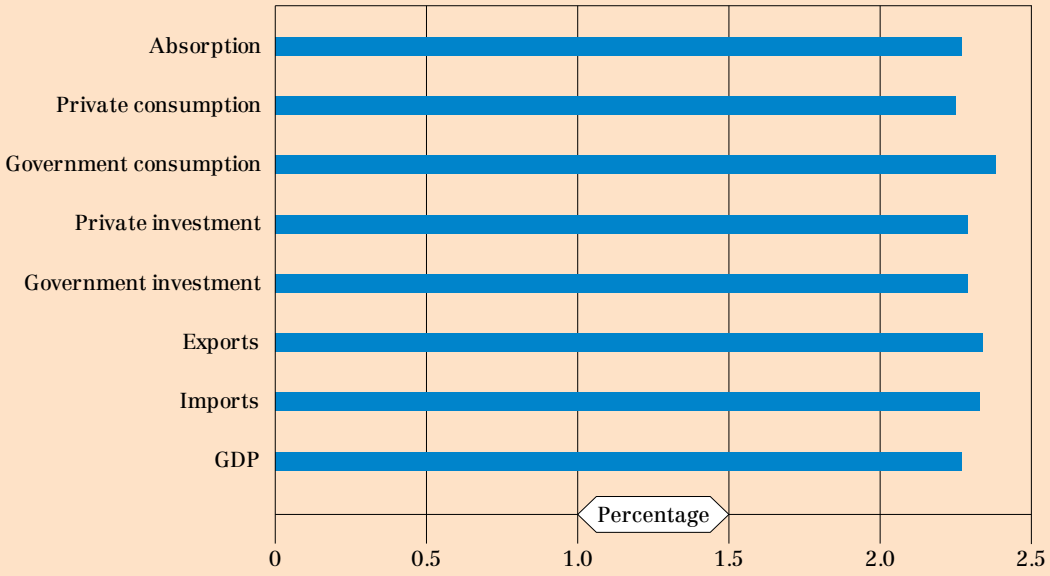


B. CONSUMPTION AND INVESTMENT (MXN BILLION OF 2018)



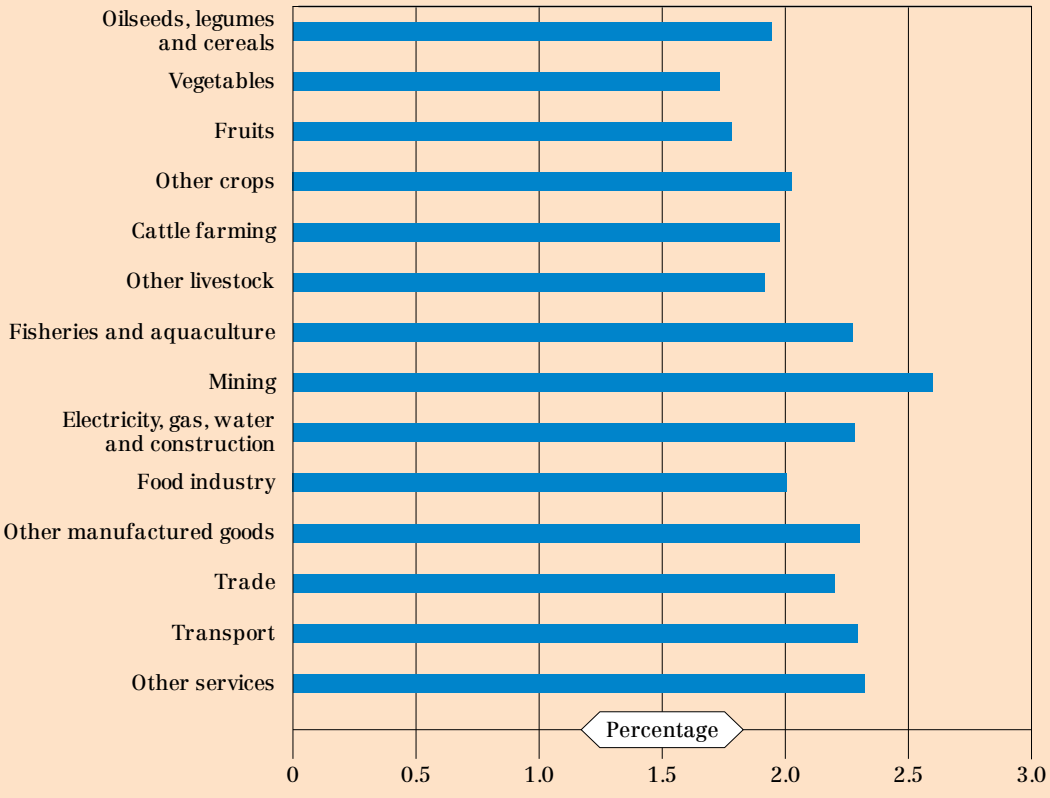
Source: Authors' own elaboration.

FIGURE 12 Average annual growth rate (%) of selected macroeconomic indicators in base scenario (2021–2030)



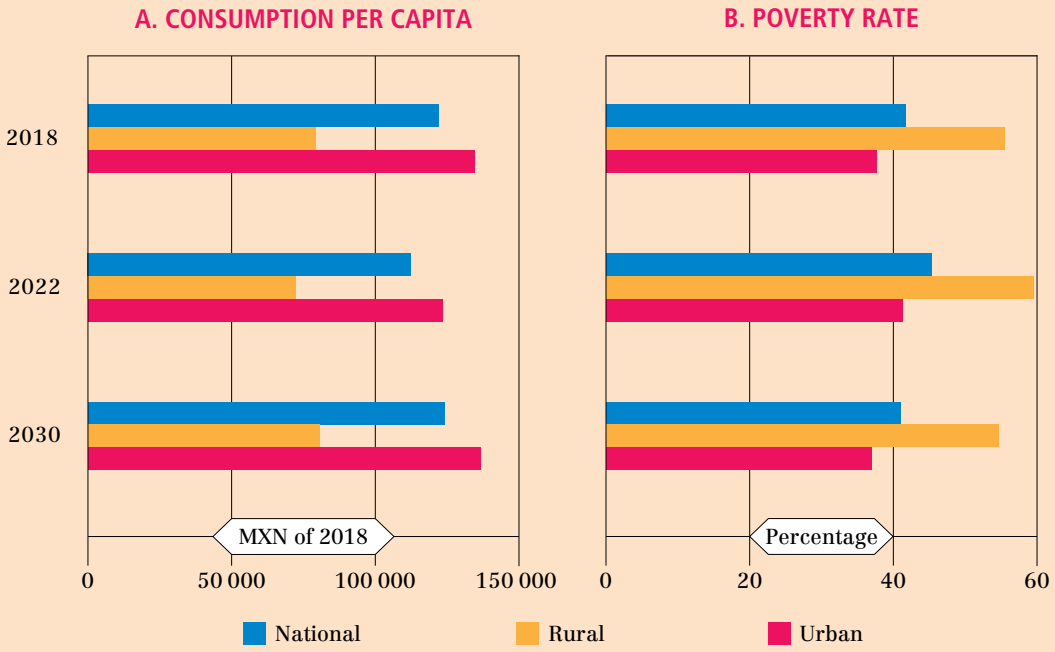
Source: Authors' own elaboration.

FIGURE 13 Average annual growth rate (%) of sectoral production in base scenario (2021–2030)



Source: Authors' own elaboration.

FIGURE 14 Per capita consumption and poverty rates in base scenario



Source: Authors' own elaboration.

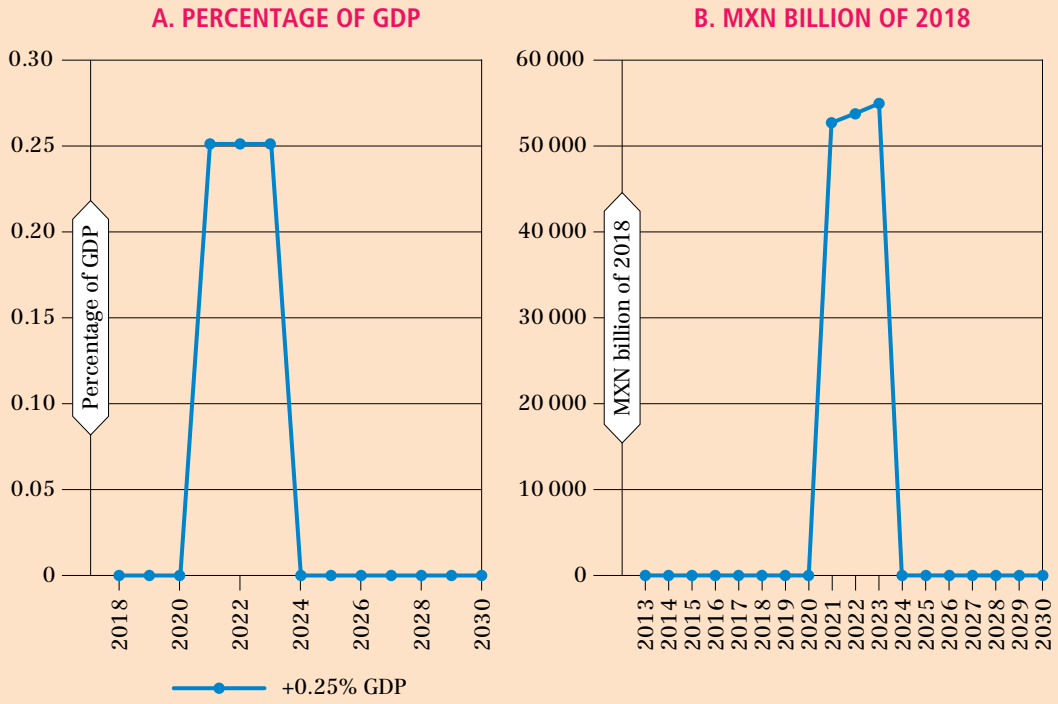
4.2 Scenarios of public investment in productive infrastructure

Definition of the scenarios

A total of 21 scenarios of public investment in productive infrastructure were developed, the results of which are analysed against the base scenario. A common feature of all the scenarios is the public investment shock that is simulated in all of them. Previous discussions with SADER determined that, as part of the economic recovery, it is realistic to think of new public investments in productive infrastructure representing 0.25 percent of GDP (around MXN 50 billion, in 2018) during the 2021–2023 period. This is precisely the investment shock that the 21 scenarios consider on top of what happens in the base scenario (see Figure 15). In addition, these 21 scenarios assume that factor productivity in the investment-receiving sectors would be increased by the equivalent of 0.3 cents for each additional peso invested. In this regard, let us remember that an increase in TFP (such as an increase in agricultural yields) will result in a higher output with the same level of utilization of production factors. Thus, the marginal product of public capital determines how much TFP increases with a given increase in public investment. The estimate used to establish a value for this parameter in the model is consistent with empirical evidence that exists for developing countries such as Mexico. Annex A considers the effects of varying the impact on the productivity (or yield) of new public investment and the amount of investment.[21]

[21] Estimates for the marginal product of public capital vary greatly in the relevant literature, but tend to range from 0.15 to 0.60 for a large number of countries (see Gupta et al., 2014 and Dessus and Herrera, 2000). In addition to the value of 0.3, this study also considers more extreme values for the marginal product of public capital (0.0 and 0.6) (see Annex A).

FIGURE 15 Increased public investment in productive infrastructure in the new scenarios relative to the base scenario



Source: Authors' own elaboration.

It is important to understand that there are major differences among the 21 public investment scenarios. Table 8 describes each scenario. The name of each scenario contains an abbreviation of the agriculture sector/subsector that the productive impact of the public investment focuses on, and the first four cases have an additional abbreviation denoting the source that finances the investment. Scenarios 1 through 4 assume that the new public investment goes to all crops considered as a whole, while considering the following four possibilities to finance the investment: foreign borrowing (crops-fbor), domestic borrowing (crops-dbor), direct tax income (crops-tdir) and increased efficiency in public spending (crops-eff). The last case assumes that investment is financed by saving resources in other areas of government, without increasing public debt or tax collection. Scenarios 1 through 4 determine the impacts of increased productivity resulting from public investment in infrastructure and compare the short- and medium- to long-term effects generated by the different financing alternatives. Based on the trade-offs they generate over time, the financing source is chosen for the other scenarios that is considered most favourable in generating short-term economic recovery; in this case, foreign borrowing, as explained below.

TABLE 8 Definition of public investment scenarios in production infrastructure

#	Name	Sectoral focus	Source of funding
1	crops-fbor	crops	foreign borrowing
2	crops-dbor	crops	**domestic borrowing**
3	crops-tdir	crops	**direct taxes**
4	crops-eff	crops	**efficiency public spending**
5	livestk	**livestock**	foreign borrowing
6	oilbrp	**oil-bearing plants**	foreign borrowing
7	bean	**beans**	foreign borrowing
8	othrlegum	**other legumes**	foreign borrowing
9	wheat	**wheat**	foreign borrowing
10	maize	**maize**	foreign borrowing
11	othrcereal	**other cereals**	foreign borrowing
12	veg	**vegetables**	foreign borrowing
13	coffee	**café**	foreign borrowing
14	othrfruts	**other fruits**	foreign borrowing
15	sugcane	**sugar cane**	foreign borrowing
16	othrcrops	**other crops**	foreign borrowing
17	flowers	**flowers**	foreign borrowing
18	bovine	**cattle**	foreign borrowing
19	pig	**pig**	foreign borrowing
20	poultry	**poultry**	foreign borrowing
21	fishing	**fisheries and aquaculture**	foreign borrowing

Notes: The element of the first scenario that is modified in scenarios 2 through 21 is highlighted in bold and blue letters. The detail of what the sectors include is presented in the note in Table 7.

Source: Authors' own elaboration.

Scenarios 5 through 21 vary in terms of which sector or subsectors benefit from the new public investment, financed, in all cases, through foreign borrowing. For example, in scenario 5 (livestk), livestock farming is the sector that, as a whole, experiences the productivity shock resulting from new investment financed through foreign borrowing. By contrast, scenarios 18 through 20 focus on livestock subsectors (specifically, cattle, pig and poultry, respectively). Scenario 21 (fishing) promotes the fisheries sector, including both fishing itself (catching fish) and aquaculture.[22] Thus, the second group of scenarios brings about increased sectoral detail and helps to rank sectors and subsectors of agriculture according to the cost-effectiveness of the new public investment that boosts their productivity, which is reflected in changes in different indicators such as GDP, private consumption, private investment, exports and net present value of investment, among others.

[22] In the CGE model, as in reality, fishing is limited by the available natural resource stock. However, aquaculture can expand its production as long as it increases its level of employment and/or capital stock. In other words, we assume that aquaculture has a flatter supply curve than fishing.

The 21 public investment scenarios that are simulated are different from the base scenario for the 2021–2030 period, while for the 2019–2020 period they are all are identical. Increases in public investment are introduced during the 2021–2023 period, and public investment returns to the levels of the base scenario in the 2024–2030 period (see Figure 15). These last years of simulation in the scenarios display the medium- to long-term effects of public investment.

Transmission channels

Panels a through c in Figure 16 summarize the main transmission channels that explain the results generated by simulating the public investment increase in all 21 scenarios. Panel a refers to effects directly linked to increased public investment itself. In all scenarios, growth in public investment builds up the stock of public capital, which in turn positively impacts the TFP of the agriculture sector (or subsectors) benefitted by the investment, depending on the value assumed for the marginal product of public capital. Increased TFP in agriculture or selected subsectors will then have a positive effect on GDP, which will depend on a number of factors, among the most important being backward and forward production linkages (that is, input–output relationships among sectors), the share of value added in gross production value and the export-orientation of the sector or subsector promoted. In all cases, increased productivity is expected to positively impact household incomes, and this, in turn, will have positive effects on consumption, savings and private investment.

The remaining four panels in Figure 16 (b, c, d and e) refer to the effects directly linked to the source of funding used by the Government to finance the new investment in productive infrastructure. In panel b, foreign borrowing finances public investment without directly affecting domestic demand. On the other hand, foreign borrowing translates into an inflow of foreign exchange, which pushes the real exchange rate up, negatively impacting the tradable sectors of the economy. In panel c, financing through domestic borrowing reduces the savings of households and enterprises that would have been otherwise available to finance private investment. Therefore, the expected net effect of public investment on GDP is, *a priori*, indeterminate. Of course, public debt stocks increase in both foreign and domestic borrowing scenarios.

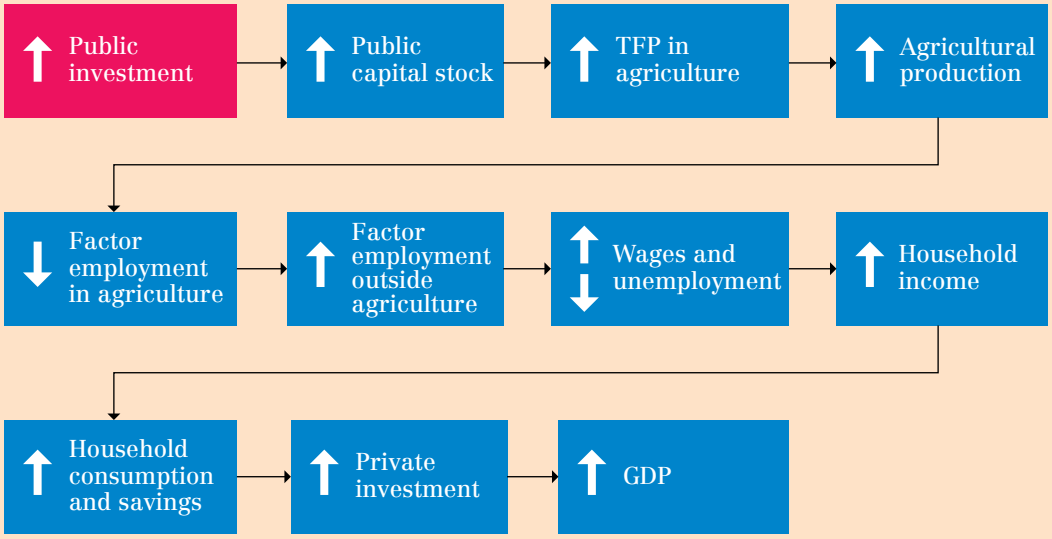
In panel d, the increase in public investment is financed by improving tax administration. This increases tax collection directly from households and enterprises. Implicitly, this is not an increase in the statutory rate of such taxes. As a result, at least in the short term, there is a reduction in disposable income, which in turn results in a drop in private consumption and savings.

Finally, in panel e, increased public investment is financed by resources resulting from an increased labour productivity in public administration. In this case, to the extent that the Government manages to provide the same public administration services, but with fewer employees, resources are freed up to finance public investment without the need to increase taxes or government borrowing. In the short term, this form of financing, however, has a negative impact on household income by reducing employment.

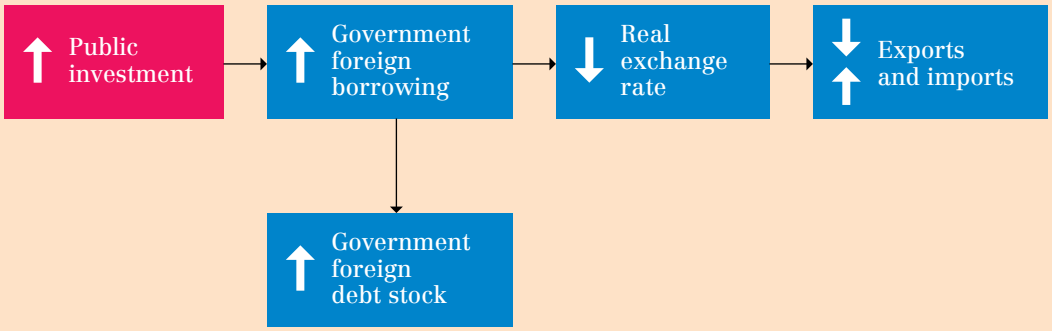
Discussion of the various transmission channels shows that the final result generated by each public investment scenario cannot simply be established *a priori*. In other words, the net effect that could be expected from increases in public investment aimed at promoting productivity in agriculture should be determined empirically.

FIGURE 16 Transmission channels of increased public investment in production infrastructure with different sources of financing

A. TRANSMISSION CHANNELS OF INCREASED PUBLIC INVESTMENT IN PRODUCTION INFRASTRUCTURE



B. TRANSMISSION CHANNELS IF FINANCING IS THROUGH FOREIGN BORROWING



C. TRANSMISSION CHANNELS IF FINANCING IS THROUGH DOMESTIC BORROWING

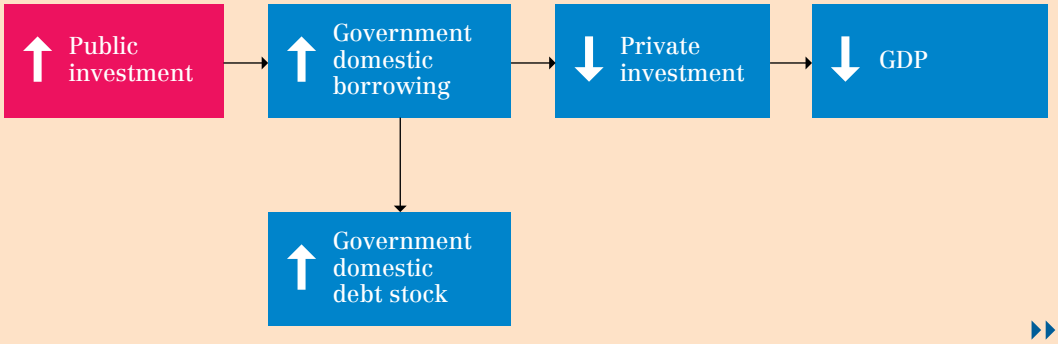
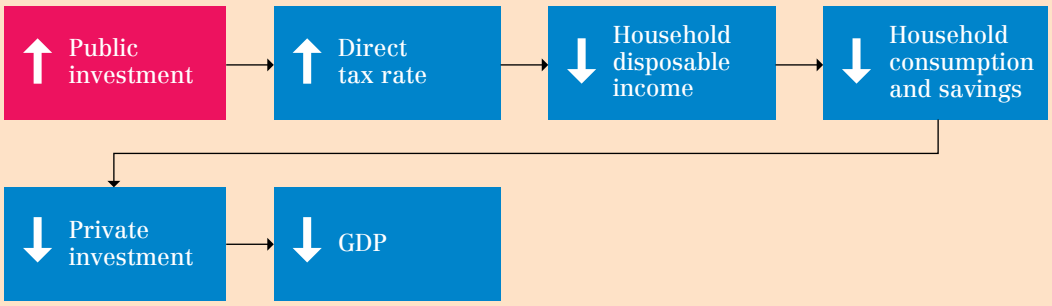
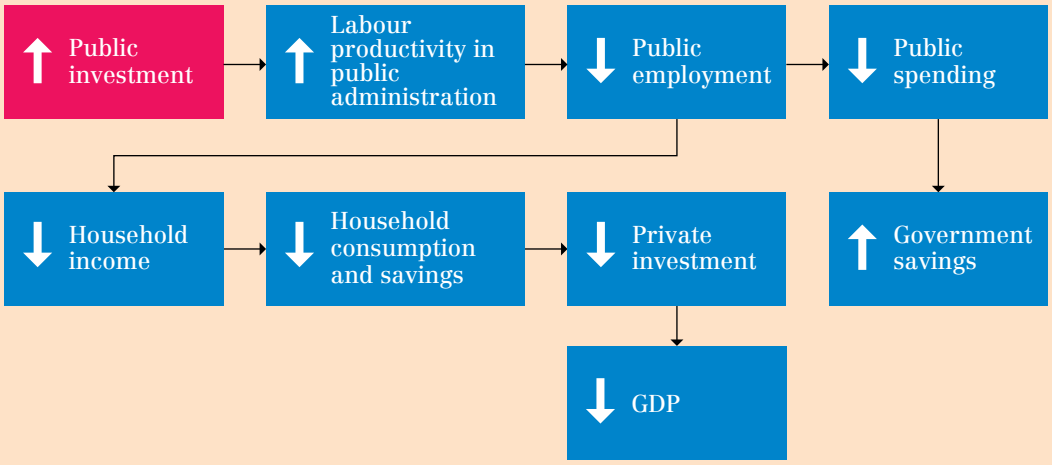


FIGURE 16 (cont.) Transmission channels of increased public investment in production infrastructure with different sources of financing

D. TRANSMISSION CHANNELS IF FINANCING IS THROUGH DIRECT TAXES



E. TRANSMISSION CHANNELS IF FINANCING IS THROUGH EFFICIENT PUBLIC SPENDING



Source: Authors' own elaboration.

4.3 Analysis of results

Of course, an extremely detailed analysis of all the outcomes of the 21 scenarios simulated with the CGE model is not necessary to answer the key questions raised in this study: Can public investment that promotes productivity in agriculture drive growth in agrifood production and have a positive impact on the economy as a whole and on rural poverty reduction? In which sectors or subsectors of agriculture will this public investment result in the most significant socio-economic payoffs, thus maximizing its cost-effectiveness? Therefore, the following analysis focuses only on the results that are key to answering these questions. The discussion of the results is mostly organized around figures that present macroeconomic, sectoral and distributional results. In general, the results for key variables in the CGE model are presented as percentage deviations from their values in the base scenario.[23]

[23] A series of tables with more detailed additional results, presented in Microsoft Excel format, is available upon request from the authors.

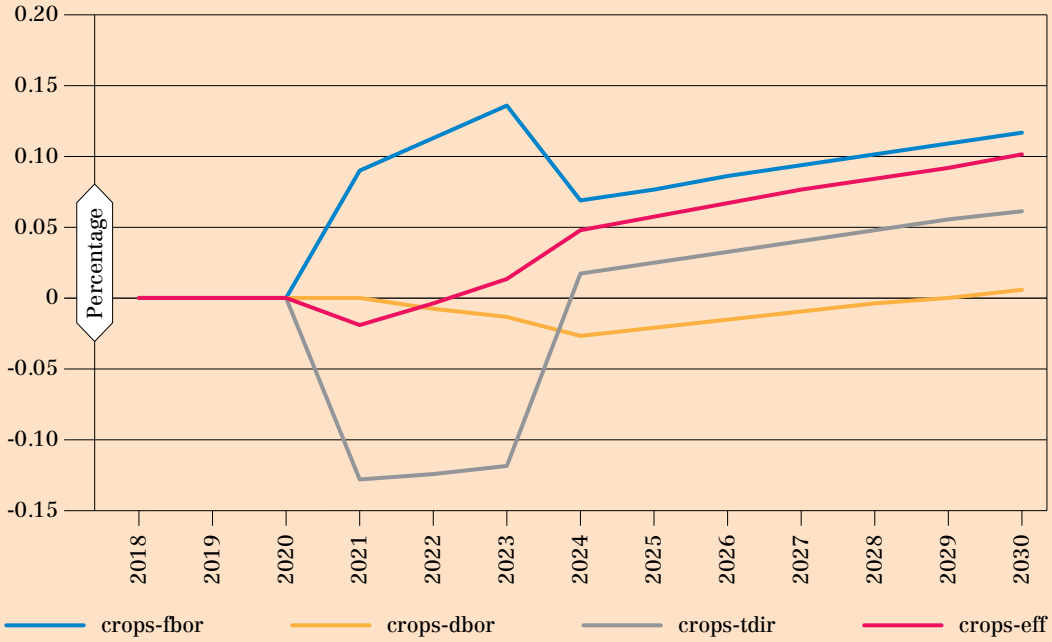
Macroeconomic results

Figure 17 and 18 show private consumption and GDP, respectively, in terms of how their annual value deviates from the base scenario. Analysing these variables reveals the potential effects of the new investment on economic recovery and household's welfare. In addition, both figures help us to compare the results generated under alternative funding sources when the investment goes to all sectors that produce crops, seen as a single group. That is, productivity is promoted only for all crop production in the first four scenarios whose results appear in these figures. In all cases, the investment made in 2021 has positive effects on TFP starting in 2022. However, the results vary substantially across scenarios, in line with the discussion around Figure 16 about transmission channels and the diverse effects of different forms of financing.

Financing through foreign borrowing does not generate any drop in private consumption; however, in the medium to long term it results in foreign debt that will accumulate until it is repaid in the future. In other words, accessing external financing would increase the level of economic activity, even in the short term, unlike the other three scenarios. Financing through domestic borrowing, in turn, crowds out private investment, which naturally has a negative impact on private capital stock and GDP growth in the short term. Interestingly, using direct-tax revenues to fund the increased public investment cuts disposable income and adversely impacts private consumption – also in the short term. However, while GDP increases, it does so at a lower rate than when the investment is financed through foreign borrowing. Finally, the public-sector efficiency gains scenario shows results that are also different when comparing the short term to the medium and long term. In particular, there is an initial decline in private consumption as household incomes suffered from a cut in employment in a public sector that can presumably produce more with less production factors. However, in the medium to long term, the positive effect of the public investment though increased productivity in crop production predominates. In fact, the level of total employment grows over time in all four scenarios. Moreover, the evolution of private consumption (household welfare) in Figure 17 is qualitatively similar to that recorded in Figure 18 for GDP (economic recovery). In quantitative terms, the effects on GDP are somewhat more significant.

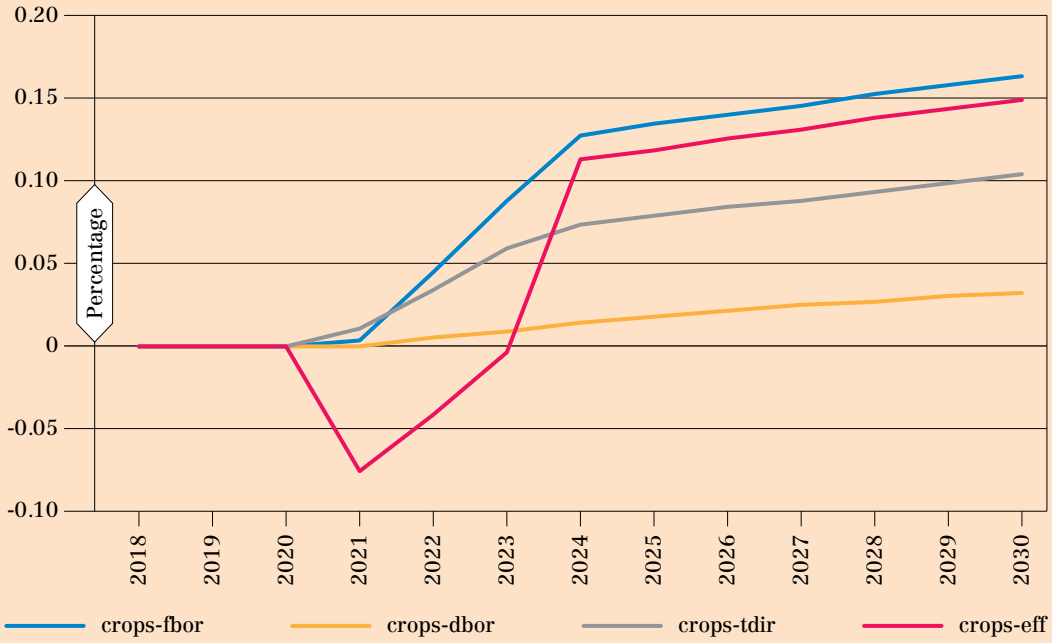
This first set of results for the first four productive public investment scenarios shows that foreign borrowing is the only alternative that promotes recovery in short-term economic activity, with gains in household welfare (measured by private consumption). Therefore, the other scenarios, which focus more on agricultural subsectors, assume that the increase in productive public investment is financed exclusively through foreign borrowing. Moreover, it should be noted that the conclusion, in terms of which is the most favourable financing source, does not change if, instead of promoting all crops together, livestock or a particular subsector is promoted within the agriculture sector. The foreign borrowing scenario is also considered viable because, as a result of the increased production, public debt does not increase by more than 0.55 percentage points of GDP in 2030 with respect to what is recorded in the base scenario for that year (Table 9).

FIGURE 17 **Private consumption in four public investment scenarios with alternative financing sources (percentage deviation from the base scenario)**



Source: Authors' own elaboration.

FIGURE 18 **GDP in four public investment scenarios with alternative financing sources (percentage deviation from the base scenario)**



Source: Authors' own elaboration.

TABLE 9 Public debt/GDP in four public investment scenarios with alternative financing sources (deviation in percentage points from the base scenario)

Scenarios	2022	2030
crops-fbor	0.16	0.55
crops-dbor	0.22	0.56
crops-tdir	-0.02	-0.11
crops-eff	0.00	-0.13

Source: Authors' own elaboration.

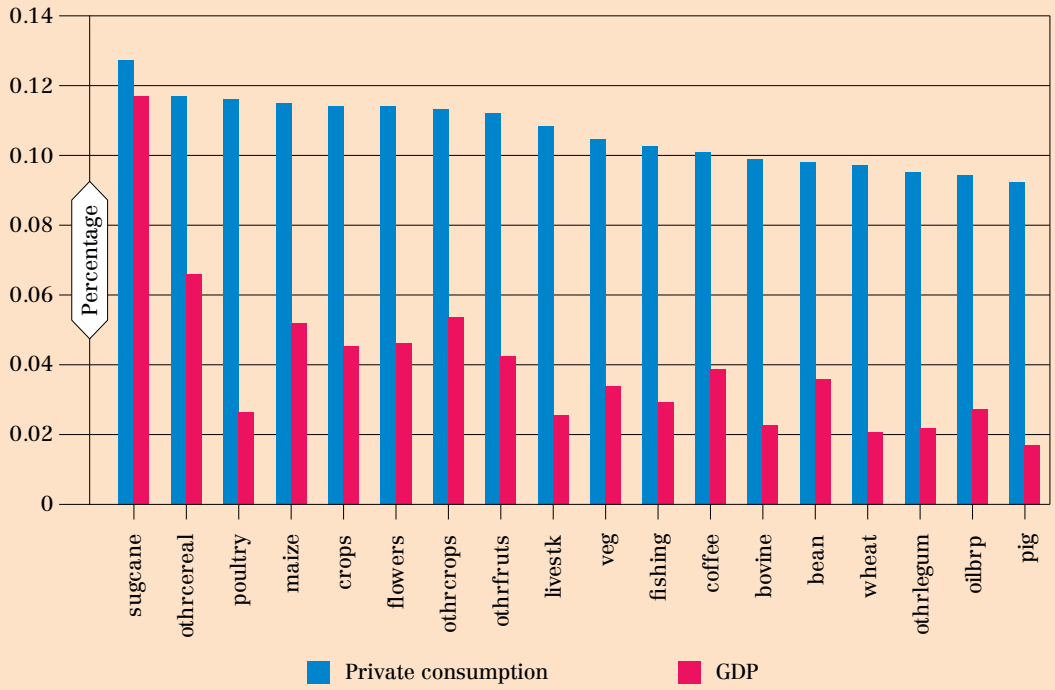
Figure 19 shows the effects on private consumption and GDP of increasing public investment to promote productivity in different subsectors of Mexican agriculture (scenarios 5 through 21 in Table 8). The results are presented only for the years 2022 (year of the last increase in investment) and 2030 (last year of the simulation period), but the conclusions do not change if we analyse the results for any other year. The year 2022 shows us the short-term results, and then one year later the period after the public investment is made continues. By contrast, 2030 shows us the longer-term effects. In all cases, favourable macroeconomic effects are observed. That is, indicators such as private consumption, GDP and private investment are higher than in the base scenario, and it is important to note that the public investment is financed using external resources. Two important comparisons stand out, as explained in the following paragraphs.

First, the promotion of all crops (scenario crops-fbor) is compared with the promotion of all livestock (scenario livestk).[24] In both cases, as the investment is financed through foreign borrowing, the short- and long-term effects are similarly positive, although the magnitudes change. As a result of the greater integration of crops with international markets, promoting all crops generates somewhat more favourable effects than promoting all livestock. In particular, the results show that by promoting the production of all crops together, exports increase over time, while also replacing (reducing) imports (Figure 20) to a greater extent than by promoting livestock. This happens "over time" because, in the short term (2022), foreign borrowing results in a real exchange rate appreciation that immediately leads to falling exports and increased imports. Moreover, by 2022 the effects of increased productivity are not yet so significant. Such findings also apply when investment is intended to promote subsectors within the crop and livestock sectors.

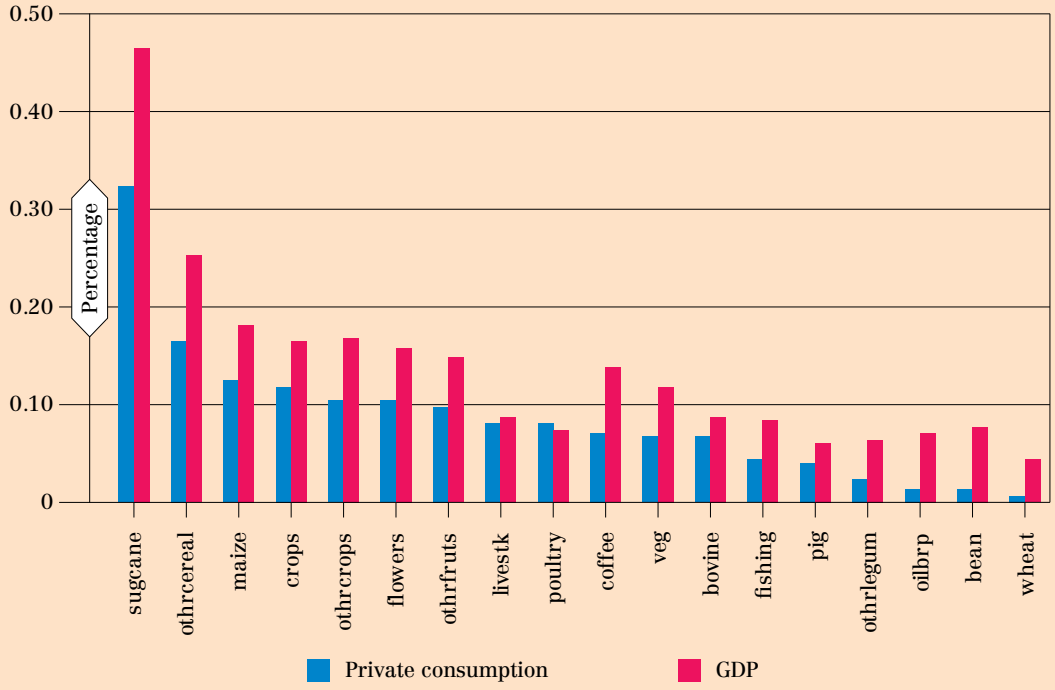
[24] Note that scenarios 5 through 21 (Table 8) do not include the abbreviation "fbor" in the names because in all of them, by choice, the new public investment is financed exclusively by foreign borrowing. That is, in these scenarios, as has been pointed out, the other sources of funding (dbor, tdir and eff) are no longer used.

FIGURE 19 Private consumption and GDP in selected public investment scenarios (percentage deviation from the base scenario)

A. 2022



B. 2030

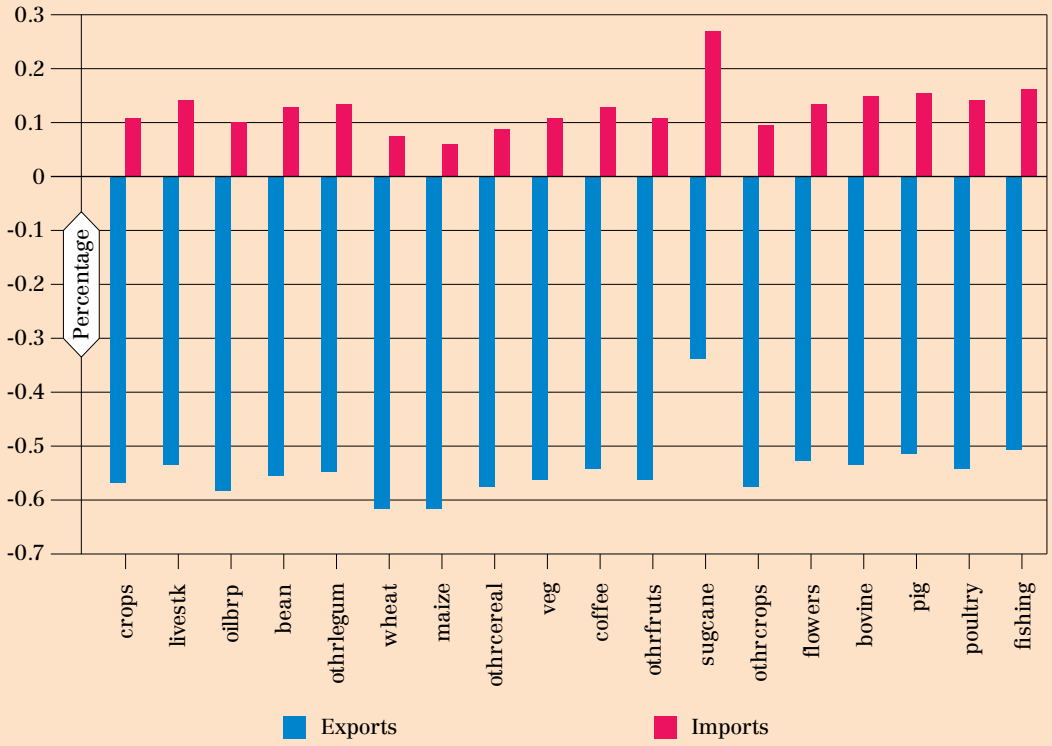


Notes: The horizontal axis represents the selected scenarios and omits the abbreviation "fbor" from the crop-fbor scenario (Scenario 1, Table 8). Several of the following graphs use this horizontal-axis format.

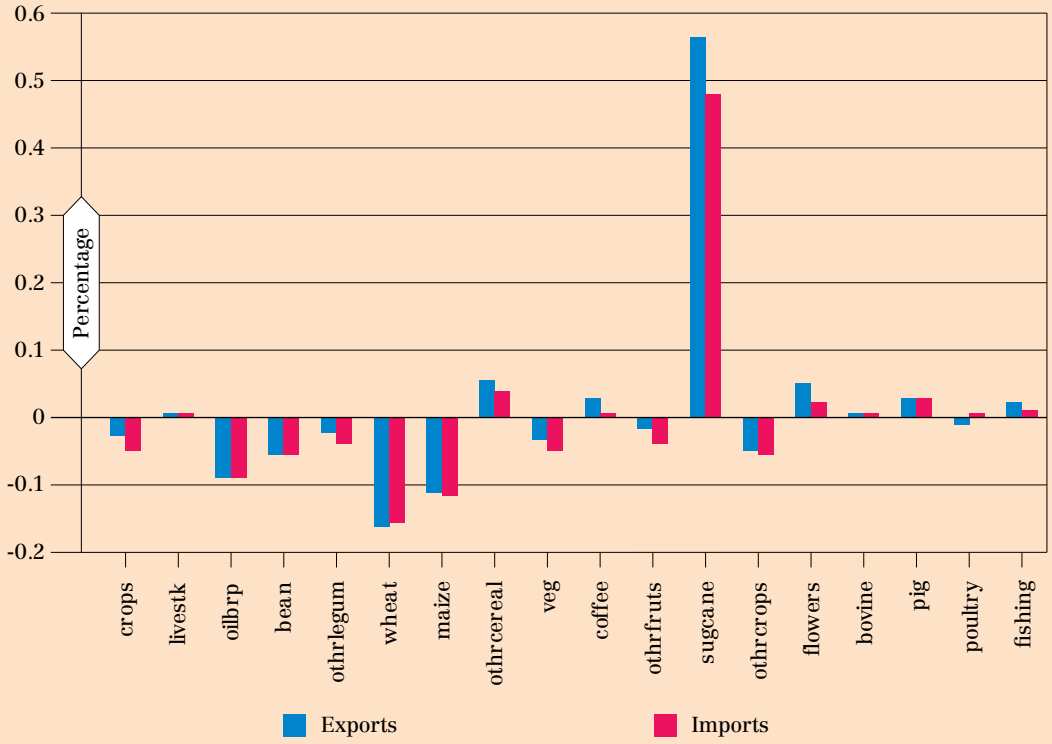
Source: Authors' own elaboration.

FIGURE 20 Exports and imports in selected public investment scenarios (percentage deviation from the base scenario)

A. 2022



B. 2030



Source: Authors' own elaboration.

Second, the promotion of different subsectors of Mexican agriculture are compared. The scenario ranking shows that the biggest impacts on private consumption and GDP are achieved when new public investment is intended to promote productivity in the sugar cane subsector (sugcane scenario). Specifically, private consumption and GDP are approximately as much as 0.3 and 0.5 percent higher, respectively, than in the base scenario in 2030. In the first year of the simulation period (2018), the value added of the sugar cane subsector represents 0.2 percent of GDP. Therefore, the increase of 0.5 percent in GDP in 2030 is not at all negligible – the cumulative increase in GDP in 2030 is equivalent to 3.5 percent of GDP in that first year of simulation. Private investment is also stepped up in the medium and long term.[25] Naturally, higher private investment translates into a larger private capital stock, which in turn has a positive second-round effect on macroeconomic indicators.

Sugar cane is the subsector showing the lowest value-added per worker of all those considered in the analysis. Therefore, the very increase in productivity allows more workers to be reallocated to other production activities. Thus, the sugar cane subsector is particularly benefited by the increased productivity generated as public investment was scaled up. In addition, it is a subsector with strong forward production linkages as all of its production goes to intermediate consumption by other production activities.

Overall, the effects on major macroeconomic aggregates, such as private consumption, private investment and GDP, are more favourable when the promoted sectors are export-oriented (e.g. coffee) or import-oriented, due to increased import substitution. This is especially the case when all the crops as a whole are affected by the productivity shock caused by the new investment. The subsectors that generate the highest increases in exports are sugar cane, flowers, other cereals and coffee. Again, the case of sugar cane is interesting because it is a product that is not exported directly. However, for a group of products for which sugar cane is an important input (sugar, chocolate, sweets and the like, and beverages), around 20 percent of their production is exported to the rest of the world. Promoting cereals through productive investment does not increase exports, but does reduce imports significantly. In general, a significant share of cereal consumption is covered by imports (see Figure 6). For example, in the scenario that promotes productivity in the wheat subsector, the ratio between imports and wheat consumption is reduced by almost 18 percentage points in 2030 compared to the base scenario, dropping from 74.1 to 56.1 percent.

Sectoral production results

This section analyses two important effects on sectoral production and production linkages caused by the productivity shock that is triggered by the new public investment in agriculture sectors or subsectors (scenarios 1 and 5 through 21 of Table 8). The first is the effect on agrifood GDP, defined as the sum of the value added generated in agriculture and the food industry. Agrifood GDP captures the production linkages between agriculture and the food industry. The second considers how the promotion of one agricultural sector or subsector affects its own production as well as that of all other production sectors of the economy.

Regarding the first effect, sectors and subsectors are ranked according to their impact on agrifood GDP when they are promoted individually (Figure 21). The three subsectors of agriculture that generally show the greatest effects on agrifood GDP are wheat, other fruits and beans. At the opposite end of the ranking, livestock subsectors have the smallest effect on agrifood GDP. Again, crops have a more significant export and import orientation than

[25] Results for private investment are shown in Annex A.

livestock. Therefore, the negative effects on domestic prices generated by increases in their production are mitigated by increased exports and/or reduced imports. As a result, agrifood GDP increases further when promoting sectors that, directly or indirectly, are more export- or import-oriented.

It is interesting to note that, while the scenario whereby the productivity shock from the new investment occurs in the sugar cane subsector ranks first, given the highest impact on GDP (Figure 19), it also ranks 15th in terms of its impact on agrifood GDP (Figure 21). This is because the sugar cane subsector is linked only to sectors of the food industry that are relatively intensive in capital use (sugars, chocolates, sweets and the like, and beverages, as noted above). As a result, public investment targeting the sugar cane subsector promotes private investment, capital accumulation and GDP growth more than in the other scenarios.

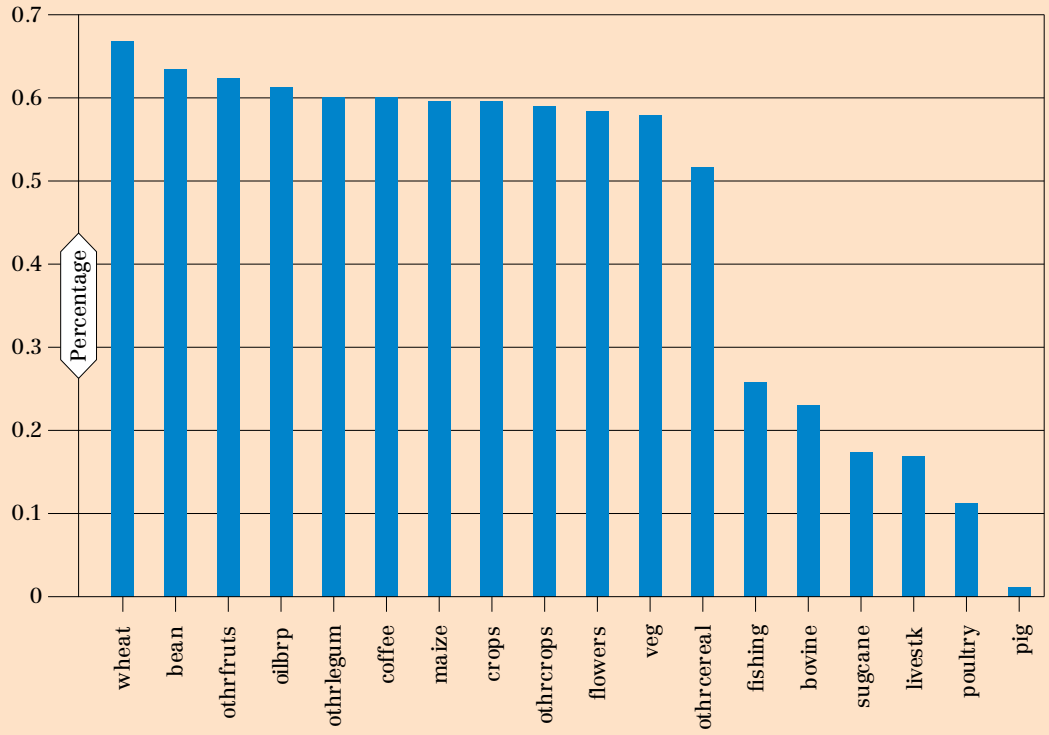
In more disaggregated terms, when new investments are made to directly boost productivity in specific sectors, production in those sectors naturally increases significantly. In addition, as discussed in the previous paragraph, in all scenarios production increases in the food industry, which uses agricultural production as intermediate inputs. The analysis also looks beyond the linkages between agriculture and the food sector. Figure 22 shows the effects on production levels in all sectors of the Mexican economy for the two scenarios where the investment promotes all crops (crops-fbor) or all livestock (livestk).[26] The results for the second of the two scenarios show that there are direct effects on the "cattle and other animals sector", with backward linkages with crops and transport, and forward linkages with the food industry, trade and transport.[27] Production linkages with the food industry are less important when investment flows to crops considered altogether (crops-fbor scenario) than to livestock sectors. This is to be expected, considering that many agricultural products, such as vegetables and fruits, are consumed directly without processing. However, linkages with sectors associated with trade, transport and public services are more important.

[26] Similar results for the other scenarios that are considered are available upon request from the authors.

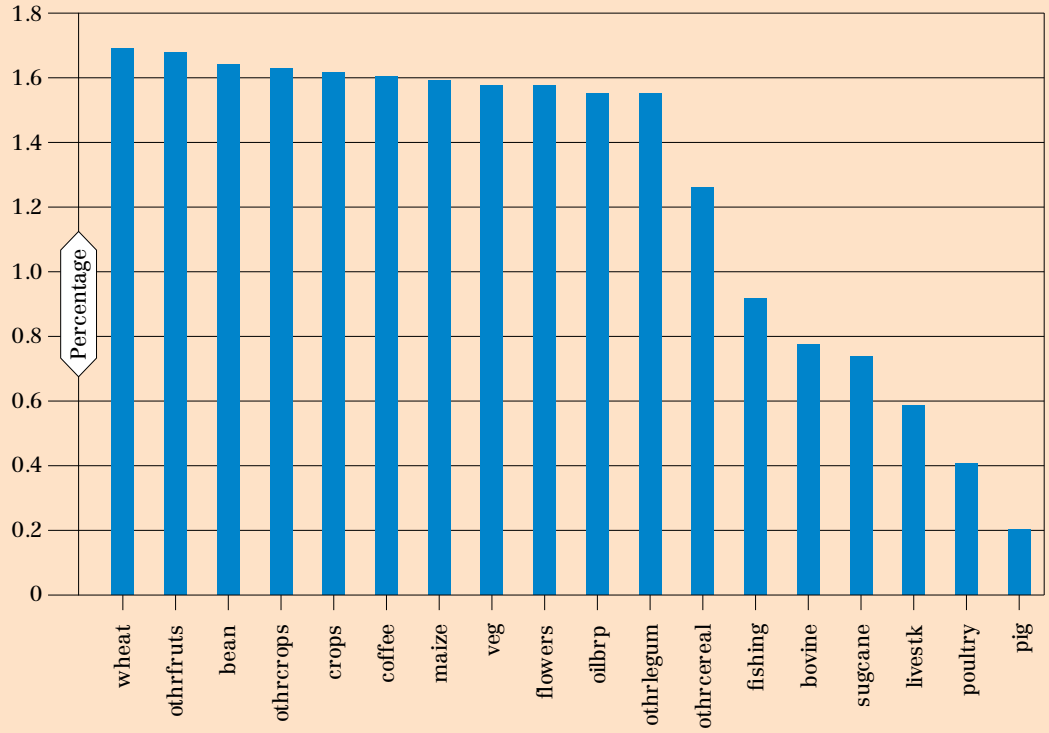
[27] It is important to keep in mind that there are forward and backward production linkages. Backward linkages measure a sector's ability to pull other sectors along with them, by purchasing intermediate inputs from them. Forward linkages measure a sector's capacity to push other sectors by producing intermediate inputs for them.

FIGURE 21 Agrifood GDP in selected public investment scenarios (percentage deviation from the base scenario)

A. 2022



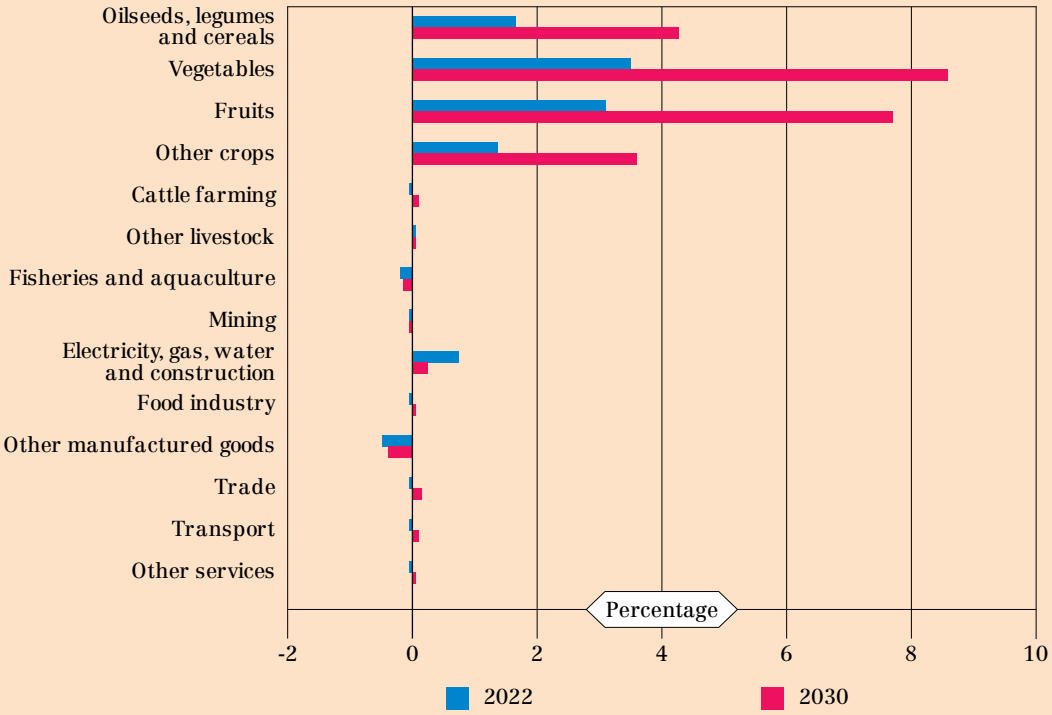
B. 2030



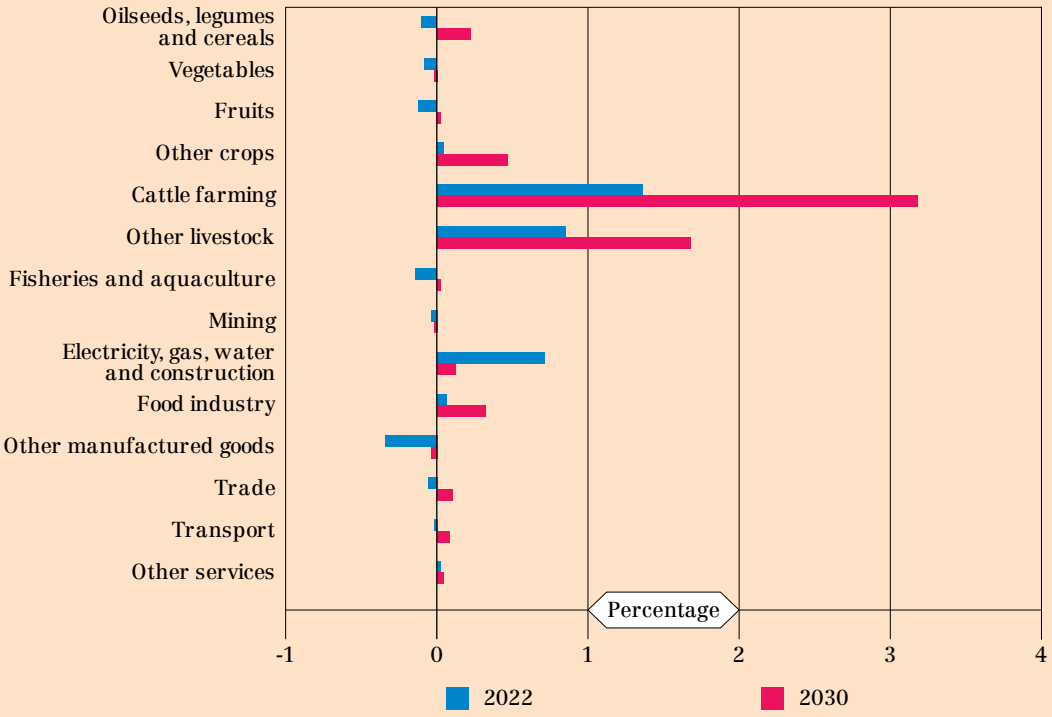
Source: Authors' own elaboration.

FIGURE 22 Production of productive sectors in selected public investment scenarios (percentage deviation from the base scenario)

A. CROPS-FBOR SCENARIO



B. LIVESTK SCENARIO



Note: The horizontal axis represents the productive sectors of the Mexican economy.

Source: Authors' own elaboration.

Crops that show the greatest sectoral effects when the new productive investment is exclusively channelled to them are maize, other cereals, sugar cane and other crops, according to the respective scenarios for these sectors (the results of which are not presented graphically). In these four cases, production growth is relatively higher in other industries and services. In addition, the four subsectors have a higher level of integration with the food industry. By contrast, a sector such as vegetables allocates most of its production to private consumption (48.7 percent) and export (43.1 percent) (see Figure 9). Therefore, increases in production drive relatively less the production in other sectors. Consequently, the scenario promoting vegetable production ranks in positions 11 and 8, in 2022 and 2030, respectively (Figure 21).

In any event, if the objective is to maximize the effects on growth, and, thus, to contribute to post-pandemic recovery, the results underscore the importance of making public investments that: a) promote sectors currently integrated into value chains, or b) promote the entire value chain rather than just the primary stage for sectors that are not currently integrated into value chains. Moreover, as discussed above, sectors with greater international integration can increase their production and their exports without being limited by the size of the domestic market.

In short, the results of this section show that promoting crops, through new public investment in productive infrastructure, generates more positive effects than promoting livestock, when considering agrifood GDP as the outcome variable. Crops are more integrated into international trade and, therefore, their promotion generates an increase in exports and increased import substitution. As a result, agrifood GDP growth is driven mainly by increased primary agricultural production. On the other hand, the forward production linkages of livestock are greater and, therefore, their promotion has more positive effects on the food industry, but not on agrifood GDP as a whole. But changes in agrifood GDP seem to matter more, as it is generally public investment in the crop sectors – rather than in livestock – that has the greatest impact on total GDP (Figure 19). These results underscore the trade-offs between promoting the different sectors and subsectors of Mexican agriculture.

Employment outcomes

Employment increases in most scenarios, except when promoting the production of other cereals, sugar cane and pigs (see othrcereal, sugcane and pig scenarios in Table 8). In these cases, the drop in employment resulting from the initially increased productivity of the subsector is not offset by increases in employment in other sectors of economic activity, as is the case in the other scenarios. However, the aggregated results are positive in terms of private consumption, which is extremely important when analysing the economy as a whole. The results underscore the importance of considering the demand side when promoting certain productive sectors. For example, increased oilseed production (oilbrp scenario) has a particularly positive effect on the employment of unskilled workers because imports of oilseeds are replaced, covering more than 95 percent of total oilseed consumption. As a result, the income and consumption of households that mostly rely on the use of unskilled labour rise and, therefore, their poverty rate is reduced, as shown below.[28]

Poverty and inequality outcomes

The effects on poverty indicators are consistent with the performance of private consumption, as the poverty rate depends on changes in income and prices. The promotion of agriculture subsectors reduces, in all cases, the average price of food. This reduction is not trivial,

[28] Employment also falls when public investment is not productive, that is when the marginal product of the new public capital is zero (see scenario crops-0-Fbor+025 in Annex A).

as food represents a relatively large proportion of the consumption basket of Mexico's poorest households. In general, the scenarios show reductions in total poverty rates by 2030 ranging from 0.01 to 0.11 percentage points, depending on the scenario and whether the poverty rate is national, urban or rural (see Figure 23). In fact, the greatest poverty reductions are in rural areas. Two aspects explain this result. One is that increased productivity in agriculture has a positive impact on the labour income of rural households. The other is that reducing the price of agrifood products cheapens the main component of the consumption basket for lower-income households.

Changes in inequality as measured by the Gini coefficient proved unimportant, though all cases show reductions due to a relative improvement of rural households compared to urban homes. That is, rural households witness higher growth in consumption (and income) per capita than urban households. However, the magnitude of the changes in the Gini coefficient are very small. For example, the Gini coefficient is reduced from 0.4944 to 0.4942 when the base scenario is compared to the scenario that promotes all crops together.

Net present value of public investment

Lastly, the scenario analysis examines the net present value (NPV) of the simulated public investments. The NPV is calculated from the equivalent variation, which measures the change in welfare experienced by Mexican households. This indicator answers the following question: How much income should be transferred to Mexican households to achieve the same change in welfare as is generated by increased public investment?[29]

Calculated in this way, the NPV ranges from 0.1 to 1.3 percent of GDP when comparing the results obtained in the scenarios that focus the new public investment on different subsectors of Mexican agriculture (Figure 24). The ranking of sectors, from highest to lowest impact, is similar to that previously used for private consumption (Figure 19) and agrifood GDP (Figure 21). All scenarios show positive effects for NPV. In addition, sugar cane, other cereals, maize and all crops are the scenarios located at the top of the NPV ranking. That is, public investment that boosts productivity in the subsectors associated with those scenarios results in a relatively higher discounted gain in the welfare of Mexican households than that of public investment that boosts productivity in other subsectors.

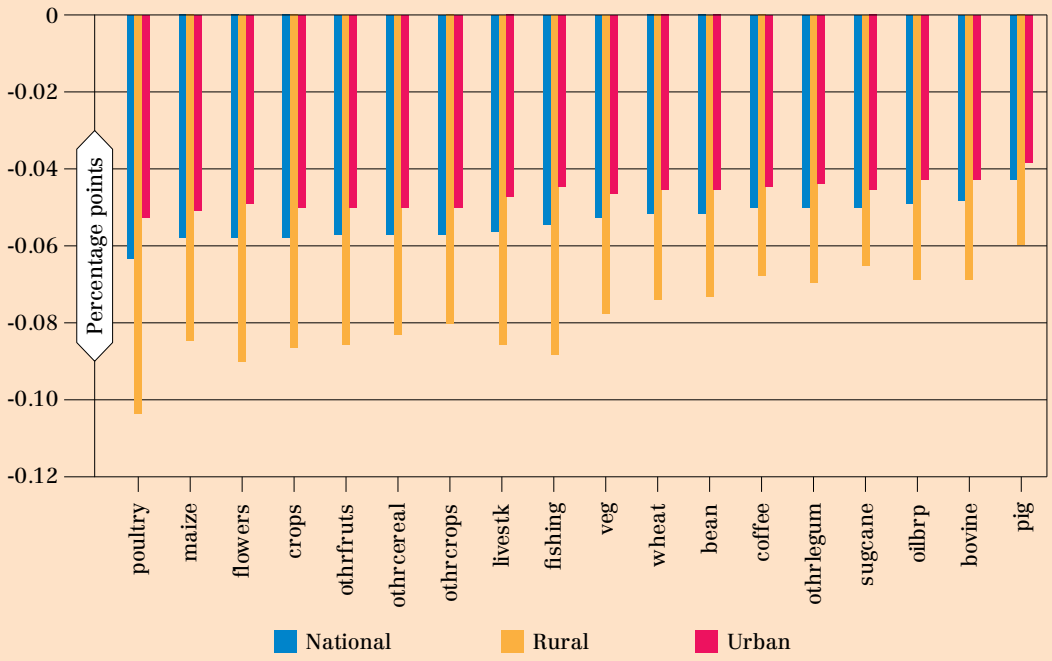
[29] The following formula was used to estimate the NPV:

$$NPV = \sum_{t=2021}^{t=2030} \frac{\Sigma_{h \in H} EV_{h,t}}{(1 + intrat)^{2021-t}}$$

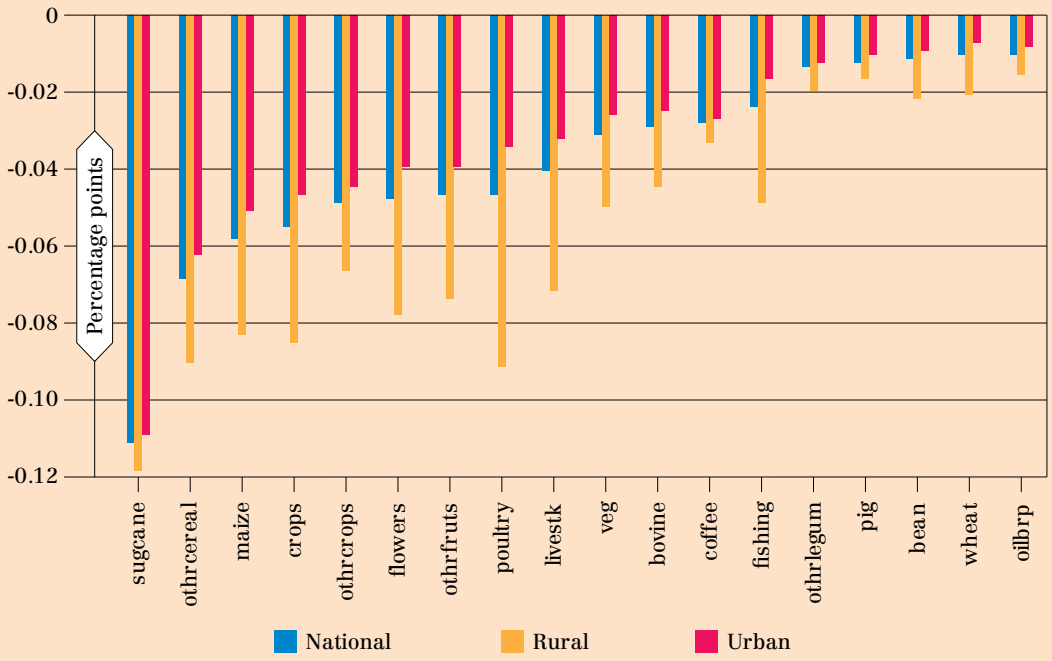
$EV_{h,t}$ is the equivalent variation or measurement of welfare of Mexican households and intrat is the interest rate that, following official practice in Mexico, is assumed to be 8 percent. The equivalent variation measures the change in welfare experienced by households. In the equation above, the welfare of each of the 18 households identified in Mexico's CGE model is weighted in the same way. That is, a utilitarian social welfare function is used implicitly. The results of the scenarios indicate that the increase in overall welfare would be higher if a welfare function that gives a higher weighting to households with the lower-consumption per capita were used.

FIGURE 23 Poverty rates in selected public investment scenarios (deviation by percentage points from the base scenario)

A. 2022

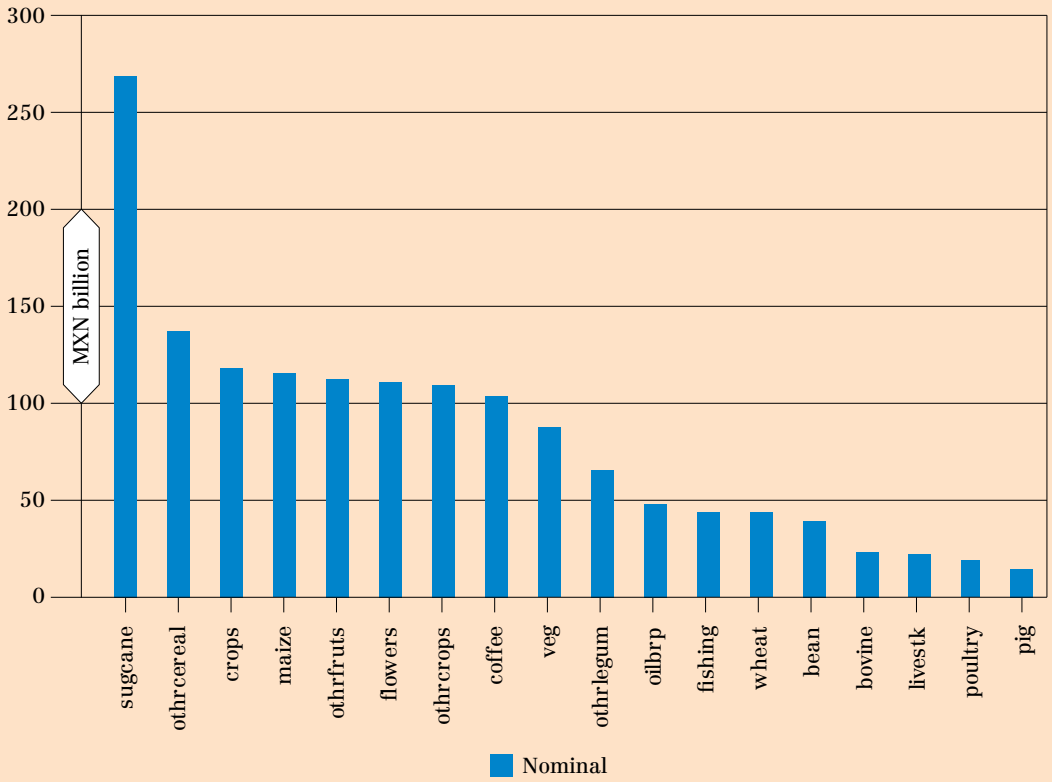


B. 2030



Source: Authors' own elaboration.

FIGURE 24 Net present value of public investments in selected scenarios



Source: Authors' own elaboration.

5 Conclusions and recommendations

As is the case with most of the economies of the world amid the COVID-19 pandemic, which are in an unprecedented recession, Mexico's economy is in great need of a strong and sustained recovery. The economic developments of recent years define the starting point for recovery. In particular, both the productive structure (and its dynamism) and existing public policies will determine, together with the available fiscal space, what new public policies Mexico will be able to implement to contribute to such recovery.

Economic stimulus measures should focus on those sectors that are important not only to the economy but also in terms of employment generation and the livelihoods of large portions of the population. Reactivating agriculture (including crops, livestock, forestry and fisheries) should then be one of the drivers of economic recovery with well-being post-COVID-19. The sector employs a significant number of workers and provides the main basis for rural livelihoods. It provides Mexican households with food not only directly but also indirectly as it supplies inputs to the food industry. In addition, agriculture is linked to international trade, both through exports and imports. In fact, because many of the agricultural products consumed by Mexican households are imported, promoting their domestic production as a way to recover from the crisis could generate longer-term benefits in terms of food security. Finally, most of the poorest Mexican households are in rural areas, where agriculture provides livelihoods for many.

Over the past 20 years, the Mexican government has changed hands four times, which has undeniably meant changes in public administration, public policy and laws. There have been major reforms in areas including fiscal policy, energy, labour, education and climate change, among others. However, there have been no agricultural reforms in recent years (the last ones were instituted in 1939 and 1992) and none involving irrigation. Furthermore, the Mexican economy has been affected by three events that led to economic crises and instability: the 2008 financial crisis, the A/H1N1 pandemic, and the current COVID-19 pandemic. All three events lowered economic growth during these crises, but prompt recoveries were seen for the first two, resulting in an average annual GDP growth rate ranging from 2 to 3 percent over the last 20 years. However, in the current crisis, GDP has contracted by an unprecedented 18 percent. Despite the economy-wide collapse, the primary sector has by and large been resilient. Although it has shown some volatility, some subsectors are growing, such as livestock farming and animal feed production. According to the SHCP's economic policy criteria for 2021, the resilience of the primary sector is due primarily to the fact that it has remained a priority activity while food prices have remained relatively stable. In contrast, the secondary sector has contracted by up to 29 percent. As such, agriculture should be a core element of economic recovery, but this requires a boost in its productivity.

Generally speaking, the agriculture sector lacks productive dynamism and is one of the sectors with the highest rates of informal work and the lowest wages for day labourers. There is also a significant lag in credits to invest in machinery, equipment and technological innovation. Furthermore, interest in improving irrigation has been shown mostly by the private sector in specific areas of northern Mexico. A policy of public investment in productive infrastructure for agriculture would undoubtedly lead to economic recovery with gains in the well-being of a large portion of the population.

This study provides an analysis of prospective scenarios based on a modelling tool that represents the functioning of the Mexican economy as a whole and its multiple sectors, in order to answer the following questions for decision-makers of the Mexican Secretariat of Agriculture and Rural Development:

- Can public investment that promotes productivity in agriculture drive growth in agrifood production and have a positive impact on the economy as a whole and on rural poverty reduction?
- In which sectors or subsectors of agriculture will this public investment result in the most significant socio-economic payoffs, thus maximizing its cost-effectiveness?

5.1 Prospective scenarios

To answer these questions, a base reference scenario was developed in order to reproduce the past and current behaviour of the Mexican economy, including its sectoral structure, and project it forward. Subsequently, the base scenario was compared with scenarios that gauge the effects of government investment that increases productivity in selected agricultural sectors.

The investment scenarios simulate an increase in total factor productivity (TFP) in selected agricultural sectors and subsectors, brought about by new public investments in productive infrastructure amounting to 0.25 percent of GDP (around MXN 50 billion, in 2018) during the 2021–2023 period. Based on empirical evidence, this type of productivity shock is linked with improvements in rural roads, irrigation systems, storage infrastructure, etc., and each additional peso of public investment increases the TFP in the sectors receiving the investment by the equivalent of 0.3 cents (MSN). Two important aspects analysed in the study are: (1) the macroeconomic effects of financing the investment using four alternative forms of financing: foreign borrowing, domestic borrowing, direct tax revenue, and increased efficiency of public spending; and (2) the medium- to long-term impact of new productive public investment and its sources of funding, for which purpose the scenarios cover the period up to 2030.

Mexican agriculture, with its wide range of sectors, generally registers relatively high values for the ratio between employment and value added. Consequently, it was known *a priori* that an increase in this sector's TFP would promote, all other things being equal, a reallocation of resources from agriculture to other production sectors. Moreover, Mexican agricultural products are not highly export-oriented when compared to industrial manufacturing goods. As such, the sectors of Mexican agriculture promoted in the 2019–2024 NDP (beans, wheat, maize, rice, coffee, sugar cane, beef cattle, milk cattle and dual-purpose cattle) are limited in expansion by the size of the domestic market. Taking into account these key characteristics of the sector, the scenarios also considered other subsectors of agriculture and sectors of the food industry that use agricultural products as intermediate inputs for their production. A number of important conclusions and recommendations are drawn from the analysis.

5.2 Integration with the external market expands the socio-economic effect of investment

The findings show that the effects on major macroeconomic aggregates are more favourable when the sectors or subsectors promoted are export-oriented (such as coffee and vegetables) or import-oriented (such as cereals in general). Public investment in these sectors and subsectors generates the greatest economic growth, both within each sector and in the economy as a whole, due to the structural characteristics of these sectors and subsectors.

When new public investment focuses on promoting the crop sector as a whole, it generates more positive effects on growth than when it is allocated to livestock as a whole. With investment in the crop sector as a whole, GDP increases 0.045 and 0.164 percent in 2022 and 2030, respectively (relative to the base scenario); while, with investment in livestock, the increase is 0.026 and 0.089 percent, respectively (Table 10). This is because crops are relatively more integrated into international trade. As such, increasing their productivity through new public investment results in a greater increase in exports and higher import substitution. However, the forward productive linkages of the livestock sector are more significant than those of the crop sectors, given their greater potential to push food sectors by supplying to them intermediate inputs.

In both cases, the increase in production within the sector itself, and the effect generated in the other sectors of the food industry through production linkages, explain why the increase in agrifood GDP is much more important than the increase shown in overall GDP. In the case of the crop sector as a whole, agrifood GDP is 0.597 and 1.609 percent higher in 2022 and 2030, respectively (compared to the base scenario), while, in the case of livestock, the increase is 0.169 and 0.578 percent, respectively. Results for peoples' well-being, as measured by private consumption and rural poverty reduction, are also favourable in all scenarios.

Viewed at a more disaggregated level, the results show that the subsectors that generate the most positive effects on GDP, private consumption (welfare) and poverty rates (national, rural and urban) are: maize, which is an important component in the consumption basket of Mexican households; sugar cane, for the reasons explained below, including its large scale; other cereals (including rice, sorghum, oats, barley and other cereals, which are also heavily consumed in households); and fruits, which are export-oriented (Table 10).

The sugar cane subsector deserves particular mention, as previously indicated, as it is a relatively labour-intensive sector and all of its production goes to intermediate consumption for export-oriented activities. In addition, the agro-industrial sectors producing sugar and beverages are capital-intensive. Therefore, a reduction in their production costs resulting from lower sugar cane prices benefit their profits in the simulated scenarios. Subsequently, enterprises that receive a relatively large share of capital income tend to have a relatively high savings rate and, therefore, more significant impacts are generated on private investment, capital stock, GDP and income from other factors; that is, on the economy as a whole. However, environmental sustainability elements of the entire sugar cane value chain are not taken into account in this analysis, and new investments may be needed in order to modernize and increase the sustainability of the sector's production processes. Moreover, given the importance of the sector in large-scale (industrial) agriculture, it will be important for productive investments not to exclude small farmers so that the sector actually contributes to spurring production while improving rural well-being.

TABLE 10 **Summary of results of productive public investment scenarios (deviation from the base scenario, in percentages for private consumption, GDP and agrifood GDP; and in percentage points for rural poverty)**

#	Scenario	2022				2030			
		Private consumption	PIB	Agrifood GDP	Rural poverty	Private consumption	PIB	Agrifood GDP	Rural poverty
1	crops-fbor	0.113	0.045	0.597	-0.087	0.117	0.164	1.609	-0.086
2	crops-dbor	-0.007	0.005	0.630	-0.011	0.006	0.033	1.520	-0.040
3	crops-tdir	-0.123	0.035	0.611	0.038	0.063	0.103	1.564	-0.065
4	crops-eff	-0.003	-0.040	0.659	-0.051	0.101	0.150	1.595	-0.083
5	livestk	0.108	0.026	0.169	-0.086	0.082	0.089	0.578	-0.072
6	oilbrp	0.094	0.027	0.613	-0.069	0.016	0.073	1.549	-0.016
7	beans	0.098	0.036	0.639	-0.074	0.014	0.077	1.642	-0.022
8	othrlegum	0.095	0.022	0.606	-0.070	0.026	0.066	1.543	-0.020
9	wheat	0.097	0.021	0.669	-0.074	0.007	0.046	1.692	-0.021
10	maize	0.115	0.052	0.599	-0.085	0.126	0.182	1.580	-0.083
11	othrcereal	0.116	0.066	0.519	-0.083	0.166	0.251	1.252	-0.090
12	veg	0.104	0.034	0.582	-0.078	0.068	0.117	1.576	-0.050
13	coffee	0.101	0.039	0.603	-0.068	0.072	0.139	1.595	-0.033
14	othrfruts	0.112	0.043	0.624	-0.086	0.099	0.148	1.676	-0.074
15	sugcane	0.127	0.116	0.177	-0.065	0.322	0.463	0.741	-0.119
16	othrcrops	0.113	0.054	0.593	-0.080	0.106	0.169	1.624	-0.067
17	flowers	0.113	0.046	0.587	-0.091	0.104	0.160	1.570	-0.078
18	bovine	0.099	0.023	0.229	-0.068	0.066	0.089	0.772	-0.045
19	pig	0.092	0.017	0.009	-0.060	0.040	0.060	0.201	-0.016
20	poultry	0.115	0.026	0.115	-0.104	0.080	0.075	0.407	-0.092
21	fishing	0.103	0.033	0.259	-0.088	0.044	0.085	0.919	-0.049

Note: Scenarios appear in the same order in which they were entered in Table 8.
Source: Authors' own elaboration.

Changes in the key variables analysed may seem small in all the scenarios; however, they should be considered in light of what the sectors and subsectors represent with respect to GDP. For example, when new public investment is allocated to the sugar cane subsector, private consumption and GDP are up to 0.3 and 0.5 percent higher, respectively, by 2030, compared to the base scenario. In the first year of simulation (2018), the added value of

sugar cane accounts for only 0.2 percent of GDP. Thus, the increase of 0.5 percent of GDP in 2030 is not at all negligible. In other words, the cumulative increase in GDP by 2030 is equivalent to 3.5 percent of GDP in that first year of simulation. Furthermore, in all the scenarios, according to the NPV of public investment, the discounted gain, in terms of Mexican households' welfare, is greater than the investment. The gains definitely outweigh the investment and, in addition, the amount of simulated investment plays a very important role. As noted, the simulated new public investments in productive infrastructure account for only 0.25 percent of GDP (around MXN 50 billion, in 2018) during the 2021–2023 period. A sensitivity analysis shows that, if this investment were doubled in those years, the effects would have been much more favourable. For example, in the scenario in which public investment in productive infrastructure is allocated to the crop sector as a whole (financed through foreign borrowing), doubling the amount of the investment to 0.50 percent of GDP causes private consumption, total GDP, agrifood GDP and the rural poverty rate to deviate from the base scenario by 0.23 percent, 0.09 percent, 1.19 percent and -0.17 percentage points in 2022, and 0.23 percent, 0.32 percent, 3.21 percent and -0.16 percentage points in 2030, respectively. These figures are certainly much higher than those presented in the top row of Table 10.

5.3 Foreign borrowing is the most viable option to support the recovery

Ordering sectors according to macroeconomic indicators (GDP and private consumption) is robust to changes in the sources of financing of the new public investment in productive infrastructure. The comparison of scenarios, however, shows which macroeconomic impacts are most favourable among the alternative sources of financing. In this sense, access to foreign borrowing allows a recovery of GDP in the short term without leading to a large accumulation of external public debt (only 0.55 percent of GDP in 2030 more than the base scenario).

By contrast, without access to foreign resources and using alternative sources of domestic financing, there is an initial drop in GDP (except for some subsectors, when direct-tax revenues are used to finance the investment) and private consumption. In some cases, direct taxes reduce disposable income and, consequently, private household consumption. At the same time, however, they increase GDP in the short term. Domestic borrowing, on the other hand, shifts a portion of private savings to finance the new public investment, thus affecting private investment and GDP in the short term. Finally, efficiency gains in the public sector would result in an initial decline in private consumption due to the negative effect of reducing public employment as a result of the increased labour productivity. However, in the medium to long term, the positive effect generated by public investment aimed at promoting productivity in the crop sectors predominates. In short, taking into account the intertemporal trade-offs, access to external financing for new public investment in productive infrastructure would be the most viable option to promote economic recovery while increasing people's well-being in the short term, with higher gains in the medium to long term.

5.4 Ranking subsectors to inform the process of prioritizing investment in agriculture

Drawing from such a wide range of results, a key question can then be answered from this study: In which subsectors should public investment in infrastructure aimed at increasing productivity be prioritized, considering its effects on national and agrifood GDP growth, household consumption (welfare) and rural poverty reduction? Table 11 shows a ranking

of the top ten subsectors (of a total of 16 subsectors considered).[30] These subsectors are ordered in terms of their impact (from highest to lowest) on the four variables identified. Clearly, the sugar cane subsector is first in three of the four indicators. Cereals, primarily maize, but also rice, sorghum, oats, barley and other cereals (excluding wheat, which is at the bottom of the ranking), are sectors whose promotion would have positive effects on private consumption, GDP and rural poverty reduction. Export-oriented crops, such as flowers and coffee, are also relatively high in the ranking. Under no circumstances are livestock subsectors among the top five positions in the ranking.

TABLE 11 Ranking of subsectors according to the socio-economic effects of public investment

#	Private consumption	PIB	Agrifood GDP	Rural poverty
1	Sugar cane	Sugar cane	Wheat	Sugar cane
2	Other cereals	Other cereals	Other fruits	Other cereals
3	Maize	Maize	Beans	Maize
4	Other crops	Other crops	Other crops	Other crops
5	Flowers	Flowers	Coffee	Flowers
6	Other fruits	Other fruits	Maize	Other fruits
7	Poultry	Coffee	Vegetables	Poultry
8	Coffee	Vegetables	Flowers	Vegetables
9	Vegetables	Cattle	Oilseeds	Cattle
10	Cattle	Fishing	Other legumes	Coffee

Note: The agriculture sectors that were considered in the scenarios but that ranked lower than 10th are not presented here (see Tables 7 and 8).
Source: Authors' own elaboration.

These findings provide important information about the priorities in existing development plans, as well as new priorities to be considered for enabling economic recovery with increased well-being post-COVID-19. The findings validate the importance of having included sugar cane and cereals, primarily maize, but also others such as rice (which falls within the "other cereals" group in our analysis), and coffee, as priority subsectors of the 2019–2024 NDP. On the other hand, other subsectors that are prioritized in the NDP, such as those involving livestock, do not appear to be the most cost-effective in terms of the variables analysed under an economic recession setting (although they have significant linkages with the food industry). The flower subsector appears among the highest positions in our ranking, but is not considered in the NDP. Although the flower subsector has no direct influence on food security, investments that promote its productivity would have a significant impact on production, and, indirectly, on household's welfare. As is apparent, the evidence from this analysis provides information for decision-making regarding sectors not currently included in the NDP that could be prioritized to reactivate agriculture and the economy with gains in rural well-being.

[30] It is worth noting that, out of a total of 21 public investment scenarios, five were not associated with subsectors, but with the aggregate crop and livestock sectors (scenarios 1 through 5 in Table 8). The ranking in Table 11 focuses only on subsectors.

In addition, the ranking of subsectors is a starting point for more focused work on the subsectors that appear at the top of the ranking. Having such starting point is essential to proceed in answering more specific questions about these priority sectors. More precisely, it is important to identify the investments that are needed along the value chains linked to the priority subsectors. In this respect, it is necessary to identify the component of primary production that should be promoted in these subsectors (what to invest in) and the amount of resources needed to that end (how much to invest) so as to justify the budgets. An additional decision-making criterion which should be considered, is the identification of those territories where such investments could have the greatest socio-economic impact in an environmentally friendly manner, due to the high production and poverty reduction potential they offer (where to invest).

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Annexes

Annex A. Additional data and results

A1. Additional data

TABLE A1 Elasticities for value added, trade and consumption

Activity or product	Value added	Armington	CET	Expenditure
Oil-bearing plants	0.25	2.00	2.00	0.65
Beans	0.25	2.00	2.00	0.65
Other legumes	0.25	2.00	2.00	0.65
Wheat	0.25	2.00	2.00	0.65
Maize	0.25	2.00	2.00	0.65
Other cereals	0.25	2.00	2.00	0.65
Vegetables	0.25	2.00	2.00	0.65
Coffee	0.25	2.00	2.00	0.65
Other fruits	0.25	2.00	2.00	0.65
Sugar cane	0.25	2.00	2.00	0.65
Other crops	0.25	2.00	2.00	0.65
Flowers	0.25	2.00	2.00	0.65
Cattle	0.25	2.00	2.00	0.65
Pigs	0.25	2.00	2.00	0.65
Poultry	0.25	2.00	2.00	0.65
Aquaculture	0.20	2.00	2.00	0.00
Other animals	0.20	2.00	2.00	0.65
Forestry	0.20	2.00	2.00	0.65
Fishing	0.20	2.00	2.00	0.65
Oil and gas	0.20	2.00	2.00	1.30
Other mining	0.20	2.00	2.00	1.30
Electricity, gas and water	0.95	0.90	0.90	1.07
Construction	0.95	0.90	0.90	1.30
Animal feed	0.95	1.50	1.50	0.65
Grinding	0.95	1.50	1.50	0.65
Sugar	0.95	1.50	1.50	0.65
Vegetable preserves	0.95	1.50	1.50	0.65
Dairy	0.95	1.50	1.50	0.65

TABLE A1 (cont.) Elasticities for value added, trade and consumption

Activity or product	Value added	Armington	CET	Expenditure
Meat	0.95	1.50	1.50	0.65
Fish	0.95	1.50	1.50	0.65
Bakery	0.95	1.50	1.50	0.65
Other foods	0.95	1.50	1.50	0.65
Drinks	0.95	1.50	1.50	0.65
Tobacco	0.95	1.50	1.50	0.65
Textiles	0.95	1.50	1.50	0.97
Leather	0.95	1.50	1.50	0.97
Wood and paper	0.95	1.50	1.50	1.30
Refined oil products	0.95	1.50	1.50	1.30
Fertilizers	0.95	1.50	1.50	1.30
Other chemicals	0.95	1.50	1.50	1.30
Rubber and plastic	0.95	1.50	1.50	1.30
Non-metal mineral products	0.95	1.50	1.50	1.30
Metals and metal products	0.95	1.50	1.50	1.30
Machinery and equipment	0.95	1.50	1.50	1.30
Vehicles	0.95	1.50	1.50	1.30
Other manufactured goods	0.95	1.50	1.50	1.30
Trade	0.95	0.90	0.90	1.30
Transport	0.95	0.90	0.90	1.15
Financier	0.95	0.90	0.90	1.30
Professional	0.95	0.90	0.90	1.30
Support person	0.95	0.90	0.90	1.30
Education	0.95	0.90	0.90	0.92
Health	0.95	0.90	0.90	1.29
Hotels and restaurants	0.95	0.90	0.90	1.30
Domestic servant	0.95	0.90	0.90	1.30
Public administration	0.95	0.90	0.90	1.30
Other services	0.95	0.90	0.90	1.30

Notes: Value added = CES function (constant elasticity of substitution) to combine factors; Armington = CES function to combine domestic and imported purchases (elasticities of substitution between domestic and imported purchases); CET = constant elasticity of transformation function to determine domestic sales and exports (transformation elasticities between domestic sales and exports); and expenditure = household consumption elasticities with respect to total expenditure on goods and services.

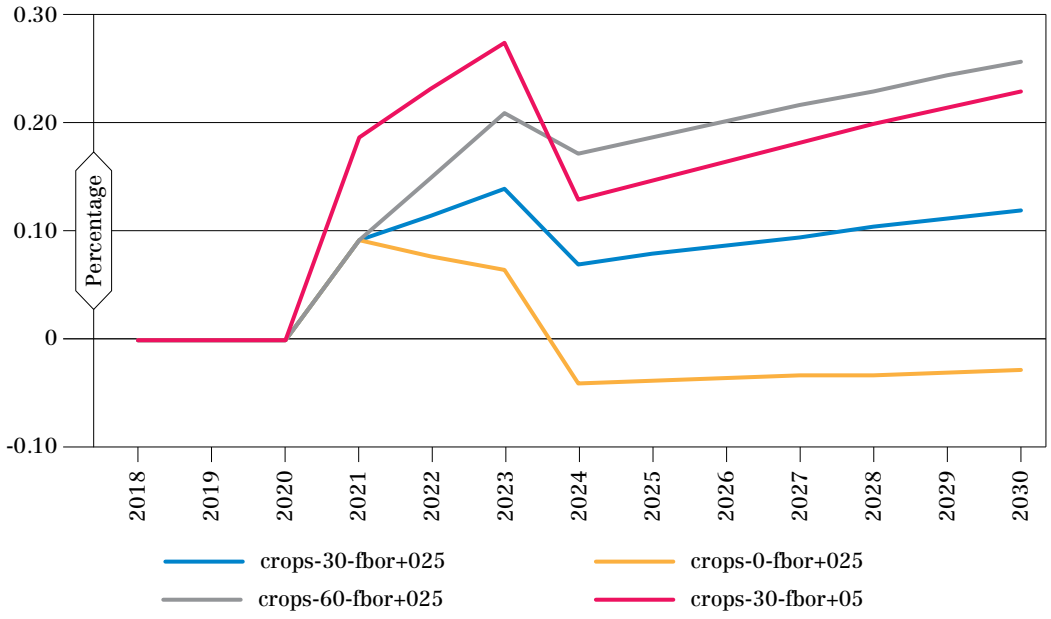
Source: Authors' own elaboration based on Sadoulet and Janvry (1995), Aguiar *et al.* (2019) and Muhammad *et al.* (2011).

A2. Results with alternative productivity assumptions and investment amounts

This annex assesses the sensitivity of the results presented in the main text and the assumptions made with respect to: (i) the marginal product of public investment, which in the main scenarios assumed a value of 0.3, and (ii) the amount of public investment, which in the main scenarios represented 0.25 percent of GDP in the 2021–2023 period. The assessment focuses on the scenario in which public investment affects the productivity of crop sectors seen as a whole. Case (i) considers two scenarios. In the first, public investment is assumed to have no effect on factor productivity (crop-0-fbor+025 scenario). In the second, the effect is doubled from the initial marginal product of capital of 0.3 (scenario crops-30-fbor+025). That is, the assumption is that, for each additional peso of public investment, the factorial productivity of the crop sector as a whole increases by the equivalent of 0.6 cents. In case (ii), the amount invested is doubled to half a percentage point of GDP (scenario crops-30-fbor+050). The results on private consumption and GDP for the main scenario (formerly crops-fbor, now crops-30-fbor+025) and the three additional scenarios, are shown in Figures A1 and A2, respectively.

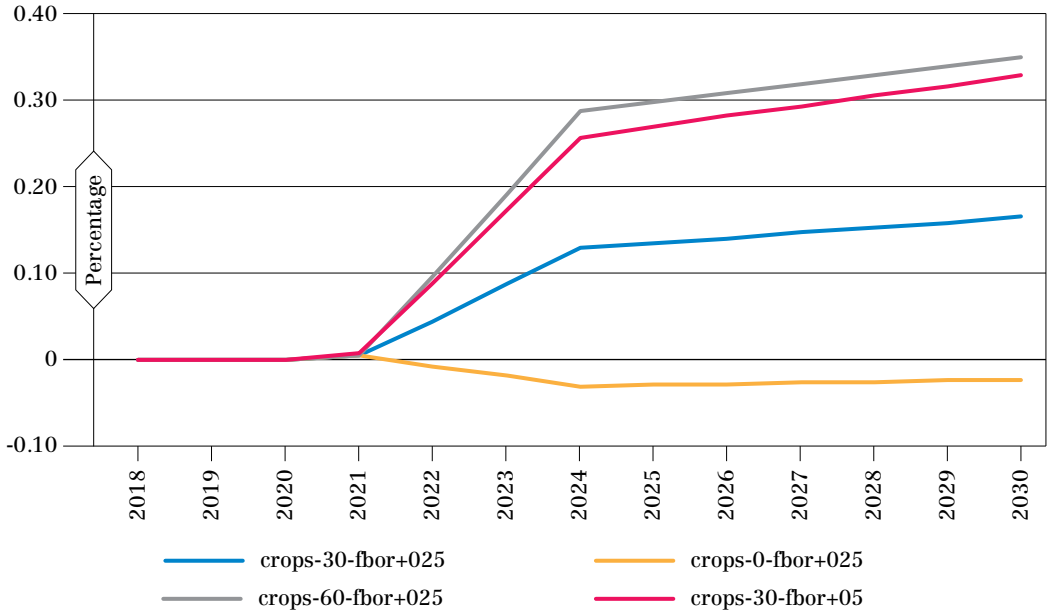
Comparing these three additional scenarios with the main scenario indicates that, as expected, the higher the marginal product of public capital is, the more positive the effects, because the additional public investment tends to generate greater increases in TFP. For example, when public investment is assumed to have no effect on the TFP, the results on private consumption and GDP are negative, in both the short and long term. In practice, these results underline the importance of selecting public investments that can ensure meaningful increases in the TFP of the agriculture sectors to be promoted the most. Finally, and for the investment amounts considered (0.25 and 0.50 percentage points of GDP), the higher the amount invested, the greater the impact.

FIGURE A1 **Private consumption in selected public investment scenarios with alternative assumptions for the marginal product of capital and the amount of investment (percentage deviation from the base scenario)**



Source: Authors' own elaboration.

FIGURE A2 **GDP in selected public investment scenarios with alternative assumptions for the marginal product of capital and the amount of investment (percentage deviation from the base scenario)**



Source: Authors' own elaboration.

Annex B. Analysis of sensitivity of scenario results to changes in elasticity values

The results of a CGE model, such as that used in this study, depend on the value assigned to the various supply and demand elasticities that populate various equations of the model. Specifically, the CGE model requires information for elasticities that define: substitution between production factors, on the production side; substitution between imported and domestically-produced products, on the consumer side; transformation of domestic production between exports and sales to the domestic market; income (or expenditure) for each of the products consumed by households; and, the level of unemployment with respect to wages (elasticity of wages with respect to unemployment). The uncertainty surrounding the value of these elasticities is transferred to the results of the simulated scenarios in Section 4 of this study.

This annex evaluates the sensitivity of the results of the various investment scenarios presented in Section 4 of the study, with respect to the value assigned to the different elasticities of the model. To do this, a Monte Carlo simulation is applied, which consists of solving the model (that is, running the scenarios) several times using each time a different set of elasticities that is chosen randomly. As a result of this procedure, the model was solved 500 times. Each time, the value of the elasticities was obtained from a uniform distribution with minimum and maximum values equal to 25 percent and 175 percent of the "central" value used to obtain the results presented and analysed in Section 4. Then, using the results of all model solutions for all scenarios, the confidence intervals for each of the results that were presented in the main body of the study were calculated.

Table B1 shows the results of the 18 scenarios simulated in this study (represented in columns) whereby only foreign borrowing is used as the source of financing for the new investment allocated to the different sectors and subsectors of Mexican agriculture (see Table 8). Only two key macroeconomic aggregates and the results for the year 2030 are included for the sake of simplicity. The presentation of results (by rows) starts with the estimated percentage of change of the two macroeconomic aggregates using the "central" elasticities (that is, the elasticities used to generate the results presented in Section 4 of this study). Then, to assess the sensitivity of the results to changes in the value of elasticities, the next results presented (by row) include the average of the 500 observations generated by the sensitivity analysis, the standard deviation, and the upper and lower limits calculated under the assumptions that the results are normally distributed and all the model solutions included in the Monte Carlo experiment receive the same weighting (see Table B1).

The results show that the percentage of change from the base scenario for private consumption and GDP reported in Section 4 are statistically significant. For example, there is certainty that the scenario in which new public investment in infrastructure promotes productivity in the sugar cane subsector (sugcane) has the most positive effects of all the scenarios considered. This conclusion is obtained by performing an average test for the results set out in Table B1.[31] The same type of assessment can be made for the other results reported in Section 4. That is, the results discussed in Section 4 are robust to changes in the elasticity values of Mexico's CGE model.

[31] That is, it was determined that the differences among the averages reported in Table B1 are statistically significant.

TABLE B1 Results of the sensitivity analysis for private consumption and GDP expressed as the percentage deviation from the base scenario in 2030

Item	crops	livestk	oilbrp	bean	othrlegum	wheat	maize	othrcereal	veg	coffee	othrfruts	sugcane	othrcrops	flowers	bovine	pig	poultry	fishing
Private consumption																		
Central elasticities	0.117	0.082	0.016	0.014	0.026	0.007	0.126	0.166	0.068	0.072	0.099	0.322	0.106	0.104	0.066	0.040	0.080	0.044
Mean	0.120	0.083	0.015	0.014	0.020	0.010	0.128	0.162	0.069	0.071	0.101	0.317	0.108	0.105	0.068	0.039	0.080	0.045
Standard deviation	0.010	0.007	0.028	0.019	0.038	0.027	0.020	0.018	0.013	0.013	0.011	0.021	0.039	0.009	0.007	0.006	0.007	0.007
Lower limit	0.101	0.069	–0.039	–0.024	–0.055	–0.043	0.088	0.127	0.044	0.046	0.080	0.276	0.031	0.087	0.054	0.027	0.066	0.030
Upper limit	0.139	0.097	0.070	0.053	0.094	0.064	0.167	0.198	0.095	0.097	0.122	0.358	0.184	0.123	0.082	0.050	0.094	0.059
Gross domestic product (GDP)																		
Central elasticities	0.164	0.089	0.073	0.077	0.066	0.046	0.182	0.251	0.117	0.139	0.148	0.463	0.169	0.160	0.089	0.060	0.075	0.085
Mean	0.167	0.090	0.073	0.078	0.058	0.051	0.186	0.250	0.118	0.138	0.150	0.459	0.172	0.160	0.091	0.059	0.076	0.085
Standard deviation	0.008	0.005	0.038	0.028	0.053	0.036	0.026	0.019	0.013	0.015	0.009	0.022	0.053	0.007	0.006	0.005	0.006	0.004
Lower limit	0.150	0.080	–0.001	0.023	–0.046	–0.020	0.135	0.212	0.093	0.109	0.131	0.417	0.067	0.146	0.079	0.050	0.065	0.076
Upper limit	0.183	0.101	0.147	0.133	0.163	0.122	0.236	0.287	0.144	0.168	0.168	0.502	0.276	0.175	0.102	0.068	0.087	0.093

Note: A 95 percent confidence interval is estimated under the normality assumption.
Source: Authors' own elaboration.

Mexico's gross domestic product (GDP) contracted unprecedentedly as a result of the COVID-19 crisis. While the primary sector has relatively been the most resilient, the agriculture sector lacks sufficiently strong productive dynamism and has high rates of informal work and low wages. Investing more in the sector's productive infrastructure would help accelerate economic recovery while improving people's well-being.

A public investment policy should be developed on the basis of evidence, such as that provided in this study. In 21 prospective scenarios that simulate the allocation of additional public investment in productive infrastructure across subsectors of agriculture, equivalent to 0.25 percent of GDP (around MXN 50 billion) between 2021 and 2023, there is an improvement in total and agrifood GDP, and in the well-being of the Mexican people, as measured by private consumption and rural poverty reduction. However, it is recommended that new investment be focused on certain subsectors and that it be financed through foreign borrowing. According to a ranking of subsectors that receive new investment, the sugar cane subsector ranks first in three of the four variables considered (private consumption, total GDP, agrifood GDP and rural poverty). Cereals, mainly maize, but also others (rice, sorghum, oats, barley and other cereals), and the more export-oriented crops, such as flowers and coffee, also appear at the top of the ranking.

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