UNIVERSIDAD COMPLUTENSE DE MADRID
FACULTAD DE ESTUDIOS ESTADÍSTICOS

TESIS DOCTORAL

Retos para el comercio y la inversión mundiales con especial atención a las políticas de EEUU:un análisis de Equilibrio

General Challenges for world trade and investment with special attention to U.S. policies : a General Equilibrium analysis

MEMORIA PARA OPTAR AL GRADO DE DOCTOR

PRESENTADA POR

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To María and Paz

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Resumen

1. Introducción

La aparición de nuevas tecnologías, los acontecimientos de índole geopolítica como los conflictos, las crisis energéticas, el cambio climático o las pandemias globales son sólo algunos de los muchos desafíos que vive el mundo. Una de las grandes virtudes de la investigación académica es la capacidad de proporcionar conocimiento y evidencia basada en datos para algunas de las preguntas que surgen de esos desafíos. Esta tesis pretende arrojar luz sobre algunas iniciativas relevantes de política económica en Estados Unidos (EE.UU.). Con el objetivo de proporcionar evidencia basada en un análisis cuantitativo, utilizaremos dos modelos de equilibrio general computable[1] (EGC).

Primero profundizamos en las implicaciones de uno de los acuerdos comerciales más importantes negociados (aunque aún por ratificar), a saber, el acuerdo comercial entre la Unión Europea (UE) y la región del Mercosur (integrada por Argentina, Brasil, Paraguay y Uruguay). Si bien la mayoría de los análisis de impacto de este acuerdo se centran en las regiones firmantes, proporcionamos resultados para EE.UU. y China, cuya actividad comercial en la región ha aumentado notablemente en la última década. Además, la modelización de las medidas no arancelarias y el comercio de servicios plantea un desafío importante, que normalmente no se aborda en los análisis cuantitativos de este acuerdo.

Más recientemente, EE.UU. aprobó una serie de leyes destinadas a fortalecer la economía estadounidense en términos de infraestructura básica, energía limpia y tecnología. Examinamos específicamente la Ley de Empleo e Inversión en Infraestructura (Infrastructure Investment and Jobs Act, IIJA por sus siglas en inglés) y la Ley de Reducción de la Inflación (Inflation Reduction Act, IRA por sus siglas en inglés), proporcionando un

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[1] Computable General Equilibrium, en inglés.

análisis profundo de sus efectos macroeconómicos, sectoriales y distributivos en el país. El uso de modelos estáticos y dinámicos para el análisis del IIJA y del IRA, respectivamente, pretende responder a diferentes cuestiones relacionadas con el impacto macro y microeconómico, los posibles efectos de medios alternativos de financiación o la eficiencia de la distribución de fondos.

El documento consta de siete capítulos. Después de introducir el tema y profundizar en la metodología en los Capítulos 1 y 2, el Capítulo 3 proporciona un análisis detallado del acuerdo comercial UE-Mercosur. Los Capítulos 4 y 5 abordan el impacto de la IIJA desde diferentes perspectivas, mientras que el Capítulo 6 aborda el impacto de la IRA. Finalmente, el Capítulo 7 concluye.

2. Objetivos y resultados

Los capítulos 1 y 2 introducen el tema y brindan una explicación detallada de la metodología utilizada en esta Tesis, respectivamente. El Capítulo 1 proporciona una introducción al contexto, las características y el alcance de las iniciativas políticas que se evaluarán a través de varios modelos de equilibrio general computable. En el Capítulo 2 se explica en detalle los tres modelos utilizados y se justifica su selección como herramientas para lograr nuestros objetivos.

El Capítulo 3 lleva a cabo un análisis integral del equilibrio general del acuerdo comercial UE-Mercosur combinando varios elementos como aranceles y cuotas, así como de medidas no arancelarias (MNA). El análisis abarca tanto sectores de bienes como de servicios. Extendemos así la literatura abordando todos los componentes del acuerdo, incluso el elemento generalmente omitido en lo concerniente a la apertura de la contratación pública a empresas extranjeras. Nuestros resultados cubren los impactos en 36 sectores diferentes en 9 regiones, algunas de las cuales son grandes economías mundiales, y países del Mercosur, mediante la aplicación del ampliamente conocido modelo GTAP. En términos de medidas no arancelarias (MNA), el desafío se basa en (1) cuantificar estas barreras no cuantitativas al comercio y (2) diferenciar dentro de las simulaciones entre medidas técnicas y no técnicas, como se explicará más adelante. Además, nuestro análisis evalúa los impactos de la contratación pública para comprender los efectos de la apertura de contratos gubernamentales.

Identificamos un impacto reducido del acuerdo en EE.UU., que reduciría el bienestar en 1.300 millones de dólares (0,01% sobre el PIB). A nivel sectorial, reduciría sus exportaciones manufactureras a los países del Mercosur en 4.700 millones de dólares (8,6%), debido a la mayor competencia de los exportadores de la UE que obtienen acceso preferencial a los mercados del Mercosur. Por ejemplo, las exportaciones de la UE a la región del Mercosur aumentan en 38.000 millones de dólares (74%). Del lado del Mercosur, Uruguay muestra el régimen más abierto y obtiene proporcionalmente mayores beneficios. Su PIB aumenta un 0,61% y los salarios un 2,31%. En el lado opuesto, Paraguay registra las menores ganancias en los países de la región debido a su negociación menos ambiciosa en el acuerdo. Brasil y Argentina muestran incrementos notables de producción en sectores específicos como el de Hortalizas, Frutas y Frutos Secos en Brasil (aumento de producción del 2,2%) o el sector de Carne de bovino y otros rumiantes (aumento de producción del 4%) en Argentina. En cuanto a los sectores de servicios, el acuerdo UE-Mercosur amplificaría la disparidad ya existente entre la presencia de la UE y EE.UU. en la región del Mercosur. La UE aumentaría sus exportaciones de servicios al Mercosur en un 10% (3.500 millones de dólares) impulsadas principalmente por sectores como Comunicaciones, Seguros o Servicios Empresariales. Por contraste, las exportaciones estadounidenses de estos sectores experimentan importantes reducciones.

El objetivo principal del Capítulo 4 es evaluar los impactos macroeconómicos de una ley federal que destina un volumen importante de inversiones a infraestructuras básicas en EE.UU. En concreto, nuestra investigación tiene como objetivo cuantificar los impactos económicos potenciales a corto y largo plazo atribuibles a la inversión federal de la Ley de Inversión en Infraestructura y Empleos (IIJA) en infraestructura básica (afectando a los sectores de Transporte, Servicios Públicos e Información). Al evaluar los impactos inmediatos del aumento del gasto público en actividades de construcción, medimos los cambios a corto plazo en el PIB, la demanda laboral y otras variables macro. Después de un año (aún en el corto plazo, durante la fase de construcción), nuestros resultados muestran un aumento del PIB del 0,24% (55 mil millones de dólares). El estímulo interno de corto plazo aumentaría el empleo en un 0,44% (650.000 trabajadores) debido principalmente al aumento de la demanda de trabajadores de la Construcción y trabajadores de otros sectores ligados al sector de la Construcción. Por otro lado, el índice de precios del PIB y el índice de precios al consumidor aumentarían un 2,33% y un 1,88%, lo que indicaría presiones inflacionarias en la economía. A largo plazo, el PIB aumentaría un 1,39% (292.000 millones de dólares) debido al aumento del capital físico y la productividad. Los salarios aumentarían un 3,94%. Estudiamos la eficiencia de la distribución actual de fondos y encontramos que una distribución sectorial más concentrada (dedicando *todos* los fondos al sector Transporte) podría beneficiar a la economía en términos de crecimiento del PIB, pero con menores subidas salariales si lo comparamos con la distribución actual de los fondos. La razón detrás de este fenómeno redunda en la mayor productividad relativa del capital sobre el trabajo en el sector Transporte.

El Capítulo 5 amplía el análisis sobre el IIJA realizado en el Capítulo 4 desde diferentes perspectivas. En primer lugar, busca comprender las implicaciones económicas de los diferentes métodos de financiación, en particular el recurso al ahorro nacional frente al ahorro extranjero, tanto para los resultados económicos de corto y largo plazo. De esta manera, nuestro objetivo es brindar información sobre las estrategias óptimas para financiar grandes inversiones públicas, como las del IIJA. El escenario del endeudamiento con el exterior implica un servicio de la deuda a más largo plazo, mientras que el endeudamiento nacional considera un servicio de la deuda distribuido más uniformemente en el corto plazo, y en el que la inversión del gobierno desplaza al consumo privado. Los resultados en el corto plazo muestran un efecto ligeramente mayor del IIJA recurriendo al ahorro exterior para el PIB (aumento del 0,22%) y el empleo (aumento del 0,43%), sin afectar significativamente el consumo privado o la inversión. Cuando la financiación es a través del ahorro nacional, el aumento del PIB y el empleo es ligeramente inferior (un 0,19% y un 0,38%, respectivamente). Sin embargo, el análisis a largo plazo muestra que el recurso al ahorro nacional (que como hemos dicho implica un servicio de la deuda en el corto plazo) genera mayores aumentos del PIB (1,39%) y de los salarios (3,94%) que el endeudamiento externo (1,19% y 2,75%, respectivamente). Además, en este capítulo analizamos los efectos distributivos del IIJA entre sectores y categorías de trabajadores. Los resultados revelan que la financiación nacional mejora el crecimiento salarial de manera más equitativa y minimiza los riesgos financieros a largo plazo. De este modo, ofrecemos no sólo estimaciones macroeconómicas y sectoriales en un mismo estudio (son escasas las metodologías que capaces de ofrecer resultados a ambos niveles) sino también matices e indicaciones para la mejor estrategia de financiación de las inversiones.

Finalmente, el Capítulo 6 utiliza un modelo EGC dinámico para analizar cómo el plan de inversiones relacionadas con el clima más importante de la historia de Estados Unidos, a saber, la Ley de Reducción de la Inflación (IRA), podría repercutir en el PIB, la inflación y la balanza comercial del país, entre otras variables. Para ello, modelizamos el efecto del principal vehículo empleado por el gobierno para incentivar la producción e inversión domésticas, esto es, los créditos fiscales. Diferenciamos cuatro escenarios: un primer escenario en el que consideramos los costes fiscales[2] estimados por la Congressional Budget Office (CBO). Dado que los créditos fiscales contemplados en esta ley no tienen tope presupuestario, la demanda final de los mismos es incierta. Varias instituciones e investigadores (Jiang et al., 2022; Goldman Sachs, 2023; Bistline et al., 2023; Committee for a Responsible Federal Budget, 2024) han estimado esta demanda final, concluyendo que podría llegar a triplicar la cifra estimada inicialmente. Por ello, añadimos tres escenarios en los que duplicamos, triplicamos y quintuplicamos las estimaciones iniciales de la CBO. Si bien un aumento de la inversión y producción domésticas generan un mayor crecimiento del PIB y del empleo, la eficiencia marginal de los incentivos fiscales disminuye a medida que se incrementan las inversiones. En el escenario en el que quintuplicamos los créditos

[2] Reducción de los ingresos fiscales como consecuencia de la demanda de créditos fiscales.

fiscales estimados inicialmente, el crecimiento acumulado del PIB alcanza un 0.67% para 2031, evidenciando rendimientos decrecientes. A nivel sectorial, sectores como Servicios Públicos (generación y distribución de electricidad, gas natural y agua), que reciben un 51% de los fondos, muestran un aumento significativo en la producción, pero con menor eficiencia en comparación con sectores como Vehículos de Motor y Equipos Eléctricos. Estos hallazgos sugieren que una redistribución más equilibrada de los incentivos fiscales podría optimizar los beneficios económicos y mejorar la eficiencia general del impacto de la IRA en la economía de EE.UU.

3. Conclusiones

Con respecto al impacto del acuerdo UE-Mercosur sobre EE.UU. y China (países no firmantes del acuerdo), a nivel macroeconómico el efecto sería muy reducido. A nivel sectorial, sectores estadounidenses como Vehículos a motor y repuestos, Metales y productos metálicos y Otra maquinaria experimentarían las mayores reducciones en las exportaciones al Mercosur. La UE aumentaría considerablemente sus exportaciones a los países del Mercosur en estos sectores. En cuanto a los sectores de servicios, el acuerdo UE-Mercosur representaría una apertura histórica de los mercados del Mercosur mediante la reducción de sus medidas no arancelarias (MNAs) y la apertura de contratos públicos. Esto aumentaría la presencia de la UE en los sectores de servicios, también en detrimento de los EE. UU. Sectores como la construcción, las comunicaciones y otros servicios empresariales serían los más afectados.

Con respecto al IIJA, los resultados de los capítulos 4 y 5 ofrecen las siguientes conclusiones. En primer lugar, el diseño de la ley con una mayor distribución de fondos entre diferentes sectores (Transporte, Servicios Públicos y Telecomunicaciones) ofrece mejores resultados que inversiones centradas únicamente en el sector de Transporte. En este sentido, aunque las necesidades de inversión son inicialmente mayores para la infraestructura de transporte, este sector tiene una relación trabajo/capital más alta (1.3) que en el caso de Servicios públicos (0.2) y del sector Información (0.6). Así, el efecto positivo sobre los salarios sería menor que en otros sectores. Ésta es una de las razones por las que una mayor distribución entre sectores favorece un crecimiento económico más inclusivo.

Por otro lado, nuestros resultados muestran un beneficio macro y microeconómico del IIJA independientemente de cuándo ocurra el servicio de la deuda. Sin embargo, arrojamos ideas importantes sobre la diferencia entre hacerlo a corto (lo llamamos *endeudamiento nacional* a corto plazo) o largo plazo (*endeudamiento exterior* a corto plazo). En este sentido, el endeudamiento nacional requiere ajustes de corto plazo que reduzcan el consumo y la inversión privados. Sin embargo, este escenario también genera mayores beneficios a largo plazo que en el escenario *endeudamiento exterior* (servicio de deuda a largo plazo). Este punto es especialmente sensible para EE.UU., que ha alcanzado niveles récord de deuda pública, evitando al mismo tiempo una crisis suspendiendo el techo de deuda autoimpuesto (World Economic Forum, 2023).

Finalmente, ofrecemos una de las primeras estimaciones cuantitativas detalladas, utilizando un modelo EGC dinámico, sobre cómo afectan a la economía de EE.UU. las partidas de gasto en energías limpias de la ley IRA. El estímulo interno impulsado por créditos fiscales impulsa el PIB y el consumo privado. Las exportaciones de las industrias relacionadas con el IRA (aquellas relacionadas con la fabricación de vehículos, baterías y minerales críticos, entre otras) muestran aumentos importantes, lo que indica un fortalecimiento real de las industrias relacionadas con las energías limpias en EE.UU. en términos de producción, empleo, inversión y exportaciones. Sin embargo, el estímulo interno aumenta la inflación, impactando negativamente la competitividad de las exportaciones en el resto de los sectores de la economía. A medida que EE.UU. hace la transición hacia fuentes de energía más limpias, aquellas industrias que no están directamente relacionadas pueden enfrentar desafíos importantes que deben abordarse mediante apoyos específicos y estrategias de transición (Gazmararian y Tingley, 2023). Por otro lado, los rendimientos decrecientes de capital y la exposición al comercio en las industrias relacionadas con el IRA son determinantes en los resultados. Al comparar los distintos escenarios (en los que contemplamos diferentes volúmenes de créditos fiscales) encontramos que la actual distribución de fondos entre sectores puede estar siendo ineficiente. El sector de Servicios Públicos recibe más de la mitad de dichos incentivos, pero sin embargo es el sector con menor rendimiento de capital, y sus exportaciones son prácticamente nulas. En contraste, los sectores relacionados con la manufactura de vehículos eléctricos, piezas y componentes para los mismos y los relacionados con componentes eléctricos (sector clave en la cadena de suministro de tecnologías renovables) tienen rendimientos superiores de capital y experimentan los mejores resultados de aumento de demanda de exportaciones. Sin embargo, la ley destina a dichos sectores menos del 17% (en conjunto) de los incentivos. Por último, un aumento de la demanda de créditos fiscales que supere las estimaciones iniciales es muy positivo para la economía tanto a nivel macro como sectorial, pero nuestros resultados muestran un rendimiento decreciente de dichos incentivos. Por lo tanto, una medida sin tope presupuestario tiene el potencial de atraer la inversión y producción, pero requiere de una adecuada distribución sectorial de los fondos que maximice su beneficio y emplee los recursos públicos de manera óptima.

Summary

1. Introduction

The emergence of new technologies, geopolitical events, climate change or global pandemics are just some of the many challenges that the world is experiencing. One of the great virtues of academic research is the ability to provide knowledge and data-driven evidence for some of the questions arising from these. This thesis aims to shed light on some relevant economic policy initiatives in the US. Aiming to provide evidence based on quantitative analysis, we will use a Computable General Equilibrium (CGE) approach.

We first delve into the implications of one of the most important trade agreements ever negotiated (but still to be ratified), namely the EU-Mercosur trade agreement. While most impact analyses on this agreement focus on the signatory regions, we provide results for the U.S. and China, whose commercial activity in the region has increased notably in the past decade. Moreover, a significant challenge arises from the modeling of non-tariff measures and trade in services, not commonly addressed in quantitative analyses of this agreement.

More recently, the U.S. approved a series of legislation aimed at strengthening the U.S. economy in terms of basic infrastructure, clean energy and technology. We specifically examine the Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA), providing an in-depth analysis of their macroeconomic, sectoral and distributional effects in the country. By means of both static and dynamic models for the examination of the IIJA and the IRA, respectively, we aim to answer different questions related to the detailed macro and microeconomic impact, the possible effects of alternative financing means of these important policies or the efficiency of the distribution of funds.

The document consists of seven chapters. After introducing the topic and delving into the methodology in Chapters 1 and 2, Chapter 3 provides an in-depth analysis of the EU-Mercosur trade agreement. Chapters 4 and 5 address the impact of the IIJA from different perspectives, while Chapter 6 addresses the impact of the IRA. Finally, Chapter 7 concludes.

2. Objectives and results

Chapters 1 and 2 introduce the topic and give a detailed explanation of the methodology in which this PhD Dissertation is based. Chapter 1 provides an explanation about the context, characteristics and scope of the policy initiatives that will be evaluated through various CGE models. Each model used is then explained in detail in Chapter 2 so to explain their functioning and to justify their selection as tools to achieve our objectives.

Chapter 3 carries out a comprehensive general equilibrium analysis of the EU-Mercosur trade agreement by combining various elements such as tariffs and quotas, as well as non-tariff measures (NTMs). The scope of the analysis covers both goods and services sectors. We extend the literature by addressing all the components of the agreement, even the usually omitted element of the openness of government procurement to foreign companies. Our results cover the impacts in 36 different sectors across 9 regions, some of which are large world economies, and Mercosur countries. We apply the publicly available (therefore transparent and replicable) and widely used GTAP model (version 7). In terms of non-tariff measures (NTMs), the challenge relies on (1) quantifying these non-quantitative barriers to trade and (2) differentiating within the simulations between technical and non-technical measures, as will be explained in detail. Moreover, our analysis assesses the public procurement impacts so to understand the effects of opening government contracts.

We identify a limited impact on the U.S. economy, which experiences a contraction in its welfare of $1.3 billion (0.01% over GDP). At a sectoral level, it would reduce its manufacturing exports to Mercosur countries by $4.7 billion (8.6%), due to the increased competition from EU exporters who gain preferential access to Mercosur markets. For instance, EU exports to Mercosur region increase by $38 billion (74%). On the Mercosur side, Uruguay shows the most open regime and proportionally obtains higher benefits. Its GDP increases by 0.61% and wages by 2.31%. On the opposite side, Paraguay exhibits smaller gains due to its less ambitious negotiation in the agreement. Brazil and Argentina show notable increases in production of specific sectors such as the Vegetables, Fruits and Nuts in Brazil (2.2%) or the Bovine and other ruminants meat sector (4%) in Argentina.

Regarding services sectors, the EU-Mercosur agreement would amplify the already existing disparity between EU and US's presence in the Mercosur region. The EU would increase its service exports to Mercosur by 10% ($3.5 billion) driven primarily by sectors such as Communications, Insurance or Business Services. Meanwhile the U.S. exports from these sectors face the most important reductions.

The primary objective of Chapter 4 is to evaluate the macroeconomic impacts of a major infrastructure investment federal law on the U.S. economy. Specifically, our research aims to quantify the potential short- and long-term economic impacts attributable to the Infrastructure Investment and Jobs Act's (IIJA) federal investment in basic infrastructure (Transportation, Utilities and Information). By evaluating the immediate impacts of increased government spending on construction activities, we measure short-term changes in GDP, labor demand and other macro variables. After one year (short-run, construction phase) our results show a 0.24% ($55 billion) GDP increase. The short run domestic stimulus would increase employment by 0.44% (650,000 workers), mainly due to the increase in demand for workers from the Construction sector and sectors related. On the other side, the GDP price index and Consumer Price Index would increase by 2.33% and 1.88%, signaling inflationary pressures in the economy. In the long term, GDP would increase by 1.39% ($292 billion) due to increased physical capital stock and productivity. Wages would increase by 3.94%. We study the efficiency of the current distribution of funds, finding that a more focused sectoral distribution (devoting all funds to the Transport sector) could only benefit the economy in terms of GDP but with smaller wage increases when compared to the current distribution of the funds. The reason behind this redundant phenomenon is the higher relative productivity of capital over labor in the Transportation sector.

Chapter 5 extends the analysis on the IIJA carried out in Chapter 4 from different perspectives. First, it seeks to understand the economic implications of different financing methods, in particular national versus foreign borrowing, towards the short-run and long-run economic outcomes. This way, we aim to provide insights into the optimal strategies for financing large public investments, such as those under the IIJA. The foreign borrowing scenario implies a debt service in the longer term, while national borrowing considers a more evenly distributed debt service in the short run (government investment crowds out private consumption). Results show a slightly higher effect of the IIJA on GDP (0.22% increase) and employment (0.43% increase) without significantly affecting private consumption or investment with foreign borrowing, while under national borrowing GDP and employment increase by 0.19% and 0.38%. However, the long-term analysis showcases that national borrowing (service debt in the short run) yields stronger GDP (1.39%) and wage (3.94%) increases than under foreign borrowing (1.19% and 2.75% respectively). Additionally, in this chapter we analyze the distributional effects of the IIJA across sectors and worker categories. The results reveal that national borrowing enhances wage growth more equitably and minimizes long-term financial risks. In this way, we offer not only macroeconomic and sectoral estimates in a single study (few methodologies are able to offer results at both levels) but also nuances and indications for the best investment financing strategy.

Finally, Chapter 6 uses a dynamic CGE model to analyze how the most important climate-related investment plan in U.S. history, namely the Inflation Reduction Act (IRA), could impact the U.S.'s GDP, inflation and trade balance, among other variables. We model the effect of the main vehicle used by the government to incentivize domestic production and investment, i.e. tax credits. We distinguish four scenarios: a first scenario in which we consider the fiscal costs estimated by the Congressional Budget Office (CBO). Since the tax credits under this law have no budget ceiling, the final demand for them is uncertain. Several institutions and researchers (Jiang et al., 2022; Goldman Sachs, 2023; Bistline et al., 2023; Committee for a Responsible Federal Budget, 2024) have estimated this final demand, concluding that it could be as much as three times the initial estimate. We therefore add three scenarios in which we double, triple and quintuple the CBO's initial estimates. While higher domestic investment and output generate higher GDP and employment growth, the marginal efficiency of tax incentives decreases as investment increases. In the scenario in which we quintuple the initially estimated tax credits, cumulative GDP growth reaches 0.67% by 2031, showing diminishing returns. At the sectoral level, sectors such as Utilities (generation and distribution of electricity, natural gas and water), which receive 51% of the funds, show a significant increase in output, but with lower efficiency compared to sectors such as Motor Vehicles and Electrical Equipment. These findings suggest that a more balanced redistribution of tax incentives could optimize the economic benefits and improve the overall efficiency of the IRA's impact on the U.S. economy.

3. Conclusions

Regarding the impact of the EU-Mercosur agreement on the U.S. and China (non-signatory countries), at the macroeconomic level the effect would be very small. At a sectoral level, U.S. sectors such as Motor Vehicles and parts, Metals and metal products and Other machinery would experience the highest reductions in exports to Mercosur. The EU would considerably increase its exports to the Mercosur countries in these sectors. Regarding services sectors, the EU-Mercosur agreement would represent a historical opening of Mercosur markets through the reduction of its NTMs and the opening of public contracts. This would increase the EU presence in service sectors, also to the detriment of the U.S. Sectors such as Construction, Communications and Other business services would be the most impacted.

With respect to the IIJA, the results of chapters 4 and 5 lead to the following conclusions. First, a greater distribution of funds among different sectors (Transport, Utilities, Information) offers higher outcomes than a sector-focused one. In this sense, although investment needs are initially higher for the transport infrastructure, this sector has a higher labor/capital ratio (1.3) than Utilities (0.3) or Information (0.6). Thus, the positive effect on wages would be less than in other sectors. This is one of the reasons why a more even distribution favors a more inclusive economic growth.

On the other hand, our results show a macro and microeconomic benefit of the IIJA regardless of when the debt service occurs. However, we shed important insights on the difference between doing so in the short term (we call it short-term *domestic borrowing*) or in the long term (short-term *foreign borrowing*). In this sense, national borrowing requires short run adjustments that reduce private consumption and investment. However, a short-term debt service generates greater benefits in the long run than under foreign borrowing (long-term debt service). This point is especially sensitive for the U.S., which has reached record levels of public debt, while avoiding a crisis by suspending the self-imposed debt ceiling (World Economic Forum, 2023).

Finally, we provide one of the first detailed quantitative estimates, using a dynamic CGE model, of how the clean energy spending provisions of the IRA affect the U.S. economy. Domestic stimulus driven by tax credits boosts GDP and private consumption. Exports of IRA-related industries (those related to vehicle, battery and critical minerals manufacturing, among others) show significant increases, indicating a real strengthening of clean energy-related industries in the U.S. in terms of output, employment, investment and exports. However, domestic stimulus increases inflation, negatively impacting export competitiveness in the rest of the economy. As the U.S. transitions to cleaner energy sources, those industries that are not directly related may face significant challenges that need to be addressed through targeted support and transition strategies (Gazmararian and Tingley, 2023). On the other hand, diminishing returns to capital and exposure to trade in IRA-related industries are determinants of the results. Comparing different scenarios (in which we consider different volumes of tax credits) we find that the current distribution of funds across sectors may be inefficient. The Utilities sector receives more than half of these incentives, yet it is the sector with the lowest return on capital, and its exports are virtually zero. In contrast, sectors related to the manufacture of electric vehicles, parts and components and those related to electrical components (a key sector in the renewable technology supply chain) have higher returns on capital and experience the best export demand growth results. However, the law allocates less than 17% (in aggregate) of the incentives to these sectors. Finally, an increase in demand for tax credits that exceeds the initial estimates is very positive for the economy at both the macro and sectoral level, but our results show a diminishing return on such incentives. Therefore, a measure without a budget cap has the potential to attract investment and production but requires an appropriate sectoral distribution of funds that maximizes their benefit and uses public resources in an optimal way.

Chapter 1. Introduction

The U.S. economy is the second largest in the world (after China), with a GDP of approximately $28.8 trillion measured in terms of purchasing power parity (PPP) as of 2024 (World Bank, 2024). Through its financial markets, consumer spending and technological innovation it remains a global power in many areas and has a significant influence over global economic and political trends. The U.S. plays a leading role in shaping international relations and global initiatives from security to climate change.

In this global world, international trade plays a key role. In this sense, a higher trade exposure increases their economic dependence on the foreign market. International treaties, widely analyzed in the research literature, have potential consequences not only for the signatory regions, but also for other trading partners. This is the focus of the first part of this dissertation, in which through the CGE methodology, we aim to answer how a trade agreement of great importance such as the EU-Mercosur can affect the U.S. economy, especially in its trade with the signatory regions.

The EU-Mercosur, although not yet ratified, is one of the most important trade agreements ever negotiated, as it accounts for approximately 10% of the global population, 23.5% of global GDP and more than 35% of global exports and imports. Within the scope of the agreement, it contemplates a 90% tariff liberalization and two aspects not usually included in these types of agreements: non-tariff measures (NTM) reductions and opening of public contracts. These aspects are new for the Mercosur region and would convert the agreement into a historical deal. The impact of NTMs reduction and public procurement openness could be wider than expected. Unlike a tariff reduction agreement, in the case of NTMs its reduction (i.e., more harmonized regulations in the Mercosur countries, aligned with United Nations standards) could benefit trade with third countries. It is at this point that the first question we have asked in this thesis arises: how will this agreement affect the U.S.? In principle, on the one hand, a tariff reduction between the signatory regions would harm the competitiveness of the U.S. in those regions, but the reduction of NTMs, especially in Mercosur, could benefit the U.S.

The U.S. maintains a high volume of trade in goods and services with the EU; major U.S. exports include aircraft, vehicles and pharmaceuticals, while EU countries import significant quantities of machinery, vehicles and pharmaceuticals. However, this fluid flow of goods and services, added to the high investment in both directions is currently experiencing a state of diplomatic and commercial tension due to the laws passed by the U.S. on renewable energies. Specifically, the law we are analyzing in this dissertation (IRA) represents a change towards protectionism and may have consequences in the US.

As for Mercosur, it represents a smaller but strategically important market for U.S. exports. US-Mercosur trade is characterized by significant exports of machinery, petroleum products and electronic equipment from the U.S. Mercosur exports to the U.S. include mainly agricultural products and raw materials (USDA Foreign Agricultural Service, 2023). Although the trade volume is smaller compared to the EU, the economic and political ties with Mercosur are of geopolitical importance, especially given the growing presence of China in the region.

In terms of infrastructure, the existing literature on the relationship between infrastructure and economic growth seems inconclusive (Timilsina et al., 2023). U.S. basic infrastructure has deteriorated significantly and is lagging, leaving the country in the 13th position in global infrastructure quality according to the 2019 Global Competitiveness Report (Schwab, 2019). Following this phenomenon and coinciding with a change of government in the country, President Biden approved a series of historic investment plans with the aim of generating long-term sustainable growth in the country. Based on a policy of increasing public spending in the short term, three laws were passed, two of which are analyzed in this thesis. The Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA), together with the CHIPS and Science Act[3], are the three main legislative initiatives

[3] Not evaluated in this dissertation.

focused on climate and infrastructure signed by President Biden since its arrival to the White House. They aim to stimulate the U.S. economy and improve the country's competitiveness through improving its infrastructure, investing in clean energy and in investing in semiconductor manufacturing, respectively.

The IIJA and the IRA, which are analyzed in this thesis, differ in their funding paths. While the IIJA increases government spending without considering a specific financial mean (i.e. it increases deficit), the IRA contemplates a series of tax reforms and cost reductions aiming to increase revenues by more than spending and lead to a deficit reduction.

The Infrastructure Investment and Jobs Act (IIJA) signed into law by President Biden in 2021 is a response to these U.S. infrastructure challenges. It represents one of the largest public investment-related legislation in basic transportation, energy and telecommunications infrastructure in U.S. history. Its importance is comparable to the establishment of the Interstate Highway System in 1956 (Blas, 2010). This Act calls for total spending of $1200 billion, of which $550 billion is above current spending levels. Beyond improving the quality of infrastructure, the bill aims to create job opportunities, support underserved communities, address climate concerns and invest in American manufacturing. This thesis delves deeply into the IIJA and aims to shed light on how this law could impact the U.S. economy, both in the short run (during the construction phase) and in the long run, once the infrastructures become fully operational.

The analyses on the IIJA carried out in Chapter 4 and Chapter 5 provide results for a broad set of macroeconomic and sectoral variables by using the CGE approach. We also estimate the results for labor across occupations, sectioning the labor force into different types of workers (even within the categories of both skilled and unskilled occupations) and by income level. This allows us to evaluate if the IIJA will generate inclusive growth or not. Moreover, we address two additional issues regarding the IIJA impact. First, we aim to determine if the current distribution of funds across industries is the most efficient. Finally, when exploring the financing of the IIJA, we delve into an important issue that will impact the real outcomes of the law. Although the financing of the IIJA is fully public through federal spending increases, the real impact will depend significantly on how this debt increase is financed, i.e., in the short or long term.

Finally, Chapter 6 provides an impact analysis on the IRA. This law represents a record in terms of public stimulus for private investments in renewable technologies and green energy, devoting $393 billion to promote clean energy production and investment. Differently from the IIJA, which is focused on increased direct public spending on basic infrastructure, the IRA includes a series of tax incentives to boost clean energy domestic production and investment. A high proportion of these incentives are in the form of uncapped tax credits (more than 65%) thus posing uncertainty on the final outcomes of the law. To address this challenge and provide data-driven conclusions, we focus our analysis on estimating the effects and efficiency of the climate-related tax incentives. This perspective allows us to answer several questions that arise from the specificities of the law: what outcomes could be expected from sector-targeted incentives? What could be the effects of a high demand for tax credits? Is the current distribution of tax credits the most efficient? To address this challenge, we use a dynamic CGE model of the U.S., defined over 74 industries, and analyze several scenarios based on different government spending volumes. By analyzing the GDP and sectoral output multipliers, we aim to compare the efficiency of public funds at national and sectoral levels.

Chapter 2. Methodology

Computable General Equilibrium (CGE) models are often used in the area of economic policy analysis. They offer a high detail on multiple and simultaneous interactions taking place in an economy (Burfisher, 2017; Latorre, 2010; Latorre, 2012). They embody many markets and agents, hence making it possible to do very comprehensive and flexible analysis of changes in national and international policy initiatives. Its *General* feature represents a strength, as it means that the model captures interactions of different sectors, agents, and markets, making analyses very flexible and detailed. They are of special value when it comes to defining scenarios for policy analysis, helping policymakers make prior anticipation of outcomes and data-driven decisions.

Specifically, to conduct the analysis of the three policy initiatives described above, namely the EU-Mercosur trade agreement, the IIJA and the IRA, we have employed three different CGE models. To analyze the potential impact of the EU-Mercosur agreement (Chapter 2), we use the GTAP standard model, a comparative static, multi-region, multi-sector, computable general equilibrium model, for which a comprehensive description is available in Latorre (2012), Corong et al. (2017) and Hertel (2013) and a more succinct one in Zhou and Latorre (2014). Chapters 3 and 4 address the impact of the Infrastructure Investment and Jobs Act (IIJA) by means of the TERM-USA Horridge (2012), a static, multi-region, multi-sector CGE model, which also differentiates different types of workers. Chapter 5 employs the dynamic version of this TERM model, namely the USAGE model, to estimate the impact of the Inflation Reduction Act (IRA) on the U.S. economy.

The static GTAP model used in Chapter 3 provides a cornerstone in discussing international trade agreements with full representation of the dynamics of the world economy. The disaggregation of the economy to very detailed sectors and geographic regions allows us to start to see which of the sectors and regions might be winners or losers from trade liberalization and opens the possibility of identifying disparities between different sections of the economy.

This means that the GTAP static model allows for robust analysis of several trade policy scenarios, giving room to the policymakers to evaluate the possible repercussions of alternative policy options (Narayanan and Walmsley, 2008). With this model we can measure how, for instance, a decrease in tariffs or other measures in trade facilitation or even regulation harmonization would affect world production, consumption, employment, and welfare. This empirical evidence is very helpful and supports the policymaker to have more informed judgment and negotiation in the process of a trade agreement that would maximize the gain in economic efficiency and welfare.

Furthermore, the GTAP Static Model makes it easy for international cooperation, since it does provide a common basis for the assessment of trade agreements (Hertel, 1997). The standardized database and modeling approach installed in it makes the tool applicable to be used by many countries' researchers and policymakers. It enables international collaboration, making it possible to compare results consistently. To put it briefly, the GTAP model is a valuable tool for analyzing international trade agreements. It helps to understand how these agreements can affect the distribution of wealth and provides insights into potential policy impacts and welfare changes that might result from these agreements.

Our simulations contemplate not only the common element in these types of agreements—tariffs—but also non-tariff measures (NTMs). By quantifying these initially non-quantitative barriers, the simulations also gauge their effects both in their strictest definition and in the form of Public Procurement openness. The inclusion of service sectors, which are often underrepresented in these types of analyses, marks another significant expansion of the scope. Three types of simulations have been conducted: (1) tariff reduction, (2) reduction of non-tariff barriers, and (3) opening of the public sector to foreign companies. Additionally, for the NTMs, the analysis goes a step further by distinguishing between technical NTMs and non-technical NTMs to calculate the percentages of reduction. As for the Public Procurement openness, also modeled in the form of NTM reductions, the percentages of reduction of these measures are based on specific details found upon deep examination of the official text of the agreement. Among others, the analysis accounts for (1) the differing graduality of this openness between the EU and Mercosur, (2) the uncertainty regarding whether Paraguay would ultimately open its Public Procurement and to what extent, therefore excluding Paraguay from this NTM reduction, and (3) sectors such as Gas, Energy, and Water Utilities not opening their Public Procurement in any of the signing countries.

In Chapters 4 and 5 we use The Enormous Regional Model for the U.S. (TERM-USA), a multi-sector and multi-region CGE model for the U.S. comprehensively described by Horridge (2012). It is based on the generic TERM and developed by the Centre of Policy Studies, from Victoria University (Australia). TERM builds on the ORANI model for the Australian economy and provides a strategy for creating a "bottom-up" multi-regional CGE model used for comparative-static simulations. Along with national constraints, it treats each region within the U.S. as an independent economy. Thus, prices and quantities can vary from one region to another. In each region, the households' preferences are defined by a representative consumer, and firms produce goods that are consumed by final users (households, government, exports) or by other firms (as intermediate inputs). In this specific U.S. version, the 11 regions are based on an aggregation for modelling electricity generation and distribution (electricity grid regions, see Appendix II). It distinguishes 26 sectors combining goods (17) and services (9), each of them producing a single product or service.

As is well known, CGE models rest on the input-output structure of the economy but assume more flexible functional forms than input-output models. Interestingly, upon national statistics, the database of the TERM-USA model adds a regional dimension based on regional statistics. The original database (Centre of Policy Studies, 2013) was updated to 2019 levels using a program developed by the Centre of Policy Studies (2019). In summary, the TERM environment provides a great insight into the extent of a national-level economic shock on its regions. Moreover, the choice of this model is strongly motivated by the possibility of introducing shocks at the regional level. Although the IIJA is a federal law, the final distribution of investments is unequal across the different states of the country, and therefore applying a national shock would distort the results. We therefore avoid this risk committed by other studies such as Bonakdarpour et al. (2021). This ability to integrate regional features into a national model allows us to capture nuanced impacts of the IIJA. A detailed description of the TERM-USA model is provided in Appendix III.

As happens in the GTAP model, the TERM-USA model uses a number of equations that represent the relationships between the various economic agents: households, firms and government, along with foreigners involved in business activities under neoclassical economic assumptions. In addition, TERM-USA considers perfect competition between sectors and therefore constant returns to scale in the production of goods/services. In these sectors, products are priced at marginal cost and no agent has control over prices. Product differentiation is done on the basis of the area of origin, according to Armington's assumption that goods are differentiated in geographical terms.

The analysis of Chapter 6 is based on the single-country (U.S.) version of the USAGE model to study the dynamic impacts of the Inflation Reduction Act of 2022 on the U.S. economy. The USAGE is a dynamic computable general equilibrium model based on the MONASH model for the Australian economy developed by the Centre of Policy Studies (CoPS) (for an exhaustive model formulation including the detail of the equations see Dixon et al., 2013). The USAGE database used for this analysis is based on an updated version from 2011. Relying on the same sources as the original version of the dataset[4], it has been updated to 2023 using data on GDP, private consumption, investment, trade, wages, exchange rate and consumer price index over the 2011-2023 period. The initial solution in the model is solved with data from the base year (2024), as is common in CoPS-style models. This data, along with the theoretical framework of the model embedded through the model equations shows us how different agents of the U.S. economy interact. After defining the

[4] Detailed data sources are explained in Section *4. Simulations and results* of Chapter 5.

scenario through the model closure and the policy simulation, the values in the database vary over time as a consequence of the shock that has been introduced.

As a natural evolution in the thesis dissertation, we used a dynamic model in Chapter 6. While the static feature of the TERM-USA means results for a specific point in time (short or long run depending on how we define the model) the dynamic nature of the USAGE model makes it possible to see the evolution of economic variables over time in response to a policy change or an external shock. The term static emphasizes the fact that we are comparing two different market equilibriums at discrete points in time—one before and one after the exogenous shocks are introduced—as opposed to analyzing the dynamic process of price and quantity changes. The latter is simulated with the USAGE model. In this case, "recursive dynamics" refers to the method through which the outcomes of one period (year) are used as inputs for the next. This allows the model to simulate how the model variables evolve over time.

The recursive dynamics should also capture another relevant aspect of capital accumulation. A dynamic captures year-on-year capital accumulation effects, reflecting the firms' investment decisions and how these changes alter productive capacity yearly. It uses industry-specific sets of equations to represent capital accumulation. It thus captures the way in which investment in the present influences future demand for labor and influences the capacity and therefore level of output from that capacity.

Another aspect of the recursive dynamics in USAGE is the modeling of government fiscal accounts over time. In other words, a good number of periods bear out the changes in public debt sector and the accumulation of financial assets/liabilities, changing the pattern of government spending, showing the dynamic nature of fiscal policy and its consequences over time on economic outcomes. From this dynamic view, the USAGE model provides the year-on-year implications of policy decisions over the 2024-2031 period.

Chapter 3. Unlocking Opportunities: An In-depth General Equilibrium assessment of the EU-Mercosur Association Agreement

Abstract

We offer a comprehensive general equilibrium analysis of the EU-Mercosur agreement considering tariffs, quotas, non-tariff measures in goods and services and a usually neglected component, namely, government procurement. We base our analysis on the well-known GTAP model and cover the results for 36 sectors and 9 regions (US, EU, Argentina, Bra9zil, Paraguay, Uruguay, Canada, China and ROW). Our estimations are based on the negotiated tariffs and quotas at the HS 8-digit level and on a thorough analysis of the texts of the agreement. Our quantitative estimations for GDP, welfare, wages and aggregate trade show larger gains in countries with current high trade barriers and a stronger liberalization commitment. GDP increases are highest in Uruguay (0.61%), and lowest in Paraguay (0.04%) and of 0.13% (in Brazil) and 0.26% (in Argentina). The EU derives a 0.20% increase in wages. Although the macroeconomic impact of the agreement on China and the U.S. is very reduced, these non-signatory countries reduce exports of manufactures and services to Mercosur in favor of the EU.

1. Introduction

The EU-Mercosur agreement has been the subject of a hot debate. Even though negotiations officially concluded in July 2019, there is some remarkable resistance from several European countries. France, for instance, has ruled out ratification until concerns over environmental protection are resolved (Brunsden & Fleming, 2021). On the other hand, some researchers point out that while the EU has been negotiating the agreement for the last 20 years, China has stablished a strong commercial position. They claim that if the EU-Mercosur agreement had been closed earlier on time, the situation would have been different (Fariza & Rivas, 2021).

The European Union (EU) has become the first major partner to sign a trade agreement with Mercosur (Argentina, Brazil, Paraguay and Uruguay). The EU could formalize an agreement with Mercosur, which neither the U.S. nor China has, granting preferential access to the EU countries in an area that is currently highly protected. In terms of the dimension of the agreement, this is the biggest trade deal signed by both regions. The agreement covers a population of 780 million citizens (10% of the world population) and almost a quarter of the world's GDP (23.5%) (Inter-American Development Bank, 2019). Not only it is the first time in which Mercosur signs an agreement with another large regional block, but also the first time that Mercosur signs a trade agreement that regulates trade in services (Timini & Viani, 2020). The relief of tariffs and non-tariff measures (NTMs) on goods trade, as well as services trade and investment, is included in this agreement. It also has big ambition for government procurement openness, particularly on the Mercosur side, which has previously been closed to foreign bidders. The agreement has not been free of criticism and controversy since the negotiations began, and on several fronts, including the deforestation of the Amazon (Arima et al., 2021) or the impact on European livestock production.

Many studies estimate the economic impact of Free Trade Agreements (FTAs) by means of computable general equilibrium (CGE) models (Bekkers and Rojas-Ramagosa, 2019; Hertel et al. 2007; Hertel 2013), which are computer-based simulations for assessing trade agreements at the region, country and broad sector level (Nilsson, 2018). We compare our results with those obtained by the UNCTAD (2017), London School of Economics (2020), Latorre et al. (2021), Sanguinet & Alvim (2020) and Carrico et al. (2020), who also use a CGE approach to estimate the impact of this deal. We believe we contribute to this literature along three main fronts. Firstly, with respect to data because we use the negotiated tariffs and quotas at the HS 8-digit level and the latest version of GTAP[5], namely GTAP 10, while the London School of Economics (2020) and Sanguinet & Alvim (2020) use the previous version of the GTAP database. Secondly, we make an in-depth analysis of the NTMs of the agreement, distinguishing between technical and non-technical measures, based on the official annexes of the agreement and applying reductions by NTM type and by region. The

[5] GTAP stands for Global Trade Analysis Project.

aforementioned papers do not make this distinction or rely on ambitious versus moderate scenarios. Finally, to the best of our knowledge we are the first to introduce a specific simulation to grasp the impact of public procurement. This simulation consists of a specific reduction of NTMs related to the opening of public contracts based on the official chapters of the agreement.

We base our analysis on the widely used GTAP model, which makes our analysis transparent and replicable. A further innovative aspect of our analysis is the combination of both goods and services sectors, on the one hand, and of macro and sectoral variables, on the other hand. There are several New Quantitative Trade Models (NQTMs) that have previously analyzed the EU-Mercosur agreement (Timini & Viani, 2020; Sinabell et al., 2020). They estimate the impact on goods trade, but they do not offer results for trade in services or more generally sectoral outcomes. Our general equilibrium analysis allows to estimate a broad set of macroeconomic outcomes for GDP, welfare, wages, aggregate trade, together with detailed sectoral impacts for production the 36 sectors in which our model economies have been split.

As has just been noted, we have based our simulations on official documents issued by the European Commission (European Commission, 2019) and by the ministries of the Mercosur countries, whose official webpages show the same documents (e.g., Ministerio de Relaciones Exteriores del Paraguay, 2019). The negotiated tariffs that are cited in these documents are offered at the 8-digit level. We have estimated tariff reductions, including the impact of the new quotas agreed. An important effort has been made to carefully aggregate data on tariffs, quotas and NTMs for the sectors of our model. Regarding NTMs, both the EU and Mercosur countries have detailed, on a qualitative manner, their level of openness for each sector. Again, a detailed analysis has been conducted to translate them into the simulations we run in our model. In addition, we pay particular attention to how government procurement openness has been negotiated. All in all, this paper constitutes an effort to base our simulations on the particular agreement that has been negotiated. This contrasts with the approach of the New Quantitative Trade Models, which rely heavily on the outcomes of previous trade agreements to infer what the current EU-Mercosur agreement would bring.

Deepening into the signatory regions' main trading partners with the data that have been used in our model, we first show the main import and export partners in Mercosur (as a region) in Tables 1 and 2.

Table 1. Origin of Mercosur Imports (2014), in $US million and % share

Sector aggregation	EU		Mercosur		US		China		TOTAL
	Total ($million)	%share	Total ($million)	%share	Total ($million)	%share	Total ($million)	%share	
Agriculture	604	7.2%	3942.1	46.8%	1234.7	14.6%	288.7	3.4%	8428.4
Manufacturing	61480.9	17.7%	40414.8	11.6%	55231.4	15.9%	67722	19.5%	347655.3
Services	37903.2	37.6%	1309.7	1.3%	16140.8	16.0%	3394.7	3.4%	100831
Total	**99988.1**	**21.9%**	**45666.6**	**10.0%**	**72606.9**	**15.9%**	**71405.4**	**15.6%**	**456914.7**

Source: authors' elaboration based on Aguiar et al. (2019)

Table 2. Destination of Mercosur exports (2014), in $US million and % share

Sector aggregation	EU		Mercosur		US		China		TOTAL
	Total ($million)	%share	Total ($million)	%share	Total ($million)	%share	Total ($million)	%share	
Agriculture	9558	12.2%	3596.5	4.6%	3299.7	4.2%	23298.6	29.8%	78220.1
Manufacturing	32368.4	13.9%	38602.8	16.5%	28657	12.3%	28965.6	12.4%	233572.2
Services	15145	28.5%	1309.7	2.5%	7191.1	13.5%	3785.1	7.1%	53135
Total	**57071.4**	**15.6%**	**43509**	**11.9%**	**39147.8**	**10.7%**	**56049.3**	**15.4%**	**364927.3**

Source: authors' elaboration based on Aguiar et al. (2019)

Although the percentages may change from year to year, especially at a more disaggregated level, our tables show that the EU is the main trading partner of Mercosur, both as an origin of its imports (21.9% share) and destination of its exports (15.6% share). Services exhibit the highest share of imports from the EU in Mercosur, (37.6%, 37.9 $US billion). After intra-regional trade among Mercosur members (46.8% share), the U.S. is the main importer of agricultural sectors in Mercosur, with a 14.6% share (1.2 $US billion). China stands out as the main destination of agricultural Mercosur exports with almost a 30% share (23.3 $US billion). China is also the main importer of manufactures in Mercosur

(19.5%, 67.7 $US billion). However, as can be seen in Table 1, the difference between the three main powers in manufactures is small, since the U.S. and the EU have shares of 15.9% (55.2 $US billion) and 17.7% (61.5 $US billion), respectively.

Tables 3 and 4 show the main origin and destination of EU imports and exports, respectively. Intra-regional trade in the EU is very relevant. Imports among EU member countries represent more than a half (52.1%, US$ 3178 billion) of total. Of the remaining, the U.S. and China have a similar share (6.6% and 6.9%, respectively), while Mercosur accounts for a much smaller 1%. China accounts for the highest share in EU imports of manufactures with an 8% share (374 $US billion), while the U.S. stands as the main services provider in the EU with a 13.7% (186 $US billion). Mercosur has a higher share (4.7% or 11.1 $US billion) in the agricultural sectors than the U.S. or China (3.1% and 1.7%, respectively), but much smaller shares in services or manufactures.

Table 3. Origin of EU Imports (2014), in $US million

Sector aggregation	EU		Mercosur		US		China		TOTAL
	Total ($million)	%share	Total ($million)	%share	Total ($million)	%share	Total ($million)	%share	
Agriculture	153859.5	65.0%	11133	4.7%	7324.2	3.1%	4000.8	1.7%	236828.1
Manufacturing	2540615.7	54.6%	36621.7	0.8%	220490.2	4.7%	374157.5	8.0%	4650768.4
Services	559796.2	41.1%	16447.5	1.2%	186493.2	13.7%	50722.4	3.7%	1362881.2
TOTAL	**3254271.4**	**52.1%**	**64202.2**	**1.0%**	**414307.6**	**6.6%**	**428880.7**	**6.9%**	**6250477.7**

Source: authors' elaboration based on Aguiar et al. (2019)

Table 4. Destination of EU exports (2014), in $US million

Sector aggregation	EU		Mercosur		US		CHINA		TOTAL
	Total ($million)	%share	Total ($million)	%share	Total ($million)	%share	Total ($million)	%share	
Agriculture	142862.2	68.5%	493.6	0.2%	2876.7	1.4%	5033.2	2.4%	208587.4
Manufacturing	2475504.1	54.1%	52533.2	1.1%	314273.9	6.9%	206656.9	4.5%	4575919.4
Services	559796.2	40.1%	33048.1	2.4%	145905	10.5%	98252.1	7.0%	1395044.4
TOTAL	**3178162.5**	**51.4%**	**86074.9**	**1.4%**	**463055.6**	**7.5%**	**309942.2**	**5.0%**	**6179551.2**

Source: authors' elaboration based on Aguiar et al. (2019)

One clear take-away from these trade data is that both the U.S. and China have a strong trade relationship with the EU and Mercosur, so it seems worth analyzing whether the agreement may have an important effect for them.

The rest of the paper is organized as follows. Section 2 explains the different sources of data we have used and our detailed modelling strategy for tariffs, quotas, Non-tariff Measures and Government procurement impacts. Section 3 describes the model, while section 4 offers the micro and macroeconomic results. Our last section concludes.

2. Data and simulations

Table 5 shows the initial values of tariffs and NTMs, and the reductions applied on each simulation. We use the latest version of the GTAP Database (Aguiar et al., 2019), which provides very detailed information on the world economy for four reference years (2004, 2007, 2011 and 2014). The world economy is split into 121 countries (and 20 regions), providing data on 65 goods and services sectors for each country or region. This global data base describes bilateral trade patterns, production, consumption and intermediate use of commodities and services. As mentioned in the introduction, data has been aggregated into 9 regions, 36 sectors and 4 factors of production. We consider both the GTAP database and the model to be appropriate tools for the analysis of trade agreements. This fully documented database undergoes continuous revisions (Aguiar et al., 2019), is widely used in the global economic modeling community and underlies most global CGEs (Aguiar et al., 2016; Hertel, 2013). Another advantage of the GTAP model is that it can be used for any aggregation of the GTAP database (Aguiar et al., 2016). This has allowed us to define regions, sectors and primary factors in the most suitable way to analyze this agreement. In addition, our simulations are replicable and verifiable. The modifications that we have introduced at the data level are the shocks experienced by tariffs, quotas and NTMs, whose modelling will be explained below.

The agreement contemplates both reduction on Tariffs and Non-tariff measures (NTMs). The difference between Tariffs and NTMs relies on their nature. The former reflects direct costs and clear numerical values. NTMs are more difficult to analyze, since they are not defined *a priori* at a quantitative level, but rather at a qualitative level (price controls, specific requirements, health regulations, etc.). According to the International Trade Centre (2012), NTMs are complex legal texts specific to the product and applying country. They are more difficult to quantify or compare than tariffs. Depending on how they are applied, these measures may or may not amount to trade barriers. We differentiate between technical and non-technical NTMs in this section.

The agreement contemplates the asymmetries between the two blocs based on a gradual liberalization scheme, with up to 15 years for tariffs reduction for Mercosur, and 10 years for the EU. The total reductions we apply are shown in Table 5. To estimate the overall impact of the Agreement, we run three simulations: (1) Tariffs & quotas, (2) Non-tariff measures (3) Public Procurement openness.

Table 5. Initial values of NTMs (Ad Valorem Equivalents) and total reductions of Tariffs, NTMs and public procurement in the final year of implementation (percentage change)

Sector	EU imports from the Mercosur countries										Mercosur imports from the EU region												
	Tariffs (% red.)	NTMs ARG		NTMs BRA		NTMs PRY		NTMs URY		PP (% red.)	Tariffs (% red.)	NTMs ARG		NTMs BRA		NTMs PRY		NTMs URY		PP (% red.) ARG	PP (% red.) BRA	PP (% red.) PRY	PP (% red.) URY
		NTM	% red.	NTM	% red.	NTM	% red.	NTM	% red.			NTM	% red.	NTM	% red.	NTM	% red.	NTM	% red.	% red.	% red.	% red.	% red.
Cereals	72.7	2.3	4.8	0.3	4.7	0.7	0.0	13.2	4.2	4.0	90.7	47.3	9.2	77.6	5.0	0.0	0.0	13.0	9.2	10.0	4.0	0.0	10.0
Vegetables, fruits, nuts	100.0	5.6	3.0	0.3	3.2	2.1	3.0	5.0	3.0	4.0	98.3	7.8	11.4	3.6	5.0	3.1	5.0	5.1	11.1	10.0	4.0	0.0	10.0
Sugar	3.1	18.4	8.7	19.2	7.6	10.2	0.0	0.0	0.0	4.0	98.8	3.3	5.0	1.4	5.0	0.0	0.0	3.0	0.0	10.0	4.0	0.0	10.0
Plant & animal fiber, others	100.0	36.5	3.0	2.1	3.0	0.0	0.0	0.0	3.0	4.0	100.0	27.4	6.9	26.4	5.0	63.2	5.0	13.6	5.1	10.0	4.0	0.0	10.0
Bovine and other ruminant meats	36.1	8.7	3.0	7.0	3.0	0.0	0.0	12.1	3.0	4.0	100.0	5.6	11.8	3.1	5.0	0.0	0.0	0.7	5.0	10.0	4.0	0.0	10.0
Other animal products	79.3	0.1	3.2	0.5	3.0	1.4	0.0	0.1	3.0	4.0	100.0	0.5	15.9	0.9	5.0	0.0	0.0	0.3	8.5	10.0	4.0	0.0	10.0
Dairy products	82.5	4.0	4.4	13.7	3.2	0.0	0.0	0.0	0.0	4.0	100.0	11.5	7.9	12.3	5.0	9.4	5.0	12.3	5.0	10.0	4.0	0.0	10.0
Forestry	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	100.0	0.0	0.0	0.0	0.0	1.5	5.0	1.9	5.0	10.0	4.0	0.0	10.0
Gas, coal, oil extraction or distribution	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.4	0.0	0.5	0.0	0.0	0.0	0.0	0.0	10.0	4.0	0.0	10.0
Live animals, meat and animal products	31.4	72.1	3.0	12.2	3.0	4.6	3.0	4.7	3.0	4.0	100.0	11.8	12.3	2.8	5.0	9.4	5.0	4.6	5.0	10.0	4.0	0.0	10.0
Vegetable oils and fats	100.0	0.4	3.0	22.4	3.0	0.0	0.0	0.2	3.0	4.0	100.0	7.0	14.3	9.4	5.0	0.0	0.0	2.1	5.0	10.0	4.0	0.0	10.0
Food products nec	100.0	40.9	3.0	7.8	3.0	7.0	3.0	2.5	3.0	4.0	91.2	17.6	12.5	10.4	5.1	6.0	5.0	5.1	5.4	10.0	4.0	0.0	10.0
Beverages and tobacco products	100.0	29.6	3.0	12.3	3.8	2.6	3.0	19.1	3.0	4.0	100.0	16.7	12.6	7.7	5.0	16.8	12.5	8.9	5.0	10.0	4.0	0.0	10.0
Textiles	100.0	3.7	3.0	7.3	3.0	1.4	3.0	1.5	3.0	4.0	100.0	7.2	14.7	2.6	5.0	0.1	5.0	1.3	5.0	10.0	4.0	0.0	10.0
Wearing apparel	100.0	6.5	3.0	18.4	3.0	4.1	3.0	5.3	3.1	4.0	100.0	33.3	9.2	9.6	5.0	5.9	5.8	8.1	5.0	10.0	4.0	0.0	10.0
Leather products	100.0	5.5	3.0	4.6	3.0	2.8	3.7	2.3	3.0	4.0	30.1	19.3	17.8	2.0	5.0	1.9	8.7	1.1	5.0	10.0	4.0	0.0	10.0
Wood products	100.0	3.7	4.6	3.2	7.0	1.4	3.0	3.1	9.3	4.0	88.2	19.4	26.0	0.7	5.3	0.0	5.0	0.2	5.0	10.0	4.0	0.0	10.0
Petroleum, coal and other chemical products	94.4	1.1	3.0	2.5	3.0	0.2	3.0	14.0	2.9	4.0	88.6	28.5	15.5	0.7	9.8	0.5	8.2	0.2	3.1	10.0	4.0	0.0	10.0
Pharmaceutical products	100.0	2.4	3.0	2.8	3.0	0.2	3.0	14.3	3.0	4.0	80.6	37.1	15.3	0.8	5.3	0.3	7.3	0.6	5.2	10.0	4.0	0.0	10.0
Rubber and plastic products	100.0	2.4	3.0	2.8	3.0	0.2	3.0	14.3	3.0	4.0	50.8	37.1	15.3	0.8	5.3	0.3	7.3	0.6	5.2	10.0	4.0	0.0	10.0
Other manufactures	100.0	1.2	0.0	1.1	3.0	13.1	3.0	5.7	3.0	4.0	90.8	17.9	0.0	1.2	13.1	0.0	5.0	0.2	12.7	10.0	4.0	0.0	10.0
Metals and metal products	100.0	1.3	3.0	0.7	3.0	0.7	0.0	0.5	3.0	4.0	100.0	28.3	18.3	3.3	16.5	0.0	0.0	0.0	5.0	10.0	4.0	0.0	10.0
Electronic products	100.0	2.0	3.0	1.0	3.0	0.1	3.0	4.8	3.0	4.0	86.5	7.8	16.8	8.5	11.3	0.0	5.4	0.1	9.6	10.0	4.0	0.0	10.0
Other machinery	100.0	14.9	3.0	9.3	3.0	0.0	0.0	5.0	3.0	4.0	100.0	8.4	17.3	13.7	14.9	3.0	5.0	3.9	18.9	10.0	4.0	0.0	10.0
Motor vehicles and parts	100.0	0.1	3.0	0.3	3.0	0.0	0.0	0.1	3.0	4.0	91.7	2.9	19.1	0.6	14.7	0.0	0.0	1.7	20.0	10.0	4.0	0.0	10.0
Transport equipment	100.0	1.0	3.0	1.9	3.0	15.7	3.0	0.3	3.0	4.0	81.8	19.4	14.0	2.3	16.0	2.3	20.0	0.1	5.0	10.0	4.0	0.0	10.0
Other services	-	41.3	3.0	41.3	3.0	41.3	0.0	41.3	3.0	16.0	-	115.8	11.0	170.6	6.5	173.5	6.3	155.8	6.2	8.0	16.0	0.0	16.0
Construction	-	45.7	0.0	45.7	0.0	45.7	0.0	45.7	0.0	0.0	-	95.6	22.5	52.3	0.0	192.2	12.0	175.3	7.5	0.0	0.0	0.0	20.0
Hotels and Restaurants	-	45.7	0.0	45.7	0.0	45.7	0.0	45.7	0.0	12.0	-	50.5	0.0	52.3	0.0	71.7	0.0	58.0	0.0	0.0	0.0	0.0	20.0
Maritime Transport	-	33.0	18.0	33.0	18.0	33.0	18.0	33.0	18.0	16.0	-	71.5	18.0	90.0	4.5	143.4	7.5	110.6	15.0	20.0	12.0	0.0	20.0
Air Transport	-	122.6	0.0	122.6	0.0	122.6	0.0	122.6	0.0	12.0	-	124.0	6.0	823.0	0.0	148.9	3.0	126.8	4.5	0.0	0.0	0.0	0.0
Communication	-	54.5	0.0	54.5	0.0	54.5	0.0	54.5	0.0	0.0	-	96.7	1.5	193.9	6.0	93.9	3.0	117.9	10.5	0.0	0.0	0.0	20.0
Banking	-	25.0	0.0	25.0	0.0	25.0	0.0	25.0	0.0	0.0	-	76.1	12.0	88.0	0.0	121.2	12.0	114.5	12.0	16.0	0.0	0.0	20.0
Insurance	-	44.7	4.5	44.7	4.5	44.7	4.5	44.7	4.5	12.0	-	79.7	15.0	74.5	3.0	157.8	4.5	87.3	12.0	16.0	8.0	0.0	20.0
Business Services	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Personal Services	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: authors' own elaboration

Notes: Mercosur has a Common External Tariff. Therefore, tariff reductions are the same across all countries. For NTMs reductions we display their final percentage cut once both reductions to technical and nontechnical NTMs are considered. See text for more details. *ARG* stands for *Argentina*, *BRA* for *Brazil*, *PRY* for *Paraguay*, *URY* for *Uruguay*, *PP* for *Public Procurement reductions* and *% red.* for *reduction in percentage terms*

We now proceed to explain the three simulations in detail.

4.1. Tariffs & quotas

Data on initial tariffs and quotas are expressed in ad valorem equivalents (AVEs) and extracted from the GTAP 10 Database (Aguiar et al., 2019). Regarding tariff reductions, Mercosur will fully liberalize 91% and the EU 95% of lines in their respective schedules (European Commission, 2019). Tariffs are significantly higher on the Mercosur side, especially in Manufactures. In some cases, the difference is almost 500% (i.e., Textiles).

In our model, the tariff reductions and the new quotas are based on official tariff elimination schedules, which are the same in the different sources available: Ministerio de Relaciones Exteriores del Paraguay (2019), Ministerio de Relaciones Exteriores del Uruguay (2019) and Ministerio de Relaciones Exteriores, Comercio Internacional y Culto de la Argentina (2019).

As reductions on these schedules are expressed in Tariff Line codes (8-digit level) and in the H4 version of the Harmonized System (HS), a previous treatment of the figures has been necessary. To obtain the corresponding ad valorem equivalent (%) MFN (Most Favored Nation tariff), we first obtained the trade volumes data at the HS 8-digit level from the TradeMap tool (average of the period 2017-19) (International Trade Centre, 2021). To cross-reference the agreed tariffs with the trade data for the years 2017-2019, an update was made to the H5 version implemented in 2017, so that the codes used for the tariffs were the same as those used for the trade flows.

We have carried out thorough work to quantify these reductions considering the quotas that affect different sub-sectors, especially in the agricultural sectors. For this purpose, we have calculated the average quantities or units for the period 2017-2019 (according to TradeMap ITC tool) expressed at 6-digit HS that will enter the regime.

4.2. Non-Tariff Measures (NTMs)

Table 5 shows the estimated initial values of NTMs in both the EU and in each of the Mercosur countries. For NTMs in the goods sectors, we use the latest data available (Ad Valorem Equivalents, AVEs) of the World Bank (n.d.). This database is internationally recognized as the best source for NTMs in agriculture and manufacturing and has been used in previous work on this treaty (LSE, 2020). As they are presented in 'ad valorem' terms, their interpretation is like that of a tariff, i.e., they indicate the initial barrier existing before the EU-Mercosur treaty. The World Bank reports AVEs of NTMs for the GTAP goods sectors. For this reason, our sectors AVEs calculation at the model sector level has again been calculated considering the most recent trade data by Trade Map (International Trade Centre, 2021)[6].

For services sectors we use the AVEs estimated by the OECD researchers (Benz & Jaax, 2020), who present 2019 estimates of NTMs for five services sectors and 46 countries – Communications, Business Services, Banking (Financial Services), Insurance and Transport services as a whole (Maritime Transport, Air Transport, Railway Transport and Road Transport). However, since this source only provides data for Brazil, for the other countries we use the data provided by Fontagné et al. (2016).

In the analysis of NTMs in the Mercosur countries, UNCTAD (2017) differentiates two types of NTMs: '(a) traditional trade policy instruments, such as quotas or price controls, which are often termed non-tariff barriers (NTBs[7]); and (b) regulatory and technical measures that stem from important non-trade objectives related to health and environmental protection

[6] Appendix I shows our model sectors conversions to the original GTAP database.

[7] Non-technical barriers to trade.

(i.e., sanitary and phytosanitary (SPS) measures or technical barriers to trade (TBT))' (p. ix). Technical and non-technical measures present a different scope for reductions.

Due to the nature of NTMs, modelers transform them into quantitative values, according to the degree of the effect for trade. NTMs do not bring economic benefit to government agents. Contrasting with tariffs, we translate NTMs into rents for importers and exporters and into trade inefficiencies, following Francois et al. (2013) and Latorre & Yonezawa (2018). Further details on this transformation can be found in the section below.

With regard to the extent of NTM reductions (see Table 5), our approach is quite different compared to the previous studies that have been carried out. UNCTAD (2017) analyzes the effects of regulation overlaps and NTMs reductions among Mercosur countries and under a possible agreement with the EU. For the latter it estimates gains using the GTAP model and under 5 possible scenarios for reducing NTMs in Mercosur. It goes from a conservative scenario in which it only eliminates non-technical NTMs within Mercosur countries to an ambitious scenario in which it (1) reduces by 100% non-technical NTMs within Mercosur countries and with the EU, (2) increases regulatory overlap (agri-food only) by 40 and 20 percentage points in Mercosur and EU respectively and (3) reduces gross AVEs of technical NTMs a 30%, 25% and 20% in manufacturing in Mercosur, manufacturing in the EU and all sectors in the rest of the world respectively. The minimum NTM reduction that it considers within an EU-Mercosur FTA is 20%.

Other recent studies such as LSE (2020) and Carrico et al. (2020) contemplate much more conservative reductions. The latter follows Disdier et al. (2016) and assume an actionable (only on the Mercosur side) 10% of the NTM-associated trade costs, i.e., the gap between the costs due to NTMs in the European Economic Area and in Mercosur would be reduced by 10%. LSE (2020) assume similar NTM reductions and apply reductions of 5% (conservative scenario) and 10% (ambitious scenario) to non-agricultural NTBs and a 3% AVE cut in the modelling for trade in services. They do not reduce NTMs in agricultural sectors arguing a lack of robust AVE estimates on agricultural trade to and from the EU.

In our case, we consider an intermediate scenario between the above-mentioned studies. Moreover, in contrast with the most recent studies, we distinguish between non-technical and technical NTMs in the reductions, and furthermore assume reductions in agriculture, manufacturing and services sectors. Details on the reductions are presented in the following sections.

4.2.1. Technical measures

Provisions on sanitary and phytosanitary measures and technical barriers are included in the agreement for safety reasons and, therefore, its reduction is not recommended. The adoption of a particular standard may make it more expensive for a country or region to produce for other markets. This effect may be mitigated when harmonization takes place on the basis of international standards (Fontagné et al., 2016). The Agreement does not bind Mercosur countries to adopt European standards, but to look for international standards as a reference. According to the official text: 'the Parties shall use relevant international standards as a basis for their technical regulations including any conformity assessment elements therein, except when such international standards would be an ineffective or inappropriate means for the fulfillment of the legitimate objectives pursued' (European Commission, 2019).

NTMS related to technical measures in the EU are significantly higher than in Mercosur, ranging between 20% and 30% in the agri-food sectors. Compared with Mercosur partners, the EU remains by far the most difficult market to access (UNCTAD, 2017). However, technical measures are more justified in the EU than in Mercosur countries and therefore with a reduced scope for reductions. In the latter, the prevalence of discretionary technical measures is high (UNCTAD, 2017). Based on the idea that these technical measures are hard to reduce due to their relationship with safety issues we simulate that they could be cut by 5% in Mercosur and by 3% in the EU.

4.2.2. Non-technical measures

As they are conceived initially to protect domestic markets, non-technical measures are usually addressed when signing a trade agreement (Hayakawa & Kimura, 2014; Cadot et al., 2015). The EU-Mercosur agreement is an example, as it includes reduction of non-technical measures (commonly known as non-tariff barriers) in its legal texts. ‘Non-automatic import or export licenses are prohibited, except for those needed to implement measures of this agreement (i.e., tariff rate quotas for products not fully liberalized)’ (European Commission, 2019).

Non-technical measures are especially high in the Mercosur region. ‘The estimated impact of these barriers is particularly high in the manufacturing sectors, especially on the crucial vehicles and machinery sectors. These NTMs cause price increases on traded goods of 3% to 4% (UNCTAD, 2017, p. x). Brazil ranked 141 out of 141 economies for burden of government regulation in the World Economic Forum’s 2019 Global Competitiveness Report (World Economic Forum, 2019) and one of the countries with the highest overall Product Market Regulation (PMR) Indicator in the OECD (OECD, 2019). For instance, U.S. companies often mention non-tariff barriers to trade in the form of duplicative, arbitrary, or sometimes discriminatory regulations for U.S. products in Brazil (International Trade Administration, 2023). In Argentina, in sectors like textiles and wearing apparel or leather products and furniture, more than 70% of imports are still subject to non-automatic import licenses, and more than 30% of all imports of sectors like machinery and electronic equipment or optical and medical instruments, among other, are still subject to non-automatic import licenses (Grundke & Arnold, 2019). These authors also state, however, that Argentina has made considerable progress in reducing the number of items subject to non-automatic import licenses. On the EU side, non-technical NTMs have a very small and symbolic presence.

We have estimated a 20% reduction in Mercosur countries and a 10% reduction in the EU for non-technical NTMs in goods sectors. These percentage reductions may give the impression that the cuts are substantial, but they represent a modest and conservative reduction measured in percentage points of tariffs. Furthermore, we distinguish between technical and non-technical reductions, so that the reduction at sector level is indeed smaller (see Table 5) and is in line with the reductions estimated in other studies such as Carrico et al. (2020) and LSE (2020), although much smaller than the ones included in UNCTAD (2017).

In services sectors, reductions are based on the level of openness expressed in chapters containing supply of services[8] (i.e., Mode 1 Services Supply) in the EU and in Mercosur. As a first step, we have assigned a level of commitment to each sector mentioned in the documents issued by each country/region. We rely on the approach of Benz and Jaax (2020), who compare NTM levels between the EU and other countries, specifically with countries that are not part of the European Economic Area (single market). The difference in NTMs between one and the other ranges between 80% and 90%, which is what we could translate into 'NTMs reductions' after signing a trade agreement. To be on the safe side, we estimate a maximum reduction of a quarter of those differences between NTMs with countries of the single market and the NTMs with respect to countries outside of the single market for those sectors where liberalization is the largest. Lowest NTM cuts in services sectors are assumed in Banking[9] and Insurance[10] sectors in both regions, based on the smaller ambition of their commitments. Air Transport will not experiment cuts in either the EU or Mercosur, as stated in the negotiated agreement.

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[8] Modes of supply can be found in https://www.wto.org.

[9] No reduction in the EU and Brazil and between 3% and 6% in the rest of Mercosur countries.

[10] No reduction in the EU and less than 6% reduction in Mercosur countries, except for Uruguay (10.5%).

4.2.3. Public Procurement

The ‘Agreement in Principle’ states that ‘The agreement will open markets on both sides and will provide, in the area of goods and services (including construction services), secure reciprocal legal access to government procurement markets where public procurement contracts are above specified thresholds.’ (European Commission, 2019). This is a historic milestone, to date Mercosur has only opened its public contracts at a regional level (i.e., among Mercosur countries) and this process has begun quite recently, so there is an important scope for public procurement openness.

We deal with public procurement in a separate simulation, as it is also differentiated in the offers of the signatory countries. The commitments are individual for each country specifying the sectors and Central State - level agencies opening to procurement for signing countries, generally through a mix of positive and negative lists. Moreover, the Agreement in Principle envisages that Mercosur countries will also consult the possibility to extend the opening of public procurement at a regional level in the first two years after entry into force.

Reductions in NTMs are derived directly from the bids of the EU and each Mercosur country. Modeling the openness of public procurement has been harder than in the case of NTMs, for two reasons. Firstly, because of the difficulty of interpreting the chapters referring to it. Each country expresses such openness for each sector and as mentioned above, in a different way (using positive or negative lists). Secondly, the nomenclature is different depending on whether the sector is goods or services sector. In the first case, the sectors are expressed in ISIC Revision 3.1, and in the case of services in the United Nations Provisional CPC nomenclature.

Moreover, we have contemplated several issues regarding public procurement: (1) Gradual openness expressed in the amount of money involved in the bids. Both regions establish minimum amounts that are reduced over the years. In the case of the EU, they are reduced earlier than in Mercosur. (2) Paraguay is the region with the most restrictive openness of public contracts, and its reductions extend up to 19 years after the entry into force of the agreement. Furthermore, it will not initially open its tenders to foreign companies. There are doubts on whether it will eventually do so and we have assumed it will not be opened. (3) Gas, energy, and water utilities will not be open to public procurement either in the EU or in any other Mercosur country. (4) Business services are quite open in both the EU and Mercosur regions. (5) Argentina's openness is smaller and stands between Brazil and Uruguay. The latter offers the most open regime. We have simulated reductions in NTMs only in sectors that are open to public procurement. In the goods sectors, in Argentina and Uruguay the reductions have been of 10% since they are the most open regimes. By contrast, in Brazil reductions in NTMs are of 4%, while in Paraguay there are no reductions.

3. The General Equilibrium Model

GTAP is a comparative static, multi-region, multi-sector, computable general equilibrium model, for which a comprehensive description is available in Corong et al. (2017) and Hertel (2013). A very succinct explanation, including model equations, can be found in Zhou and Latorre (2014). Our simulations are based ont he latest version of the model, with 4 factors of production (land, labor, capital, and natural resources) and 9 regions (EU, Argentina, Brazil, Paraguay, Uruguay, US, China, Canada and Rest of World). We have therefore aggregated the 65 original GTAP 10 sectors into 36, 26 of which are goods (agricultural goods from 1-8, manufacturing goods 9-26) and 10 of which are services sectors (27-36). Appendix I shows model sectors and their correspondence with GTAP 10 sectors.

The static setting of the GTAP model allows estimating the differences in an economy between two possible states (pre- and post-FTA scenario), assuming perfectly competitive markets and constant returns to scale. In each region, a representative household maximizes utility subject to a budget constraint and each sector is represented by one firm that produces a unique commodity minimizing the cost of the intermediates and primary factors needed to produce total output. Through an input-output structure all intermediates or final goods are demanded by sectors or final users (household consumption, investment, government consumption, export demands) and all agents are price takers (Corong et al., 2017). A series of behavioral equations define how agents demand commodities following CES demand/production functions, and the different agents (firms, private households and government) differentiate between domestic and imported varieties (and among import origins).

Regarding model closure, we have defined fixed national endowments of factors of production and, therefore, results are expressed as a percentage change in factor remuneration. In terms of mobility, we have set Labor and Capital as perfectly mobile. This implies that their remuneration should be equated across all uses. Therefore, the percent change in endowment returns is uniform across activities and market equilibrium is determined by setting aggregate demand equal to (exogenous) supply (Corong et al., 2017). By contrast, Land and Natural Resources are defined as sluggish.

Our results show the impact once the agreement is fully implemented. As stated in the previous sections, we estimate the effects of tariff reductions and the quotas negotiated, NTMs reductions related to the convergence to international standards in goods and services sectors and NTMs reductions related to public procurement openness.

We now explain how parameters are affected by our simulations in the main equations of the model. Variables (in lower case) in the model reflect percentage change in quantities (q), prices (p) or technical change (a) and those in upper case correspond to absolute values or coefficients. Variables in bold are those that remain fixed throughout the simulations or that are shocked (tms, txs and/or ams). Since the simulations comprise shocks in three variables, 36 sectors and 5 regions (4 Mercosur and EU) in both directions of trade, the number of shocks we introduce exceeds 1900, making them difficult to trace. However, we concentrate on the main equations affected by these shocks. We omit all the technological change variables from the equations (except for the ams variable that we shock) and other exogenous variables which remain fixed throughout the simulations. The equations shown correspond to their linearized form, which reduces data requirements (Corong et al., 2017).

In the GTAP model the zero-profit market clearing condition is represented in the equations that equate changes in output (supply) with changes in domestic and export demands:

qo(i,r) = SHRDM(i,r)*qds(i,r) + sum(s,REG,SHRXMD(i,r,s)*qxs(i,r,s)) (1)

where SHRDM and SHRXMD are shares of domestic and export sales.

On the demand side of equation (2) (right-hand side), the domestic sales qds(i,r) are at the same time calculated as the sum of demands for domestic and imported varieties by industries (intermediates) and final users (households and government):

qds(i,r) = sum(j,PROD_COMM,SHRDFM(i,j,r)*qfd(i,j,r)) + SHRDPM(i,r)*qpd(i,r) + SHRDGM(i,r)*qgd(i,r); (2)

where qfd(i,j,r) is the domestic good i demanded by industry j in region r, qpd(i,r) and qgd(i,r) are household and government demands for commodity i in region r and SHRDFM, SHRDPM and SHRDGM correspond to the share of domestically produced commodity (i) used in region (r) by firms (j), households and government, respectively. Each quantity component on right hand side of equation (2) is associated with a price component which is linked to the market price of each commodity in each region.

When a tariff shock is introduced in the GTAP model, both quantities and prices adjust so that the changes in firms and households' demand of domestic and imported goods are satisfied. In our analysis we exogenously reduce the price of commodities through reduced tariffs or NTMs. This turns into a price decrease which drives demand for imported variety to the detriment of the domestic variety of a good or service. This implies an efficiency increase itself, as those less competitive industries would reduce their market share against foreign industries.

After updating GTAP 10 to initial NTM levels, we introduce shocks to tax variables (rents to importers and rents to exporters), i.e., tms (import tariff) and txs (export tariff) and to the variable related to trade efficiency, i.e., ams (trade efficiency). The direct price transmission effect of a tariff reduction in commodity i for imports from region r in region s is a domestic price reduction of commodity i in region s, given by the equation:

pms(i,r,s) = **tms**(i,r,s) + pcif(i,r,s); (3)

where pms (i,r,s) is the change in the domestic price of commodity i in region s coming from region r and pcif (i,r,s) is the CIF world price of commodity i supplied from r to s. Thus, the tariff/NTM reduction has a direct effect on domestic prices. The reduction in the domestic price of imports (pms(i,r,s)) and the increase in trade efficiency (ams(i,r,s)) turns into a decrease in the price of aggregate imports:

pim(i,s) = sum(k,REG, MSHRS(i,k,s) * [pms(i,k,s) - **ams**(i,k,s)]); (4)

where pim(i,s) is the price for aggregate imports of commodity i in region s and MSHRS the share of imports from r in import bill of s at market prices. The efficiency variable in the equation, ams(i,k,s) is exogenously affected by a NTM reduction, which turns out to further reduce the price and lift demand for imported varieties. The variable pim(i,s) is the price related variable for firms, government and household's demand for imported varieties. Thus, all agents vary their quantity demands in the same proportion, and the quantity variable representing the aggregate demand for imports (qim(i,s)) is the sum of the demand variations of each agent. These price and quantity variations have a direct effect on import (export[11]) demands:

qxs(i,r,s) = qim(i,s)-**ams**(i,r,s)-ESUBM(i)*[pms(i,r,s)-**ams**(i,r,s)-pim(i,s)]; (5)

where qxs(i,r,s) corresponds to the demand for imported (exported) commodity (i) by (from) region (s) from (to) region (r). Thus, the equation is composed by an expansion term

[11] Depending on the r and s regions contemplated, qxs(i,r,s) is used to calculate imports or exports.

(trade-creation effect) qim(i,s) and a substitution term (trade-diversion effect)[12] (-ESUBM(i) * [pms(i,r,s) – ams(i,r,s) -pim(i,s)]).

We turn now to the supply side (left hand side) of equation (1). The production structure in the GTAP model follows a nested structure. It considers a Leontief fixed-proportions production function, i.e., assumes all inputs (endowments and intermediates) are used in fixed proportion to output. Moreover, the supply price satisfies the zero-profit condition, i.e., the sum of input costs (supply price ps(j,r)) needed by industry j to produce commodity i in region r equals the total revenue from sales of commodity i produced by industry (j) in a region (r):

ps(j,r) = sum(i,ENDW_COMM, STC(i,j,r) * pfe(i,j,r)) (6)

+ sum(i,TRAD_COMM, STC(i,j,r) * pf(i,j,r));

This equation links input and output prices. One of the market clearing equations in the model ensures that primary factors are fully employed (and fixed at the regional level). Although fixed at the regional level, we define capital and labor as mobile factors, i.e., mobile across sectors. This means that labor and capital move across production activities due to changes in their relative prices until the ratios between wages and rents are equalized. Since employment remains unchanged at the regional level, the reduction in demand for output from a specific sector reduces the labor force in that sector, which 'migrates' to other industries where there is an increase. At the same time, given that all taxes are exogenous and therefore they remain fixed throughout our simulations (except

[12] i.e., how each region substitutes imports from different regions as a result of the tariff, quotas or the NTMs reductions.

for import and export taxes), the variation in the supply price equals the variation in the market price:

$$ps(i,r) = \mathbf{to}(i,r) + pm(i,r); \qquad (7)$$

where ps(i,r) is the supply price of commodity i in region r, to is output (or income) tax and pm(i,r,) is the market price of commodity i in region r.

In terms of export tariffs (or subsidies) the shock is introduced as a subsidy, i.e., rents for exporters. In this case the FOB export price is linked to the basic price similarly to equation (5):

$$pfob(i,r,s) = pm(i,r) - \mathbf{tx}(i,r) - \mathbf{txs}(i,r,s); \ (8)$$

where txs (c,s,d) corresponds to destination-specific change in the tax (or subsidy if <0) on exports of commodity (i) from region (r) to region (s). Any variation in the FOB (Free on Board) price has its impact on the CIF (Cost, Insurance and Freight) price and in the domestic price (equation 3). In our baseline scenario both the EU and Mercosur regions have negative values on tax exports, i.e., their exports experience tariffs in their destination markets. As a result of the decrease in txs(i,r,s) there is a reduction in the price of imports. .

The reduction in the domestic price of imported commodities increases the demand for them, following the demand functions for households, government and firms. Note that in each sector there is a representative firm, that operates under a cost minimizing behavior.

Regarding primary factors, their remuneration follows market prices similarly to equation (7) for both capital and labor (fully mobile primary factors). Thus, in the absence of tax variations its price variation follows the market price variation:

$$pfe(i,j,r) = \mathbf{tf}(i,j,r) + pm(i,r); \qquad (9)$$

where pfe is the firms' price for endowment commodity (i) in industry (j) in region (r). This price variation has its effect on the quantity demand for primary factors:

qfe(i,j,r) = - afe(i,j,r) + qva(j,r) - ESUBVA(j) * [pfe(i,j,r) - afe(i,j,r) - pva(j,r)] (10)

where qfe(i,j,r) is the percentage change in the quantity demanded for endowment i to be used in industry j in region r.

Regarding private consumption, it follows regional expenditure which, in turn, follows regional income, that is mainly driven by factor income. There is one representative household for each region. Finally, factor income is related to market prices and output variations according to the equation:

FY(r) * fincome(r) = sum(i,ENDW_COMM, VOM(i,r) * [pm(i,r) + qo(i,r)]) (11)
- VDEP(r) * [pcgds(r) + **kb**(r)];

where fincome(r) is the percentage change in factor income for region (r) at market prices net of depreciation and is calculated as the sum (over endowment commodities) of the percentage change in market price plus the percentage change in output (for endowment commodity I, in region r) minus the depreciation (VDEP is the value of capital depreciation in region r) and pcgds(r) is the percentage change in the price of investment goods.

Although the results obviously vary according to the simulation, region and sector, the general behavior of the equations can be summarized as follows:

1- Reductions in tms (Simulation 1, tariffs and quotas' reductions) or reductions in tms, txs and ams (Simulations 2 and 3, NTMs reductions) reduce the domestic and import prices (pms and pim) following equations (3) and (4).
2- Due to the price decrease, agents will tend to switch from domestic to imported varieties (following a CES function), increasing the aggregated demand for imported varieties (equation 5) and reducing the demand for domestically produced varieties (equation 2). This import increase is the main source of GDP and welfare gains.
3- Results for exports depend on the importance of trade-creation and trade-diversion effects (equation 5) but, in general, the trade diversion effect reduces the positive outcomes from the increase in import purchasing power (trade-creation effect),

limiting the scope of export increases. As shall be seen below, results show higher import increases than export increases.

4- Primary factor remuneration follows market price variations (equation 9) and its increase/decrease has a direct impact on demand for primary factors following equation (10). Primary factors' supply is fixed at a regional level, but it is mobile across sectors. Therefore, it migrates from those sectors in which domestic demand and/or export demands decrease to those industries that grow.

4. Results

4.3. Results on signatory regions

4.3.1. Macroeconomic results

Table 6 shows the impact of the EU-Mercosur agreement on macroeconomic variables and disaggregated by simulation for the EU, the Mercosur countries, China and the US[13]. We report variations in GDP, private consumption, aggregated exports and imports, wages, capital remuneration and welfare (measured in terms of equivalent variation) over GDP. All these variables are expressed in percentage change with respect to the benchmark and in real terms except for Equivalent Variation, which is also expressed in $US million.

Our simulations isolate the effects of the EU-Mercosur agreement including both tariff and non-tariff measures (also accounting for public procurement openness) once it has been fully implemented, i.e., approximately after 15 years from entry into force. The impact of other recently approved agreements or events such as the Covid pandemic should be added or subtracted from our results.

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[13] The impact of the agreement on Canada was negligible (i.e., very close to zero), so we have taken it out of the tables.

Table 6. Impact on macroeconomic variables disaggregated by simulation (year 16)

Region	Description	GDP	Private Consumption	Aggregated Exports	Aggregated Imports	Wages	Capital remuneration	Welfare	Welfare / GDP
EU_27	Tariffs & quotas	0.02	0.06	0.11	0.20	0.16	0.15	7469.33	0.05
	NTMs	0.00	0.01	0.00	0.02	0.02	0.02	1069.3	0.01
	Public Procurement	0.01	0.01	0.00	0.01	0.02	0.02	1502.12	0.01
	Total	**0.04**	**0.08**	**0.11**	**0.23**	**0.20**	**0.19**	**10040.75**	**0.06**
Argentina	Tariffs & quotas	0.05	0.04	0.80	1.57	-0.25	-0.31	187.20	0.03
	NTMs	0.11	0.14	0.14	0.56	0.11	0.11	686.38	0.12
	Public Procurement	0.10	0.12	0.20	0.64	0.23	0.22	621.08	0.11
	Total	**0.26**	**0.30**	**1.14**	**2.77**	**0.09**	**0.02**	**1494.66**	**0.27**
Brazil	Tariffs & quotas	0.04	0.03	2.35	3.84	0.16	0.18	574.67	0.02
	NTMs	0.04	0.05	0.03	0.24	0.07	0.07	1035.49	0.04
	Public Procurement	0.05	0.08	0.11	0.41	0.17	0.16	1647.06	0.07
	Total	**0.13**	**0.16**	**2.49**	**4.49**	**0.40**	**0.41**	**3257.22**	**0.13**
Paraguay	Tariffs & quotas	0.00	-0.03	0.12	0.22	-0.10	-0.07	-8.75	-0.03
	NTMs	0.03	0.04	0.00	0.04	0.05	0.04	11.52	0.04
	Public Procurement	0.01	0.03	-0.06	0.04	0.11	0.13	8.13	0.03
	Total	**0.04**	**0.04**	**0.06**	**0.30**	**0.06**	**0.10**	**10.90**	**0.04**
Uruguay	Tariffs & quotas	0.17	0.43	-1.07	2.05	1.12	1.10	214.50	0.37
	NTMs	0.16	0.26	-0.54	0.44	0.40	0.44	127.19	0.22
	Public Procurement	0.28	0.45	-0.84	0.86	0.79	0.83	221.41	0.38
	Total	**0.61**	**1.14**	**-2.45**	**3.35**	**2.31**	**2.37**	**563.10**	**0.97**
US	Tariffs & quotas	0.00	-0.01	0.04	-0.10	-0.05	-0.05	-930.28	-0.01
	NTMs	0.00	0.00	0.01	-0.02	-0.01	-0.01	-168.11	0.00
	Public Procurement	0.00	0.00	0.01	-0.02	-0.01	-0.01	-189.74	0.00
	Total	**0.00**	**-0.01**	**0.06**	**-0.14**	**-0.07**	**-0.07**	**-1288.13**	**-0.01**
China	Tariffs & quotas	-0.01	-0.01	0.02	-0.11	-0.06	-0.06	-1337.73	-0.01
	NTMs	0.00	0.00	0.00	-0.01	-0.01	-0.01	-136.15	0.00
	Public Procurement	0.00	0.00	0.01	-0.01	-0.01	-0.01	-115.91	0.00
	Total	**-0.01**	**-0.01**	**0.03**	**-0.13**	**-0.08**	**-0.08**	**-1589.79**	**-0.02**

Source: Authors' estimation.

Notes: results are expressed in percentage change compared to the benchmark except for Welfare, whose results are expressed in $US million.

All FTA countries experience an expansionary impact across their macroeconomic variables, with the only exception of exports in Uruguay. The shock impacts first on the trade flows. As a result, both imports and exports experience the largest increases among macro variables, particularly on the Mercosur side. Indeed, all FTA regions benefit from the price reduction of imports, due to the lower barriers to trade. Aggregate consumption is boosted by the increase in demand for imported varieties and welfare also goes up. Cheaper imports cause an excess in profits. Given the zero-profit condition, a reduction in the price of imported intermediate inputs induces an increase in output, which in turn raises the demand for primary factors. This generates an excess demand for labor and capital, bidding up the prices of these factors, and transmitting the shock to other sectors in the liberalizing regions. The latter occurs because a change in the ratio of factors remunerations (i.e., wages/capital remuneration) causes a reallocation of mobile factors across sectors till a new equilibrium for this ratio is achieved, when the value for the ratio is the same in all sectors.

The size of the macroeconomic impacts is explained by the relative sizes of the signatories and by the level of liberalization commitment that they have negotiated (Table 5). The largest GDP impact occurs in Uruguay for 2 main reasons. Firstly, because it is the country with the most open regime. This results in significant macroeconomic gains especially in service sectors, which benefit from both lower NTMs and the additional impact of public procurement opening, as will be seen below. Secondly, it is a small country compared to the rest of the regions[14]. This asymmetry in sizes causes stronger impacts from the agreement than in other regions. Additionally, due to the small initial size, high percentage changes are achieved with relatively small effects in absolute terms. For example, Uruguay experiences the most sizeable welfare impact (0.97 %), which corresponds to 563.1 $US millions in change in equivalent variation in absolute value. This is the lowest change in welfare in absolute terms across the signatories, and indeed significantly lower, with the only exception of Paraguay. Uruguay experiences high increases in factor production prices (wages and capital remuneration), which results from a strong process of factors' reallocation. This results in sizeable increases in welfare (in percentage terms), but harms its export competitiveness, since its exports become more expensive due to the increase in costs of production (high wages and income remuneration).

On the opposite extreme, GDP in the EU and Paraguay would increase by the same 0.04%, but for different reasons. Paraguay is the country that is least open to trade with the EU

[14] Except for Paraguay. But Paraguay has the least open regime to trade among the signatories.

and vice versa, therefore its GDP growth is the smallest across the Mercosur countries. GDP still increases, due to an increase in private consumption. This is mainly due to the increase in demand for cheaper imports since Paraguay still reduces NTMs to a certain extent and also enjoys the same tariff reduction as the other Mercosur countries since it has the Mercosur common external tariff. The main reason of the limited GDP impact in the EU is the difference in size with its partners. All other macroeconomic variables in the EU show much more positive results in comparison with Paraguay. For instance, wages in the EU grow almost three times more (0.2%) than in Paraguay. This is because, as we will see in the sectoral results, the agreement favors the specialization of the EU in sectors with more value added, similarly to the case of Uruguay.

We now zoom into the contribution of the different components, namely, tariffs reductions and new quotas, NTMs reductions and Public Procurement openness. In the EU most of the impact would be caused by 'tariffs and quotas' because tariffs are huge in Mercosur, compared to world standards. Thus, tariffs are the main driver for aggregate results in the EU, contrasting with the general wisdom that NTMs are more important in 'new' trade agreements. Nonetheless, openness of public contract would also slightly contribute to the positive outcomes of the agreement for the EU.

On the Mercosur side, the general wisdom of NTMs being crucial holds for Argentina (with a 0.11% increase in GDP out of a total increase of 0.26%). What is more remarkable, however, is the very important role played by government procurement. Uruguay, which has the most open regime (Table 5), stands out with 0.28% GDP increases rising from this component out of a 0.61% total GDP increase. In addition, do also note that its ambitious negotiation can be seen in the fact that all components of the agreement (tariffs, NTMs and public procurement) contribute to the largest macroeconomic outcomes of Uruguay. Public procurement openness also plays a very important role in Argentina, increasing GDP by 0.10% out of 0.26, with the impact being only slightly smaller than the one caused by the reduction in NTMs. In Brazil the impact of public procurement openness on GDP is slightly superior to the one of NTMs (0.05% vs 0.04%). Finally, in Paraguay, the impact is smaller and more related to the growth of its Mercosur trade partners and the overall expansionary effect in the Mercosur block, than to public procurement impacts within Paraguay.

Finally, the U.S. and China are slightly negatively impacted, with a welfare loss of -1.3 $US billion in U.S. and -1.6 $US billion in China. They experiment limited falls in wages (-0.07% and -0.08%, respectively) and capital remuneration (-0.07% and -0.08%, respectively).

4.3.2. Sectoral results

Table 7 presents the impact on output (Prod.), exports (Exp.) and imports (Imp.) for the EU-Mercosur partners. The rows show the 36 sectors followed by three aggregates for agriculture (sectors 1 to 8 of the model), manufactures (9 to 26) and services (27 to 36). The last row collects the aggregate impact for all sectors and, thus, coincides with the aggregate results from Table 6 (aggregated exports and imports). In addition, a final column summarizes the impact for Mercosur as a whole.

Results show similar patterns in Mercosur countries. Although value added goes up, as reflected in GDP results, Mercosur countries reduce their production slightly at an aggregated level, with values ranging between -0.03% and -0.07%. This is because the reduction of trade barriers shifts production to more efficient producers, in particular to services sectors which have a larger value added than other agricultural and manufacturing sectors. However, tendencies vary at a sectoral level among countries, and production does not fall in all sectors. An extreme case is the one of Uruguay. The lower NTMs and the additional impact of public procurement opening drives a strong concentration of production in services sectors. As we showed at the macro level, sizeable wage and capital remuneration increases followed from this adjustment, with GDP and welfare increasing heavily. More generally, all the Mercosur countries experience a certain push for production in services sectors in their economies. What is more, they heavily increase their services exports, contrasting with the slight contraction of services sectors in the EU.

Table 7. Total impact in percentage change on production (Prod), exports (Exp) and imports (Imp) in EU, Argentina, Brazil, Paraguay, Uruguay and Mercosur as a region

Sector	EU27			Argentina			Brazil			Paraguay			Uruguay			Mercosur		
	Prod.	**Exp.**	**Imp.**	**Prod.**	**Exp.**	**Imp.**	**Prod.**	**Exp.**	**Imp.**	**Prod.**	**Exp.**	**Imp.**	**Prod.**	**Exp.**	**Imp.**	**Prod.**	**Exp.**	**Imp.**
Cereals	-0.33	-0.29	-0.36	0.45	0.16	1.05	0.18	-1.36	3.68	0.11	0.28	-0.46	-1.48	-1.36	0.35	0.19	-0.90	3.41
Vegetables, fruits, nuts	-0.32	-0.33	-0.07	2.03	6.69	5.24	2.20	6.68	3.27	0.05	1.04	-1.87	1.32	9.03	4.50	2.11	6.76	3.64
Sugar	-0.32	-0.44	-0.11	0.44	1.78	13.07	-0.23	-0.73	9.22	0.16	1.46	8.63	-1.22	-5.13	0.38	-0.21	-0.69	5.90
Plant & animal fiber, others	-0.27	-0.19	-0.19	0.77	4.83	3.48	0.01	-1.17	1.73	-0.40	1.84	-1.40	-0.37	-4.28	-0.45	0.11	-0.78	1.57
Bovine and other ruminant meats	-1.73	-4.67	1.19	3.97	32.45	8.36	1.32	7.55	1.33	0.36	0.62	-2.78	3.23	6.70	9.49	1.90	9.72	1.78
Other animal products	-0.59	-0.41	-0.58	1.10	2.46	1.23	1.98	-1.63	1.93	0.04	0.46	-0.56	0.61	-0.58	2.82	1.77	-0.05	1.42
Dairy products	-0.09	-0.08	0.01	0.20	-0.03	25.46	-0.20	0.44	11.66	0.18	-0.32	1.57	-5.15	-9.50	16.70	-0.28	-2.95	12.41
Forestry	-0.06	-0.24	0.10	-0.55	1.51	3.99	-0.03	-1.05	2.93	-0.38	-0.62	-0.60	-2.05	-5.36	-0.21	-0.12	-2.05	3.05
Gas, coal, oil extraction or distribution	-0.21	-0.45	0.18	-0.05	1.18	-0.14	-0.06	0.49	-0.50	0.05	-0.32	0.61	-0.08	-10.72	-1.26	-0.06	0.52	-0.45
Live animals, meat and animal products	-0.82	-1.59	0.65	0.33	3.06	9.56	2.52	6.52	29.79	0.01	0.72	-0.31	-4.30	-17.38	11.92	1.87	6.15	16.89
Vegetable oils and fats	-0.52	-0.31	-0.22	0.20	0.20	5.87	1.61	2.86	13.82	-0.76	-0.88	1.56	-8.25	-9.55	1.40	0.99	0.86	11.14
Food products nec	-0.68	-1.12	0.59	1.56	7.37	3.53	4.05	57.22	6.09	-0.22	0.10	0.40	-1.59	-3.50	4.33	3.36	32.75	5.20
Beverages and tobacco products	-0.05	-0.03	0.19	0.33	2.32	4.42	0.19	5.61	11.16	-0.22	0.35	0.83	-0.05	-4.09	5.59	0.21	4.34	7.03
Textiles	0.21	0.65	0.20	-2.42	-2.61	5.38	-1.44	-0.38	6.66	-1.74	-6.80	-0.38	-4.86	-11.70	6.78	-1.60	-1.67	6.18
Wearing apparel	-0.09	-0.02	0.14	-0.15	9.91	7.06	-0.77	14.41	11.15	-1.52	-5.96	5.85	-2.06	-0.32	7.61	-0.70	9.85	10.26
Leather products	-0.86	-0.93	0.03	2.16	8.22	0.85	2.30	10.58	3.21	0.90	1.19	-0.02	0.64	2.82	3.60	2.21	9.27	2.54
Wood products	-0.04	-0.03	0.09	-0.77	-1.83	9.15	-0.47	-0.03	12.09	-0.56	-3.22	1.31	-3.08	-9.23	3.59	-0.57	-0.50	9.94
Petroleum, coal and other chemical products	0.18	0.38	0.16	-0.37	2.39	1.81	-0.35	1.71	1.66	-0.55	-0.52	0.07	-1.49	-1.55	0.79	-0.37	1.81	1.60
Pharmaceutical products	0.02	0.05	0.05	-5.58	-0.30	4.81	-1.70	-2.13	6.26	-1.14	-0.15	0.93	-4.17	-6.46	4.51	-2.12	-1.79	5.82
Rubber and plastic products	0.03	0.05	0.15	-1.87	-0.36	3.58	-0.59	-1.53	3.89	-1.76	-4.46	-0.05	-4.10	-8.64	1.54	-0.77	-2.04	3.52
Other manufactures	-0.03	-0.03	0.22	-0.24	0.26	6.95	-0.05	-1.15	10.53	-0.93	-7.70	1.86	-0.62	-9.09	9.93	-0.10	-1.36	9.41
Metals and metal products	0.21	0.34	0.32	-2.52	1.25	4.50	-1.93	-0.47	9.87	-0.90	-0.71	0.49	-6.09	-13.02	5.71	-2.00	-0.25	8.39
Electronic products	0.09	0.25	0.24	-3.64	6.08	0.63	-0.49	-0.10	3.78	-0.16	-1.34	0.13	-4.82	-6.93	3.75	-0.58	0.66	3.00
Other machinery	0.43	0.76	0.30	-6.58	0.02	3.83	-3.84	0.33	11.15	-10.76	-16.71	0.20	-7.32	-20.53	6.12	-4.01	-0.03	9.16
Motor vehicles and parts	0.57	0.76	0.30	-9.73	-13.32	2.49	-2.07	-1.35	8.69	-2.44	1.28	0.81	-13.34	-17.94	3.09	-3.01	-6.52	6.54
Transport equipment	-0.40	-0.45	0.07	-0.63	3.10	2.71	0.32	4.69	4.88	-0.59	1.47	0.12	-0.56	-6.57	3.40	0.23	4.60	4.29
Other services	0.00	-0.44	0.25	0.14	0.41	0.17	0.03	-0.97	0.76	-0.04	0.25	-0.03	0.29	-5.05	4.40	0.05	-1.14	0.55
Construction	0.06	-0.28	0.34	1.48	8.32	6.13	1.52	5.93	23.78	0.41	5.73	0.74	4.40	-0.18	26.51	1.59	6.54	35.80
Hotels and Restaurants	0.05	-0.15	0.14	-0.06	0.10	10.82	0.01	-1.22	0.96	-0.06	0.29	0.07	0.13	-6.15	10.91	-0.01	-1.23	3.98
Maritime Transport	0.02	0.03	0.06	0.79	3.65	0.07	-0.02	0.01	0.34	-0.36	0.96	-0.65	7.48	12.94	-12.26	0.11	0.47	0.39
Air Transport	-0.14	-0.23	0.18	1.41	6.36	-0.25	0.15	3.43	0.45	0.60	5.32	-0.37	2.47	6.81	3.61	0.40	4.68	0.10
Communication	0.03	0.40	0.32	0.15	15.40	13.25	-0.34	7.47	8.97	0.20	14.50	0.08	0.28	11.45	15.87	-0.27	11.48	15.23
Banking	-0.11	-0.56	0.20	0.17	12.61	0.92	-0.01	11.58	0.56	-0.18	13.87	-0.09	0.34	14.85	1.86	0.03	11.95	0.75
Insurance	-0.05	-0.24	0.13	0.09	-0.07	0.46	-0.28	-0.88	0.52	-0.54	-0.14	-0.09	0.34	9.74	-7.47	-0.20	-0.51	5.87
Business Services	-0.03	0.04	0.49	-0.22	9.13	12.46	-0.29	5.93	10.13	2.54	8.87	19.27	-3.37	4.36	8.46	-0.30	6.47	6.38
Personal Services	-0.04	-0.49	0.15	0.21	0.54	0.12	0.03	-0.87	0.76	0.04	0.41	0.00	-0.73	-6.55	1.82	0.07	-0.91	0.46
Total Agriculture	**-0.47**	**-0.66**	**-0.04**	**1.45**	**4.07**	**5.65**	**0.64**	**0.06**	**3.77**	**0.14**	**0.42**	**-0.83**	**-0.13**	**-0.02**	**1.83**	**0.75**	**0.84**	**3.70**
Total Manufactures	**0.09**	**0.26**	**0.22**	**-0.99**	**-0.65**	**2.69**	**-0.48**	**3.11**	**5.61**	**-0.70**	**-1.85**	**0.37**	**-2.79**	**-6.61**	**3.61**	**-0.58**	**2.02**	**4.75**
Total Services	**0.00**	**-0.19**	**0.23**	**0.23**	**5.34**	**2.15**	**0.11**	**3.03**	**0.91**	**0.10**	**1.21**	**-0.04**	**0.68**	**-2.11**	**2.18**	**0.14**	**3.05**	**1.12**
TOTAL	**0.01**	**0.11**	**0.22**	**-0.03**	**1.14**	**2.77**	**-0.05**	**2.49**	**4.49**	**-0.07**	**0.06**	**0.30**	**-0.06**	**-2.46**	**3.34**	**-0.05**	**1.94**	**4.00**

Source: authors' estimation

As we would expect, in agricultural sectors, Argentina and Brazil experiment the biggest output increases due to the easier access to the EU market, compared to the other Mercosur economies. Vegetables, fruits and nuts increase output by 2.2% (0.73 $US billion) in Brazil and Bovine and other ruminant meats by 4% (0.77 $US billion) in Argentina. These increases are mainly derived from tariffs' reductions and larger quotas in the EU. Mercosur agricultural exports would grow by 0.84% (0.66 $US billion), while EU agricultural exports would decrease by -0.66% (1.4 $US billion). In the Bovine sector, Mercosur increase its exports by 9.72% (1.1 $US billion). Almost a half of this increase corresponds to Argentina, which increase its exports in this sector by 32.45% (0.45 $US billion). Moreover, Argentina experiences the largest increases in agricultural exports, with an increase of 4.07% (0.62 $US billion). Although it does not appear in Table 7, Agricultural exports from Mercosur to the EU would rise by 19.2% (1.8 $US billion). On the EU side, output in agriculture would experiment a decline of 0.47% (3.8 $US billion).

Again, intuitively, the EU experiments the largest increases in output in manufacturing. Motor vehicles and parts stand out (0.57% and 5.3 $US billion). By contrast, in Mercosur production in Motor vehicles and parts, Other machinery and Metals and metal products goes down by 3.01% (4.1 $US billion), 4.01% (3.6 $US billion) and 2% (3.5 $US billion), respectively. Brazil would experiment the strongest impacts on production in some manufacturing sectors. Food products n.e.c.[15] would increase its output levels by 4.05% (3.6 $US billion), mainly derived from an increase of exports to the EU (153% or 3.4 $US billion).

Although exports from the EU to Mercosur in manufacturing sectors would grow by 71.7% (38.5 $US billion), exports to regions outside the agreement would decline in all cases, especially to China (reduction of 1% or 12.7 $US billion) leaving a positive increase of 11.3 $US billion at the aggregate level. Trade diversion effects will be smallest when Preferential Trade Agreement (PTA) countries have low levels of trade with the rest of the world or when the rest of the world is not as competitive as the nations joining the agreement (Lawrence, 1996). But in this case, both Mercosur and the EU have strong trade relationships with other countries such as China and the US, which are as competitive as the signatories.

[15] Not elsewhere classified.

4.3.3. Results on U.S. and China

As shown in Table 7, U.S. welfare would be reduced by 1.3 $US billion, which would be mainly caused by terms of trade losses. Our results are in line with the conclusions of the preliminary analysis published by the United States Department of Agriculture (USDA, 2021). They highlight that “based on presumed tariff reductions and quotas, (…) U.S. agricultural products that compete with MERCOSUR and EU products will be at a significant disadvantage (…). Nearly $4 billion in U.S. products are potentially threatened by MERCOSUR competition and tariff reductions under the new EU-MERCOSUR trade deal.” (USDA, 2021). In particular, USDA states that products like Feeds, Fooders or Beef & Beef products would be at risk. Regarding exports to Mercosur, the USDA highlights some overlapping competitive interests at risk for some sectors, such as Dairy products or Processed vegetables.

Our estimates are also in line with this intuition. With respect to U.S. exports to Mercosur, Sugar and Dairy products would be especially affected, with reductions of 5.3% (0.002 $US billion) and 10.9% (0.003 $US billion) in exports. However, aggregated agricultural exports to Mercosur would experiment increases, mainly due to Cereals, whose exports to Mercosur would increase by 3.7 % (0.027 $US billion). Although U.S. aggregated exports to the EU show an increase of 0.6% (2.5 $US billion), agricultural sectors would experience a reduction of 0.6% (0.038 $US billion).

As the USDA preliminary analysis shows, sectors in which Mercosur countries compete with the U.S. in exports to the EU would be affected. U.S. Vegetables, fruits and nuts would reduce its exports to EU by 0.4% (0.012 $US billion) and the Bovine sector by 6.2% (0.021 $US billion). These sectors experiment the highest increases in exports to the EU from Mercosur. Highest impacts on the U.S. take place in manufactures, where exports to Mercosur experiment important reductions, i.e., Pharmaceutical products by 12.4% (0.25 $US billion) or Other machinery by 20.4% (1.7 $US billion). U.S. would also lose competitiveness in Services sectors, with an overall reduction of its exports to Mercosur of

3.3% (0.54 $US billion). However, although these results seem high in percentage change terms, exports from the U.S. to the Mercosur only represent a minor share of total U.S. exports. Thus, the impact on U.S. production of this industries is negligible.

Although results show some reductions in China's exports to the EU, the main impacts are driven by a decrease in trade with the Mercosur region. China would increase its manufacturing exports to the EU by 0.9% (3.1 $US billion), whereas it would reduce its manufacturing exports to the Mercosur region by 11.7% (6.5 $US billion). Highest decreases in exports rely on Electronic products and Other machinery, with reductions of 9.1% (1.4 $US billion) and 6.3% (2.9 $US billion), respectively.

These negative impacts could have a higher importance than perceived, as China could lose competitiveness in manufacturing sectors, in which it traditionally has had a dominant position in the world. They would reinforce the change in China's strategy due to a rise in wages and competitiveness erosion in labor-intensive manufacturing industries (Lawrence, 2019; Latorre et al., 2018).

5. Sensitivity analysis

We carry out a sensitivity analysis following the approach of Ortiz & Latorre (2019). We have doubled and halved the initial values of the following three elasticities:

- Elasticity of substitution between primary factors in production (ESUBVA)
- Armington elasticity of substitution between imported/domestic varieties (ESUBD)
- Armington elasticity of substitution for regional allocation of imports (ESUBM)

We rerun all three simulations (Tariff reduction, NTM reduction, Public Procurement reduction) with the new elasticities and compare the results for GDP with the ones presented above. Table 8 shows that our results are robust to changes in the elasticities.

GDP impact remains unaffected when the elasticity of substitution between primary factors in production (ESUBVA) is modified. Besides, the changes in ESUBD elasticities (imported/domestic) lead to small changes in GDP, in which higher values lead to larger GDP impacts, and vice versa. Larger elasticities increase the easiness with which consumer and producers can substitute varieties. Thus, reduction of trade restrictions leads to higher GDP because the number of similar imported varieties increases.

Table 8. Sensitivity analysis results

qgdp	Original GDP impact	ESUBVA		ESUBD		ESUBM	
		Double	Half	Double	Half	Double	Half
EU_27	0.04	0.04	0.04	0.05	0.04	0.07	0.02
ARGENTINA	0.26	0.26	0.26	0.29	0.25	0.39	0.20
BRAZIL	0.13	0.13	0.13	0.14	0.13	0.17	0.10
PARAGUAY	0.04	0.04	0.04	0.04	0.04	0.09	0.03
URUGUAY	0.61	0.61	0.62	0.60	0.63	0.73	0.53
USA	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHINA	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.00

Source: authors' own elaboration.

Regarding the elasticity of substitution for regional allocation of imports, the expected gains are higher with larger elasticities because consumers perceive the different imported varieties as more similar. Therefore, Mercosur varieties can displace varieties coming from other areas more easily and the same applies to EU varieties in Mercosur.

Harrison et al. (2002) compared different scenarios under Chile's strategy negotiation of bilateral free trade agreements. They use two levels of elasticities for ESUBD and for ESUBM. In the first case, which they call *low elasticities,* values are very similar to those used in this study. In the second case, they assume a level of 15 for ESUBD and of 30 for ESUBM (both of which are around 5-6 times larger than the original values). They call these larger elasticities *central elasticities.* Results for a scenario in which Chile forms an FTA with Mercosur show very different impacts depending on the elasticities used. With *central elasticities*, trade diversion would dominate trade creation and lead to welfare losses for Chile's economy, while with *low elasticities* a positive welfare result for Chile is obtained.

To further check the robustness of our results, we replicate the analysis of Harrison et al. (2002) and rerun our simulations with their 'central elasticities' (i.e., 15 for ESUBD and 30 for ESUBM). Interestingly, contrary to the findings of Harrison et al. (2002) we still obtain that trade creation effects dominate trade diversion in signatory countries and this phenomenon is found to be more accentuated when we increase these elasticities. This provides additional support for the positive outcomes of this agreement.

6. Comparison with other studies

We obtain larger impacts on the EU but slightly lower results for Mercosur than those of the LSE (2020). They estimate for the conservative scenario an increase of 0.1% of EU-28's GDP, 0.5% for Argentina, 0.2% for Brazil, 0.1% for Paraguay and a 0.2% for Uruguay. This study was initiated before the Agreement in Principle was reached. Therefore, it does not include real reductions agreed upon. Moreover, it was later updated in December 2020, but simulations remain the same. Although it considers specific tariff cuts for several agricultural products, it does not differentiate among the different sensitive agricultural sectors and, therefore, expected gains from these sectors are higher (higher tariff reductions). By contrast, we have included the different negotiated regimes for each of the sensitive agricultural sectors. Moreover, this study uses a dynamic version of the GTAP model. Dynamic models capture the gains derived from economic growth of participating countries and, therefore, the expected results from these kinds of models are higher than those from static setting (Baldwin, 1992).

Our results are also in line with Sinabell et al. (2020) who estimate GDP increases between 0.03% and 0.16% in EU countries, and between 0.33% and 0.52% in Mercosur countries. In terms of what they call absolute gains, the EU gains the most from the agreement, with € 12.2 billion, while Mercosur as a region would increase its welfare by € 7.2 billion. Timini & Viani (2020) estimate changes in real welfare between 0.33% and 0.71% in Mercosur and between 0.01% and 0.39% in EU countries. They derive a higher GDP impact for the smaller

Mercosur countries (Paraguay and Uruguay), even though they do not contemplate public procurement opening.

Latorre et al. (2020a) explain that NQTMs use a small group of structural-type variables to estimate trade impacts. Some of these are national income, geographical distance and technology. Timini & Viani (2020) describe that NQTMs use one sector and one factor of production. Among other differences with CGEs, NQTMs do not consider substitution elasticities deviating from 1 in the choice between intermediates and between factors of production (Bekkers, 2017). It is also important to emphasize that neither Sinabell et al. (2020) nor Timini & Viani (2020) consider trade in services.

Finally, we reach similar conclusions to those obtained by Carrico et al. (2020). This study, which does not take into account opening of public contracts, estimates the highest GDP increase in Uruguay (0.9%) and the lowest in Paraguay (0.25%) for Mercosur countries. Regarding the EU, it estimates a GDP increase of 0.02%.

As noted above we run our model in a climate of perfect competition and constant returns to scale, as other studies do (e.g., LSE, 2020; Carrico et al., 2020). This implies that products are differentiated by country-of-origin à la Armington (i.e., there is a single domestic variety in each country for each sector). For example, Latorre et al. (2021), who study the impact of this agreement considering imperfect competition and economies of scale à la Krugman (1980) for some service sectors and à la Melitz (2003) for some manufacturing sectors, find more sizeable trade impacts than we do.

7. Conclusions

At a time of political and economic uncertainty, the EU-Mercosur agreement has been the subject of intense debate. The development of trade and investment with like-minded partners to find alternatives to Russian supplies and markets has increased the EU's interest to ratify the trade agreement with Mercosur (Tähtinen, 2024). In the absence of ratification by some European countries led by France, our analysis aims to shed light on its economic consequences.

We provide a tailor-made sectoral impact analysis of the agreement, taking into account the exact tariffs' reductions and the quotas based on the negotiated tariffs and quotas at the HS 8-digit level in sensitive sectors together with other negotiated outcomes, including services sectors and public procurement. Besides, we extend the micro and macro results offered in previous studies such as LSE (2020), Sinabell et al. (2020) or Timini & Viani (2020). Our main contributions in relation to these studies are: (1) we provide a broad set of quantitative results at the macro level but also the impact on production, imports and exports for 36 sectors and (2) our estimates are based on official documents from the European Commission and Mercosur countries, instead of being based on how previous treaties shocked trade.

We have performed a specific simulation for the reductions in NTMs related to the openness of public contracts, which has not been included in the previous analysis of this kind (to the best of our knowledge). Thus, we unveil an unexplored role for public procurement. The impact of this component of the agreement is quite remarkable, particularly for Mercosur countries. Public procurement openness is a historic milestone. To date Mercosur has only opened its public contracts at a regional level (i.e., among Mercosur countries) and this process has begun quite recently, so there is an important scope for openness. Translating this into simulations has been a time-consuming exercise, due to the difficulty of interpreting the chapters referring to it. Each signatory country expresses the openness for each sector in a different way, using either positive or negative lists. Further, the nomenclature is different depending on whether the sector is goods or services sector. In the first case, the sectors are expressed in ISIC Revision 3.1, and in the case of services in the United Nations Provisional CPC nomenclature and had to be converted to GTAP sectors.

We also shed light on the role that services sectors can play in this agreement, which is again an aspect that has passed unnoticed in the previous literature, in part, because methodologies such as NQTMs do not consider services trade. Interestingly, we find that Mercosur countries could become more specialized in services sectors that have greater value added, than other agricultural and manufacturing sectors. What is more, the agreement results in important increases of exports of services and agricultural products and smaller increases of manufacturing exports.

The reduction of tariffs is what drives the positive results for the EU, because Mercosur countries exhibit very high tariffs according to international standards. Given the differences in size, the scope of gains is greater (in percentage terms) for Mercosur countries. However, although the four Mercosur countries reduce tariffs in the same way (Common External Tariff), the commitments in terms of NTM reduction and public procurement are different. Thus, the country that gains the most is Uruguay, which is a rather small country with the most open regime. By contrast, Paraguay, which is also small but has been less ambitious in the negotiations, derives less from the agreement, while Argentina and Brazil lie somewhere in between. All in all, the gains for the Mercosur countries depend to a great extent on their degree of commitment to trade liberalization. Thus, our main policy recommendation is that the more ambitious your negotiations are, the more you derive from the agreement.

Chapter 4. Modeling the impact of public infrastructure investments in the U.S.: a CGE analysis

Abstract

This study offers a computable general equilibrium analysis of the 550 $US billion devoted to new infrastructure investment (new and remodeled physical infrastructure for transportation, information and public services) in the United States (U.S.) under the Infrastructure Investment and Jobs Act, a federal law signed by President Joseph Biden in November 2021. The simulations are based on the state-level distribution of funds and distinguish between the construction phase (short run) and the operational phase (long run). Gross Domestic Product (GDP) and labor demand react to the government spending stimulus after the first year by growing 0.24% and 0.44%, respectively. The gains derived from this investment plan are higher in the long term once the investments increase the country's capital stock; GDP increases by 1.39% and wages by 3.94%. This paper analyzes the efficiency of the current distribution of funds across sectors and finds that the current distribution benefits the U.S. economy more. Even though a slightly higher GDP impact could have been reached (1.42%) if all the funds were devoted to Transport services, the price increases would result in lower real wage increases.

1. Introduction

The *Infrastructure Investment and Jobs Act* (IIJA) signed by U.S. President Biden in November 2021 is aimed at modernizing the country's roads, bridges, rail, ports, airports, broadband and drinking water (The White House, 2021a). From the $1.2 trillion bill, $550 billion correspond to spending over the initial levels, i.e., spending on new infrastructure over five years (2022-2026).

According to the 2019 Global Competitiveness Report (Schwab, 2019) the U.S. ranks 13th in global infrastructure quality and 17th in road infrastructure quality. Total (real) public infrastructure spending[16] has decreased since 2003, when it peaked at $480 billion, falling to $440 billion in 2017 (Congressional Budget Office, 2016). The American Society of Civil Engineers (2021) estimated a $2.6 trillion infrastructure investment gap during the period 2020 to 2029. Thus, even though this plan does not fully cover the investment gap, it counteracts the declining trend of the past decades.

The purpose of this study is to ascertain whether this investment stimulus will benefit the U.S. economy and if so, to what extent, providing results based on a robust methodology and simulations based on official figures.

2. Infrastructure expenditure and economic growth

Physical capital is intuitively an essential part of an economy, as it connects supply chains, enables the movement of goods and services, and ultimately facilitates greater opportunities for economic growth. However, major infrastructure projects are large-scale and capital-intensive, implying high initial costs, while profits are spread out over time and thus their benefit is harder to estimate. Most federal investment for nondefense purposes contributes to the economy on an ongoing basis by improving the private sector's ability to invent, produce, and distribute goods and services (Congressional Budget Office, 2016).

The relationship between infrastructure investment and a country's economic growth has been the subject of analysis for many decades and is now in the spotlight due to the challenges posed by the Covid-19 crisis. Early studies that analyzed this relationship yielded mixed results. Aschauer (1989) found that much of the decline in the U.S. productivity had a close relationship with the descending rates of public capital investment. His findings were later reaffirmed by Munnell (1992). Other studies were skeptical about these results, arguing statistical problems related to the aggregated nature of data (Jorgenson, 1991) or

[16] Includes spending on capital and maintenance of transportation and water infrastructures.

spurious correlation between public capital and income due to the non-stationarity of the regressed variables (Tatom, 1991).

The most recent economic literature does seem to agree on the positive relationship between infrastructure investment and economic growth. Rozas & Sánchez (2004) found that although the measurement of the impact of infrastructure investments on the development of a region or a country has yielded mixed results, much of the empirical evidence in the literature shows that infrastructure investments contribute to output growth, cost reduction and improvements in profitability. According to Lawrence (2023), the high share of investment and hence manufacturing in Asian economies is closely related to their rapid growth. Infrastructure investment has also been part of the trade facilitation strategy of developing countries over the past decades, making the flow of trade cheaper, faster and more reliable.

In terms of physical infrastructure investments, recent literature points to a positive relationship between physical infrastructure investment and economic growth, but this relationship is relatively complex and can be studied from different perspectives. Stupak (2018) overviews the trends surrounding infrastructure investment in the U.S. and carries out a qualitative analysis on how different financing mechanisms may affect GDP and employment, and the effect on private sector. Some studies go beyond this effect and analyze the crowding effect that public investments may have on private capital productivity (Congressional Budget Office, 2016; Abiad et al., 2016).

Another part of the literature focuses on one type of infrastructure and provides empirical results for broadband investments (Czernich et al., 2011), transport investments (Melo et al., 2013) and energy investments (Li & Li, 2020). From other perspectives, Chakamera & Alagidede (2018) analyze the relationship between infrastructure investments and economic growth focusing on the quantity and quality of the infrastructures, while Blimpo & Cosgrove-Davies (2019) study how the access to those infrastructures can influence the expected economic outcomes of such investments. Finally, the literature contains some studies with a closer focus on this analysis, such as Canning & Pedroni (2004). They investigate the long-run consequences of the provision of different types of infrastructure but put the focus on per capita income.

This computable general equilibrium (CGE) analysis not only provides reliable macroeconomic estimates of impact of the IIJA, but also contributes to the existing literature by providing insight into how an increase in public infrastructure investments affect development over the longer term. According to Timilsina et al. (2020), the current literature lacks empirical analyses on how physical infrastructure investments can provide economic growth in the longer term across the economy. It claims that some studies such as Lenz et al. (2017) provide short-term effects on specific users but do not provide longer-term effects across the economy. This is precisely one of the strengths of the CGE approach. Additionally, another advantage of CGEs compared to other techniques is that they do not focus on one market or user but consider a broad set of sectors and all agents in the economy.

Therefore, this analysis provides the impact of the IIJA across all sectors of the U.S. economy and for different agents such as different types of workers and the government. Finally, compared to other less detailed techniques, this study takes into account the input-output linkages and macroeconomic identities in the economy, considering the transmission mechanisms across sectors including forward and backward linkages of the IIJA and other knock-on effects triggered by this policy.

3. Overview of the Infrastructure Investment and Jobs Act

Within the $1.2 trillion appropriation, more than half, $650 billion, is earmarked to extend ongoing programs such as the Highway Trust Fund, the Waterways Trust Fund and other comparable funding sources that are already included in the government's budget. This allocation does not indicate any extra government spending (The White House, 2021a). This study only considers the remaining $550 billion that correspond to public spending above baseline levels.

Table 9 shows how the new investment funds will be allocated. The infrastructures that are built in the short term imply a short-run increase in the demand for construction. Once they are built, they mainly increase the capital stock of these three sectors[17] in the long run: Transport services ($283 billion for land transport, air transport, water transport, and transit), Utilities ($202 billion for energy distribution infrastructures, water, and sewage services) and Information services ($65 billion for telecommunications, cable networks, information services, and data processing services).

Table 9. New investment allocation of funds (in $U.S. billion)

Model sector	Category	Total spending 2017 ($US billion)	Total spending increase 2022-2026 ($US billion)	Annual spending increase 2022-2026 ($US billion)
Transport	Roads and bridges Passenger and freight rail Transit Airports Ports and waterways Safety	136	283	57
Utilities	Clean energy and grid Water infrastructures Resiliency Environmental remediation	53	202	40
Information	Broadband	6	65	13
	Total	**195**	**550**	**110**

Source: created by the authors based on The White House (2021a), The White House (2021b), U.S. Census Bureau (2021).

[17] Although some sub-items could be classified in other sectors, these correspond to comparatively much smaller amounts. Therefore, they are not modeled explicitly, which implies this analysis is still conservative.

In terms of financing these new investments, the plan initially proposed offsets that would cover the $550 billion of new spending (Cantwell, 2021). However, recent estimates find that total savings will cover less than half of it, as some of the reported offsets have already taken place (Committee for a Responsible Federal Budget, 2021).

4. Methodology and data

Computable general equilibrium (CGE) models are a class of economic models that estimate how an economy might be impacted due to a change in a specific policy, technology or other kind of external factors. They are based on mathematical equations that capture the interactions between factor markets and goods markets and can integrate both the macro and microeconomic levels (Latorre 2012; Latorre et al., 2020a). They use actual real data in a rigorous theoretical framework and present the relationships among economic agents as a system of equations derived from microeconomic optimization theory. Resting on the usual progression of the circular flow of the economy (production, income distribution and domestic and foreign demand), CGEs describe the equilibrium conditions in goods, factor markets and in the foreign sector. They cover the behavior of households, firms and government in the economy.

The model used in this study is the U.S. version of The Enormous Regional Model (TERM-USA) aggregated for 11 regions and 26 sectors. The TERM model follows a bottom-up strategy, meaning that regional results sum up to obtain the national results (Horridge, 2012). Data sources for this study include different U.S. official databases such as the Bureau of Economic Analysis (n.d.) and the U.S. Census Bureau (2021). By using a program developed by the Centre of Policy Studies (2019), the original database (Centre of Policy Studies, 2013) was updated to 2019 levels. Appendix III provides a detailed description of the TERM model.

The simulations conducted using a CGE consist of a comparison between two scenarios, before and after the policy shock. The pre-policy scenario assumes that the economy is in equilibrium, i.e., all the equations in the model are solved at a set of prices in which quantities supplied and demanded are equal in all markets. After changing one or several exogenous variables, this equilibrium is broken, and the equations are solved to find the new equilibrium. The percentage change in the endogenous variables (the modeler defines the endogenous and exogenous variables in the closure of the model) corresponds to the impacts caused by the distortion.

The *general* feature of the model implies that, differently from the partial equilibrium models, a change in the demand or supply for a good of one market can lead to changes throughout the entire economy. A shock (e.g., in the price or quantity of a good) introduced in one market will lead to changes in demand or supply for goods from other markets.

5. Simulations and results

The results shown in this paper cover the (1) effects after the first year (once the construction phase is initiated (Simulation 1), in which the stimulus is based on an increase in government demand for construction and the (2) long-term effects during the operational phase (Simulation 2), in which infrastructures increase the country's physical capital stock. The results reveal variations in main macroeconomic variables expressed in percentage change from the initial data.

Table 10 shows the macroeconomic results of the two simulations. The first column presents the impact after the first year of the plan (i.e., very short run), assuming 1/5 of the funds are already allocated and the increase in outlays occurs after the first year (see second column). Considering the $550 billion in new investments are distributed equally between 2022 and 2026, government spending increases in one year by 2.55% from the initial level ($110 billion each year). This would represent the highest annual government spending increase in the last decades.

After the first year (Simulation 1) it is assumed that wages are unable to vary and employment adjusts to meet the increase in demand. Additionally, there is not enough time for capital adjustment, and therefore capital stocks remain fixed. The shock after the first year reflects the immediate response to the stimulus, i.e., increase in government demand for construction output (government spending rises by 2.55%). During the construction phase the rise in construction expenditure stimulates a direct increase in both the output and the price levels as shown in Table 10.

Table 10. Macroeconomic results

Variable	Simulation 1 $110 billion (first year)	Simulation 2 $550 billion (long run)
Real consumption	0.69	1.44
Real investment	0.00	0.56
Government spending	2.55	1.46
Exports	-2.93	1.35
Imports	1.89	0.70
Real GDP	0.24	1.39
Aggregate Employment	0.44	0.00
Real Wage	0.00	3.94
Aggregate Capital Stock	0.00	2.52
GDP Price Index	2.33	-0.64
Consumer Price Index	1.88	-0.93

Source: authors' estimations based on Centre of Policy Studies (2013, 2019). See *Methodology and Simulations* for additional information on the data used.

The labor market responds to the initial stimulus by increasing demand for labor (real wages remain fixed). Shocks are defined on a percentage change basis (2019 as base year), using an estimated distribution of funds across states[18] (see Appendix II).

Driven by the increase in demand for construction output, results after the first year show that GDP would grow by 0.24% ($55 billion) and national employment by 0.44% (equivalent

[18] Calculations are set by statute and can vary over time. Estimates are based on prior legislation that could vary over time.

to 650,000 workers). With fixed capital and no variation after the first year, the increase in demand for non-traded construction goods leads to a real domestic appreciation (the GDP price index and the Consumer Price Index increase by 2.33% and 1.88% respectively) and causes the economy to move towards an increase in the trade deficit (exports fall by 2.93% and imports increase 1.89%).

There are two main assumptions for the long-run simulation: an investment stimulus raises capital stocks and increases the output productivity. Regarding capital stocks, they are determined endogenously in the long run following a fixed growth rate of capital (fixed investment/capital ratio) in all industries except for the Transport[19], Utilities and Information industries. In this simulation the shock introduced corresponds to a capital stock increase in these three industries[20] based on the allocation of funds shown in Table 9. In the long term it is also assumed that the U.S. national real balance of trade as a share of real GDP remains constant and that, regarding the labor market, employment returns to initial equilibrium, while the real wages are defined as endogenous.

In terms of productivity increase, a meta-analysis by Bom & Ligthart (2014) aggregated almost three decades of studies on measuring the output elasticity of public capital. They found a long-run output elasticity of public capital supplied at the central government level of 0.122. This is the elasticity used to increase the output productivity of the Transportation, Utilities and Information industries in Simulation 2, considering the capital stock increase for each of them.

As a result of the increase in capital stock and output productivity, GDP would rise by 1.39% ($292 billion) and real wages by 3.94%. The competitiveness loss described in the short run

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[19] Transportation capital stock is the value of transportation infrastructure (e.g., roadways, bridges, and stations) and equipment (e.g., automobiles, aircraft, and ships)

[20] Total capital stock increases by 2.52% (see the second column in Table 10).

is reversed in the long run, once the investments increase, the capital stock and the foreign debt must be paid back. Prices fall (GDP price index decreases 0.64% and CPI a 0.93%) and domestic consumption increases (private and public consumption increasing more than investment).

An additional question addressed in this article concerns the efficiency of the actual distribution of investments in the long term. For this purpose, three simulations have been compared, in which the total IIJA new spending ($550 billion) has been devoted exclusively to the Transport, Utilities and Information sectors. The simulations include, as in the original long-run scenario, two types of shocks: (1) sectoral capital stock increase and (2) sectoral output productivity increase using the long-run productivity elasticity estimated by Bom & Lightart (2014).

Results show that the most efficient sector in terms of economic growth is the one to which most of the funds have been dedicated, the Transport sector. Investment in transport obtains the highest GDP increase (1.42%), over Information (1.23%) and Utilities (0.88%). In addition, investment in Transport is the only one that obtains a higher GDP increase than in the original simulation (1.39%). However, it is also the one that obtains the least sizeable real wage increase (2.98%). If the full investments ($500 billion) were devoted exclusively to the Information or the Utilities industries, the aggregate real wage increase in those scenarios would be 3.15% or 3.11%, respectively.

The main reasons behind these results are that (1) the Transport sector has the lowest capital stock, i.e., the capital stock increase is proportionately higher than in the other sectors and (2) it is the least capital-intensive sector among the three considered. In fact, Transport is the only sector that has a capital over labor (K/L) ratio below 1 (i.e., it is a labor-intensive sector), Information and Utilities have a K/L ratio over 1 (i.e., they are capital-intensive sectors). These two facts imply that the same amount of additional capital in Transport is the most productive comparatively speaking and leads to the highest GDP outcome for the whole economy. By contrast, Information and Utilities experience the diminishing returns to capital that arise due to capital accumulation more intensively (because of their larger initial K/L ratios) than transport, and therefore results in lower increases in GDP.

On the other hand, the accumulation of capital in one particular sector tends to reduce its rate of return in that sector, relative to labor, since capital becomes relatively more abundant than labor in that sector. This reflects the fact that capital becomes relatively less productive when it is more abundant, and labor becomes relatively more productive when it is scarcer. As mentioned earlier, diminishing returns to capital tend to be more sizeable in the more capital-abundant sectors (implying that labor becomes relatively more productive than capital in them). Consequently, transport capital remains much more productive (and labor remains less productive) than in the other two sectors. This explains why wage increases are of smaller magnitude after the investment in transport than after the investment in the other two sectors. A similar analysis of the microeconomic mechanisms underlying these adjustments can be found in Latorre (2013).

Note that the mechanisms of adjustment that take place in the sector receiving the IIJA shock prevail over other adjustments and drive the macroeconomic evolution of GDP and aggregate real wages. This is because the initial shock is the largest occurring in the economy even though it triggers other knock-on effects across the rest of sectors.

All in all, the results of these additional simulations show that even though the current distribution of funds benefits workers the most, if the funds were fully allocated to the Transport sector, the benefits in terms of economic growth would be slightly higher in terms of GDP.

5.1. Comparison with other studies on the Infrastructure Investment and Jobs Act

There are two relevant analyses[21] that were conducted on the IIJA, namely, Bonakdarpour et al. (2021) and Zandi & Yaros (2021), both using an econometric approach. The results shared in this study are the first obtained using a computable general equilibrium approach, to the best of our knowledge. Moreover, this paper provides results for some macro variables which the rest of the analyses (to date) do not offer, such as impact on exports, imports or price increases.

Zandi & Yaros (2021) use Moody's Analytics macro-econometric model over the decade through 2031 and forecast the impact considering the estimated changes in direct spending on a yearly basis using estimates from the Congressional Budget Office (2021). They compare a baseline scenario with several possible scenarios, including the impact of the America Rescue Plan[22] (ARP) (The White House, 2021c), the IIJA and the Build Back Better framework. As for the IIJA, its impact is shown as an add-on to the ARP, comparing a scenario in which only ARP is contemplated with a scenario in which ARP and IIJA are combined. The results obtained are in line with those from the current analysis, with some differences that make these estimates a bit larger. After the first year of investments (i.e., by 2022) they estimate a GDP and employment reductions due to lags in starting the infrastructure projects. Once infrastructure projects have started after the second year (i.e., by 2023) they estimate a GDP increase of 0.65% and an employment increase of 0.21% (around 320,000 workers), and results for subsequent years are more reduced (or even negative). The results from the present paper are in line with these estimates, as it is considered that funds are equally distributed through five subsequent years. Additionally, Zandi & Yaros (2021) consider the changes in revenues estimated by the Congressional

[21] Both analyses were published prior to the approval of the law.

[22] Signed into law by President Biden in March 2021.

Budget Office through various means ranging from the rescission of Covid-19 appropriations to spectrum auctions, thus obtaining larger GDP impacts than the present analysis, which does not consider those and is more conservative.

The Bonakdarpour et al. (2021) study was commissioned by the American Road and Transportation Builders Association and analyzed the additional highway, bridge and public transit spending in the IIJA ($150 billion). It used a combination of two models, the IHS Markit model and the IMPLAN model. Results are expressed as an annual average between the years 2022-27 and show a very positive impact of the funding dedicated to highways and bridges. It estimated an annual GDP increase of $82 billion (0.3%), and an increase in employment of 200,000 workers per year 2022-27. Considering that these results showed the impact of $150 billion on the U.S. economy, they are clearly above the impact estimated in this study. For example, it claimed that the $150 billion investment increase[23] would raise GDP by $488 billion (1.8%).

The IHS's Markit's U.S. Macroeconomic model used by Bonakdarpour et al. (2021) is an econometric dynamic equilibrium growth model, i.e., solved period-by-period and considering capital accumulation. This is one of the main causes of the higher impact estimated by Bonakpardour et al. (2021). Macro-econometric models are based on time-series data, are statistically rigorous and have predictive skills, but can only provide aggregated (macro) impacts. They capture the dynamic benefits of infrastructure investments but do not incorporate shocks at a sectoral level as CGEs do.

Additionally, econometric models assume stronger impacts from increasing uncertainty (Latorre et al., 2020a), whereas in CGEs the economic agents react to a shock by maximizing profits (firms) and utility (households). Differently from econometric forecasting models, CGE models link the economic theory to data from regions and countries. To obtain sectoral

[23] Sum of investment on highways & bridges ($110 billion) and public transit ($39.4 billion).

impacts, Bonakdarpour et al. (2021) run an Input-Output model, which differs from a CGE model in that it does not assume resource constraints and captures only the supply side of an economy.

6. Conclusions

This study analyzes the impact that the Infrastructure Investment and Jobs Act signed into law by President Biden in November 2021 would have on the United States economy. This law contemplates $650 billion of normal allocated funds, plus $550 billion in new investment for core infrastructure projects (highways, bridges, waterways…), the latter being the ones simulated in this paper. The results show the impact one year after the construction works start, once the funds are fully allocated across states (short run) and in the long run, i.e., the new / renewed infrastructures increase the country’s physical capital stock.

The model used is a regional computable general equilibrium model (CGE), namely The Enormous Regional Model (TERM) for the U.S., aggregated into 11 regions and 26 sectors. Therefore, it allows shocks to be introduced at regional and industry levels. The original database has been updated to 2019 values using a program developed by the Centre of Policy Studies (2019).

In the first year, after the increase in government demand for construction, the first reaction comes from the demand for construction output. Since the capital stock and productivity do not change, this increase in demand raises labor demand mainly in the construction sector, and other related sectors. On the other hand, the country's competitiveness is eroded by rising prices, increased imports and declining exports. These results are more pronounced after the fifth year of the stimulus plan, right after the construction phase. GDP and employment increase and there is a boost in private consumption, but at the same time there is an important price increase that reduces external competitiveness (increase in the trade deficit). Once the investments increase the capital stock in the long run (operational phase), the employment returns to initial levels and there is an important increase in the national real wage.

Regarding the efficiency of the investments, the estimates from this study conclude that the current distribution of funds is the most beneficial across the main macroeconomic indicators. However, if all funds were devoted to the Transport industry, a slightly higher GDP and a lower real wage increase would have been reached. All in all, the results obtained in this analysis indicate a positive outcome for the U.S. economy both in the short and long run as a consequence of the IIJA, since it generates GDP growth, new jobs and increases real wages.

Chapter 5. The positive effects of the Infrastructure Investment and Jobs Act (IIJA) and how financing strategies matter

Abstract

Limited evidence exists for the U.S. Infrastructure Investment's impact. We estimate a comprehensive set of micro and macroeconomic effects of the Infrastructure Investment and Jobs Act (IIJA), based on computable general equilibrium modelling. In the construction phase, heightened government infrastructure spending annually boosts GDP by 0.19%-0.22%, creating 600,000-680,000 jobs. In the long term infrastructures become fully functional. During this phase, national borrowing, with a balanced distribution of short-term debt, outperforms foreign borrowing, leading to a 1.39% GDP increase and over 3.9% wage growth, compared to 1.19% and 2.75% under foreign borrowing. Foreign borrowing slightly boosts short-term GDP and employment more than national borrowing, due to increased expenses funded from abroad. However, it involves distinct economic adjustments and accumulating debt constrains long-term growth and wages. Jobs and wages grow across most workers' categories, but inequality is only marginally decreased, as seen in the wage distribution and labor income share in GDP.

1. Introduction

The world has recently faced the consequences of the Covid-19 pandemic. To aid economic recovery, many countries, including the United States (U.S.), have implemented various public policies. One common approach has been to increase public spending (Amin and Taghizadeh-Hesary, 2023; Jiang et al., 2022; Can et al., 2021). In November 2021, U.S. President Biden signed the Infrastructure Investment and Jobs Act (IIJA), a significant piece of legislation aimed at rebuilding America's infrastructure (The White House, 2021a). This act involves a substantial investment of $550 billion from 2022 to 2026 to enhance the nation's infrastructure, along with an additional $650 billion sourced from existing infrastructure funds and repurposed funds from other areas (United States Congress, 2021). The goal of this legislation is not only to improve infrastructure but also to create job opportunities, support underserved communities, address climate concerns, and invest in American manufacturers (The White House, 2021b).

The IIJA represents a groundbreaking moment in the history of infrastructure investments in the U.S., comparable to the establishment of the Interstate Highway System in 1956, which was a monumental public works project (Blas, 2010). However, for the U.S. case, limited research exists on the specific micro and macroeconomic implications of major infrastructure investments using Computable General Equilibrium (CGE) models. This technique allows us to consider a wide set of dimensions of the IIJA and, at the same time, isolates its effects, helping to analyze its impact. Zandi & Yaros (2021) analyze the IIJA together with the American Rescue Plan (ARP). This makes it challenging to attribute outcomes solely to the IIJA, as the present paper does. On the other hand, Bonakdarpour et al. (2021) only consider the highway, bridge and public transit spending provisions included in the IIJA. In contrast, our analysis directly assesses the impact of all the expenses contained in the IIJA. Thus, our study based on the TERM-USA model fills these gaps in the assessment of this policy.

More broadly, previous studies have generally explored the overall positive association between infrastructure investments and *some* macroeconomic variables. By contrast, our CGE approach enables us to provide a comprehensive and consistent set of macro and microeconomic results. Another advantage of this methodology is that it allows estimating both numerous macro and microeconomic results stemming from the IIJA, using a unique model. This enhances the consistency of the different outcomes derived and is of interest for policy makers. The latter need quantitative results on the overall effects (e.g., does the policy generate GDP growth, jobs and wage increases? and, by how much?), while identifying which sectors lose and which ones gain.

Thus, we cover an ambitious set of findings that, to the best of our knowledge, cannot be found in the different and dispersed analyses of infrastructure effects from our literature review. First, we analyze the distributional impact across different occupations, further separating the results for skilled and unskilled categories. We provide the effects for the wages and employment gap between ten different worker categories, together with the distribution of wages across deciles and labor and capital shares in GDP. Therefore, our study offers a real-world test on whether new government programs that emphasize construction for infrastructure, renewable energy and climate change mitigation could serve to offset some of the non-inclusive impacts that have been found in R&D-intensive programs (Lawrence, 2023). Second, we provide the impact of the IIJA across the 26 sectors in which the U.S. economy has been split. This helps to understand the outcomes on employment and wages across occupations, while estimating which sectors gain and which ones lose.

Third, we examine a wide range of macroeconomic variables, including GDP, private consumption, private investment, exports, imports, the aggregate capital stock and prices. Fourth, we consider various financing options for the infrastructure bill to illustrate their distinct implications. By doing so, we aim to provide an assessment of the short- and long-term impacts of the IIJA on the U.S. economy, considering both the construction phase and the subsequent operational phase of infrastructure projects. We also illuminate the effects of different financing strategies for a country like the U.S. that has one of the largest public debt and deficit among advanced economies (121. 3% of GDP in 2022, according to the IMF and 6.3 and largest public deficits for 2023 according to The Economist). All these findings should provide a comprehensive set of insights and quantitative estimations for policymakers and can guide their decisions on resource allocation, implementation strategies, and policy adjustments.

The rest of the paper is organized as follows. We start by detailing the various items under the Infrastructure Investment and Jobs Act (IIJA) that correspond to new investment and that are under the scope of our analysis. In section 3 we provide a literature review on the impact of infrastructure investments. In section 4 we describe the TERM model and the simulations considering different ways of financing the deficit generated by the increase in public spending. Sections 5 and 6 present the macroeconomic results and the distributional impact across occupations and economic sectors, respectively. Finally, the last section draws several conclusions.

2. Main characteristics of the Infrastructure Investment and Jobs Act

Our impact analysis specifically focuses on the $550 billion allocated within the IIJA for new federal investment in basic infrastructure (see Table 11). When a $1.2 trillion is offered as the figure related to Biden's plan (e.g., U.S. Department of Transportation, 2022) it includes additional funding normally allocated each year for highways and other infrastructure (e.g., Federal-aid Highway Program, Federal Railroad programs or Research, Technology & Education). Thus, the funding beyond $550 billion is already included in the figures of government spending in our model and does not imply any additional government spending.

The first column in Table 11 highlights the TERM-USA industries that cover the specific sub-areas (second column) to which these funds ($550 billion) will be devoted to. The Transport Industry is a major beneficiary of the IIJA. This industry is expected to receive more than half of the funds ($283 billion). These funds will be used for the construction and repair of roads and bridges, upgrading passenger and freight rail networks, enhancing public transit systems, modernizing airports, and improving ports and waterways. Moreover, the allocation is specifically designed to address safety measures in the transport sector, ensuring the efficiency and resilience of the nation's transportation infrastructure. This stimulus will constitute an annual government spending increase of 35.1% over the 2022-2026 period, compared to the baseline levels.

The Utilities Industry is allocated $202 billion under the IIJA, which will be directed towards clean energy and grid enhancements, water infrastructures, resiliency projects, and environmental remediation. This allocation leads to a substantial annual government spending increase of 79.4% over the five-year 2022-2026 period from the baseline levels. In the Information Industry, the IIJA designates $65 billion to expand broadband infrastructure. Consequently, there will be a remarkable 44.6% annual government spending increase over the 2022-2026 period from the baseline levels. Overall, the IIJA allocates a total of $550 billion to the specified industries over the 2022-2026 period, resulting in a 13.3% of increase in total annual government spending compared to the baseline levels (equivalent to a total 2.55% government spending increase annually).

Table 11. New investment allocation of funds (in $U.S. billion)

Model industry	**Specific provisions on the IIJA**	**Total gross government fixed investment 2021 ($US billion)**	**Total government spending increase over the 2022-26 period ($U.S. billion and % increase*)**	**Annual government spending increase over the 2022-26 period ($U.S. billion and % increase*)**
Transport	Roads and bridges, Passenger and freight rail, Transit, Airports, Ports and waterways, Safety	161.4	283 (75.3%)	56.6 (35.1%)
Utilities	Clean energy and grid, Water infrastructures, Resiliency, Environmental remediation	50.4	200 (300%)	40 (79.4%)
Information	Broadband	30	65 (116%)	13.4 (44.6%)
	Total	827	550 (66.5%)	110 (13.3%)

Source: authors' elaboration based on The White House (2021a), Congressional Budget Office (2018; 2021), U.S. Bureau of Economic Analysis (2023)

* From 2021 (column 3).

The infrastructures that are built in the short term imply a short run increase in the demand for construction. Once they are built, they can be grouped into three main sectors[24]:

[24] Although some sub-items could be classified in other sectors, these correspond to comparatively much smaller amounts.

Transport services ($283 billion for land transport, air transport, water transport, transit), Utilities ($200 billion for energy distribution infrastructures, water, sewage services), and Information services ($67 billion for telecommunications, cable networks, data processing services). Thus, the IIJA will increase the capital stock in these three sectors in the long run.

3. Literature Review

Infrastructure investments play a critical role in driving economic growth, improving productivity, and reducing income disparities. This literature review explores a wide range of research on their macroeconomic effects, with particular attention to their effects for employment and inequality. These are indeed the aspects that have received most attention in previous studies.

Early studies found a positive relationship between infrastructure investments and macroeconomic variables. Aschauer (1989) found that the productivity decline in the U.S. during the 1970s had a strong relationship with the declining rates of public capital investments. This work was later confirmed by other studies (Munnell, 1992; Morrison and Swartz, 1996). However, Tatom (1991) and Holtz-Eakin and Schwartz (1995) challenged these results, using state level panel data and finding no significant correlation between infrastructure and economic growth at a national level. In the early 2000s, Calderón and Servén (2004) conducted a comprehensive empirical evaluation across multiple countries and time periods. Their study highlights the dual benefits of infrastructure investments in promoting both economic growth and inequality reduction. Interestingly, Clarke and Batina (2019) replicated Aschauer study, extending the data until 2015, and found close results.

Recent studies have focused on the specific impacts of infrastructure investments on reducing the wage-employment gap and enhancing sustainable economic growth. Abiad et al. (2016) provide evidence of the positive macroeconomic impact of public investment in advanced economies. The research shows that a 1% of GDP increase in public investment is associated with an average output increase between 2.2% and 2.8% in the long run. They suggest that increasing public infrastructure investment will be particularly effective in providing a stimulus to aggregate demand and expanding productive capacity in the long run, without raising the debt-to-GDP ratio, if it is debt financed rather than under a budget-neutral scenario. Glaeser and Poterba (2021) highlight the transition from labor-intensive public works projects to capital-intensive infrastructure investments. Modern infrastructure projects increasingly require skilled laborers who would likely be employed regardless of the infrastructure investment. This shift limits the short term employment effects of infrastructure policies, as the focus moves towards utilizing advanced machinery rather than employing less skilled workers.

An empirical work carried out by Hooper et al. (2018) used U.S. state-level panel data on infrastructure spending and on per capita income inequality from 1950 to 2010. They found a causal effect from infrastructure spending growth to a reduction inequality through better access to education and employment opportunities. Ding & Liu (2023) conducted empirical research highlighting the significance of allocating investments towards non-motorized transportation infrastructure and upgrading public transit services, which aligns with the objectives of the IIJA. Their findings emphasize the importance of prioritizing these areas for infrastructure development to enhance sustainable and efficient transportation systems.

The impact of major infrastructure investments in the U.S. using Computable General Equilibrium (CGE) models has been relatively understudied. However, valuable insights can be drawn from CGEs applied to other countries, particularly those based on the TERM (The Enormous Regional Model) framework, as we do. Giesecke et al. (2008) conducted a comprehensive analysis of regional government infrastructure provision for Australia, employing a regional CGE model based on the TERM framework. They captured the linkages between infrastructure investments and regional economies. The study examined the effects of alternative financing methods, such as debt or taxation, on regional economic outcomes. The findings revealed diverse impacts of different financing strategies on infrastructure provision and regional economic performance, highlighting the importance of considering financing options when implementing infrastructure-related policies. In a similar vein, Horridge & Wittwer (2008) developed a tailored version of the TERM model, known as SinoTERM, to estimate the economic impacts of a specific construction project in the Chinese economy. The study assessed the effects of the construction project on key macroeconomic variables, including output, employment, exports and imports, among others. The results demonstrated positive economic outcomes associated with the construction project, indicating the potential benefits of infrastructure investments in stimulating economic growth and generating employment opportunities. These examples showcase the applicability of the TERM model in quantifying the economic impacts of infrastructure projects, providing insights for policymakers and researchers.

Upon concluding this review, substantial evidence emerges demonstrating the favorable macroeconomic effects of infrastructure investments. Nevertheless, a critical void in the existing literature pertains to the scarcity of studies based on Computable General Equilibrium (CGE) models to analyze these effects in the U.S. context. As noted above, the advantage of this methodology is that it allows estimating both numerous macro and microeconomic results stemming from the policy analyzed, using a unique model. These insights should be helpful in guiding policymakers to make informed decisions on effective infrastructure policies.

4. Methodology

5.1. Model and calibration

This study uses the United States static version of The Enormous Regional Model (TERM), known as the TERM-USA, which is a Computable General Equilibrium (CGE) model. CGEs are based on mathematical equations that capture the interactions between the macro and microeconomic levels (Latorre 2012; Latorre et al., 2020a). They incorporate real data into a rigorous theoretical framework and present the relationships among economic agents as a system of equations derived from microeconomic optimization theory and cover the behavior of households, firms and government in the economy. Resting on the usual progression of the circular flow of the economy (production, income distribution and domestic and foreign demand), CGEs describe the equilibrium conditions in goods, factor markets and in the foreign sector. Moreover, they are flexible tools able to take into account many economic sectors considering the linkages among them and assess which of them benefit or would be negatively affected after a policy shock. Appendix III provides a detailed description of the TERM model.

The TERM framework was originally developed for the Australian economy (Horridge, 2012), and builds on the ORANI model (Dixon et al., 1982). Its database follows a bottom-up strategy, meaning that regional results sum up to obtain the national results. All the initial values for micro and macroeconomic variables in the model come from detailed official and regional statistics. The specific version of the TERM-USA used in this study divides the U.S. economy into 11 regions, 26 sectors and 10 occupations. Its original database (Centre of Policy Studies, 2013) was calibrated to 2019[25] levels using the TERMSCAL program[26] (Center for Policy Studies, 2019).

Static CGE models produce results that come from the comparison of a baseline scenario with the policy scenario (after 1 or 5 years if short or long run, respectively). In other words, in the initial year we assume the economy is in equilibrium. We then introduce the policy shock, and the model is solved following an optimizing behavior (utility maximization and cost minimization approach) to achieve a new equilibrium. In this process, parameters,

[25] As of March 2022 (when the database was updated), the latest available data for all the main macroeconomic variables (Bureau of Economic Analysis) and for government spending (U.S. Census Bureau) corresponded to 2020 (U.S. Census Bureau, 2021). The reader may observe that government spending did not follow the previous trend due to the Covid-19 pandemic outbreak. Therefore, we consider 2019 to be a more realistic base year for our shock estimations.

[26] This program rebalances the entire database by setting target values for several variables such as GDP or employment.

elasticity values and initial values feeding the equations of a CGE model are important to assess the impact of a policy simulation.

The calibration process involves calculating quantities, normalized prices, and the shift and share parameters utilized in the production and utility functions within the TERM-USA model. The purpose of the calibration procedure is to ensure that the solution to the model equations accurately reproduces the initial equilibrium, as reported in the base data. Given the balance conditions in input-output data, we can be sure that the quantities and prices derived in this way are compatible with demand/supply equality and zero pure profits (Dixon et al., 2013). Regarding the equations derived from utility maximization and cost minimization, they are fulfilled by setting prices equal to one and adjusting the resulting quantities based on input-output data through parameter calibration or the inclusion of shift variables.

A set of elasticity parameters were employed, including the elasticities of substitution between domestic and imported sources of commodities (known as Armington elasticities), elasticities of substitution between primary factors, export demand elasticities, and the elasticity of substitution between importing origins. The elasticity values used in our analysis come from the renowned GTAP 10 Data Base (Aguiar et al., 2019), which has been tailored to match the 26 sectors defined in our study[27]. This, together with database weights derived directly from the variables initial values, ensures the data's accuracy and relevance for our specific research context. Additionally, in order to account for potential existence of inaccurate values of certain parameters, we conduct a sensitivity analysis[28].

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[27] We provide further information on specific elasticities when explaining the simulations and results obtained.

[28] See section 7. Sensitivity analysis

The latter confirms that our results are robust to changes in the elasticities and in other assumptions.

5.2. Simulations design

From a theoretical point of view, due to nonrivalry in consumption and/or non-excludability in use, the private sector will tend to underprovide infrastructure capital. On the other hand, investment[29] affects aggregate demand in the short run and the capital stock in the long run. The short-term effects represent the construction phase, in which the stimulus is based on a government demand increase for construction and results show the effects after one year (in 2023). The long-term effects are those during the operational phase, i.e., after 2026. At this point in time, it is assumed that the infrastructures are fully functional and increase physical capital in Utilities, Transport services and Information services sectors. In the long run the increase in government demand ceases but its effects work through a larger and better infrastructure.

Bearing in mind that we are dealing with public investment our simulations exogenously increase the size of this variable in the short run and the amount of capital available for production in the long run within our CGE model. Our methodology, therefore, does not model investment endogenously responding to the determinants identified or emphasized

[29] To be precise "investment" corresponds to the national accounts concept of "aggregate fixed capital formation". The Bureau of Transportation Statistics defines capital expenditure as any expenditure that adds to the productive capacity of the economy, i.e., includes construction and reconstruction/rehabilitation/restoration of existing infrastructures except for routine maintenance expenditures.

in different investment theories[30]. Additionally, as is customary in CGE approaches, our model does not include the financial markets, nor explicitly the direct effects of interest rates. What we model is that public investment entails an important upfront cost and two alternative ways of financing it (foreign versus national savings). Only in the long run adjustment of the economy we allow the capital stock to reach its long run equilibrium except for the three sectors (Transport services, Utilities and Information services), in which we exogenously increase the capital stock (see below). The capital stock adjusts to maintain fixed rates of return.

We assume that under national borrowing, the government is simultaneously financing public investment through an effective reduction in private consumption and national investment[31]. If the borrowing comes from the domestic financial market, the increased demand for loans may lead to a crowding out effect, resulting in a reduction of private consumption and investment. In a way, this national borrowing can be seen as paying back the debt in the short run in a more evenly distributed manner, without accumulating an important amount of debt to be paid suddenly in the long run. By contrast, our foreign borrowing simulations assume that financing the investment does not affect national savings in the short run. However, in the long run all the accumulated debt must be paid back. Foreign borrowing involves engaging in bilateral long-term borrowing. All in all, we are comparing the impact of different debt maturity periods, with foreign borrowing being

[30] Among the determinants emphasized by the theories there are: Firms' profits ("internal funds theory"), firms' output ("accelerator theory"), output levels together with user cost of capital ("neoclassical theory"), the relationship between the market value of new additional investment to its replacement cost ("Tobin's Q theory"), rational expectations, risks, etc. A classical analysis of investment theories is the one by Caballero (1999).

[31] In the real world this can happen through several means such as through higher taxes, reductions in government transfers or other fiscal austerity measures. These precise details are not explicitly modelled in our CGE.

a proxy for long run maturity (i.e., the accumulated debt is paid back in the long run), while national borrowing is a proxy for short debt maturity (i.e., the debt is paid back in the short run).

Our modelling framework grasps a mix of Keynesian and neoclassical elements of the theories of investment at the macroeconomic level. On the one hand, the model captures the neoclassical feature that public investment raises the marginal product of both private capital and labor, thus incentivizing firms to invest more in capital and hire more labor in the long run. On the other hand, we leave room for a certain Keynesian short run stimulus of investment, assuming that wages are fixed and there are income multipliers[32].

We define shocks on a percentage change basis (2019 as base year), using an estimated distribution of funds across U.S. states[33] (see Appendix II). For the short run simulations, we run a government spending increase in the Construction sector, following the information available on the IIJA. Considering the $550 billion in new investments are distributed equally between 2022 and 2026, government spending increases in one year by 2.55% from initial levels ($110 billion each year). We assume an equal yearly distribution of funds of the IIJA because we focus on broader implications of the IIJA, rather than getting too granular with specific year-to-year fluctuations. This approach allows for a more holistic understanding of the potential impacts of major infrastructure investments in the short run. Moreover, this is a common approach in CGE modelling when analyzing infrastructure to simplify the numbers introduced in the simulations while maintaining the overall magnitude of the policies (Horridge & Wittwer, 2008; Mostert & van Heerden, 2015).

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[32] For a more detailed analysis of public investment theories see Ramey (2020).

[33] Calculations are determined by statute and subject to potential variations over time, while estimates are based on prior legislation that could also vary over time.

Ensuring the solvability of a model requires that the number of equations matches the number of variables to be solved. To achieve this, before conducting a specific simulation we determine which variables will be held constant and which will be solved, which is referred to as the model closure. It is through the model closure that we distinguish between the short and long term and between the two financing scenarios.

Table 12 summarizes the four simulations contemplated in this study, which are defined over two dimensions: temporal (short and long run) and financing source (national or foreign borrowing). Thus, it shows 4 columns of results, i.e., two financing options for the short run and two for the long run.

Table 12. Definition of simulation scenarios. Model closures.

Macro variables	Foreign borrowing		National borrowing	
	Short run	**Long run**	**Short run**	**Long run**
Fixed	Private consumption National investment Real wages Capital stock	Private consumption National investment Aggregate employment	Balance of trade as a share of GDP Real wages Capital stock	Balance of trade as a share of GDP Aggregate employment
Variable	Aggregate employment	Real wages Capital stock*	Private consumption National investment Aggregate employment	Private consumption National investment Real wages Capital stock*

Source: authors' elaboration.

Notes: the model incorporates thousands of variables, by default defined as fixed/variable in the model. The variables shown in the table represent the ones that have been modified to better represent each scenario. Because the labor market serves as primary driver of much of the activity in each region, in all scenarios we make regional consumption follow regional wage income.

*Variable in all industries except the ones shocked in the simulations.

We start by explaining the short and long run differences in the closures. In the short run (i.e., after the first year) the economy's production response to an external shock is limited, and investment flows are not yet transformed into capital stocks. Therefore, we keep capital stocks fixed, while we allow the rental price of capital to vary. It is also assumed that wages are unable to vary, whereas employment adjusts to meet the demand increase stemming from the higher public investment (real wage remains exogenous while we allow employment to vary).

The long run simulations consider the allocation of the $550 billion towards new public spending and are grounded on three key premises: the stimulus from investments leads to an increase in capital stocks, output productivity improves, and employment returns to its initial levels. Capital stocks in all industries are now determined endogenously, except for the Utilities, Transport services and Information services industries. We exogenously increase the capital stock in these three latter industries, based on allocation of funds shown in Table 11. This treatment of capital stock is different in dynamic CGE models, as we will see in the next chapter. Unlike static CGE models where capital stocks are fixed or predetermined (as we do in the simulation), dynamic CGE models allow capital stocks to vary over time, capturing the effects of investments and economic policies on capital accumulation and economic growth across multiple periods.

Regarding output productivity, a meta study by Bom & Ligthart (2014) aggregated almost three decades of studies on measuring the private output elasticity of public capital. They found a long run output elasticity of public capital supplied at the central government level of 0.122. Based on this finding, we apply that elasticity to increase productivity in the Transport services, Information services and Utilities industries considering capital stock increase in each industry. Differently from the short run closure rules, in the long run we assume employment returns to initial levels, while national real wages adjust to labor market conditions.

5. Macroeconomic results

Table 13 shows the short and long run results for the main macroeconomic variables under each financing scenario. All the variables are expressed in real terms and in percentage change with respect to the initial data. As mentioned previously, the short run simulations are based on a government demand increase for Construction (which corresponds to a total government spending increase of 2.55%). In the long run simulations capital stocks are exogenously increased in the affected industries (Transport, Utilities and Information) based on the distribution of funds shown in Table 11, but we allow the capital stock to vary in the rest of the industries.

Table 13. Impact on macroeconomic variables (% change with respect to initial levels)

Macro variables	Foreign borrowing		National borrowing	
	Short run	Long run	Short run	Long run
Private consumption	0.00	0.00	-0.17	1.44
National investment	0.00	0.00	-0.35	0.56
Government consumption	2.55	4.00	2.55	1.46
Exports	-0.72	6.64	0.02	1.35
Imports	0.61	-2.47	0.12	0.70
Real GDP	0.22	1.19	0.19	1.39
Aggregate Employment	0.43	0.00	0.38	0.00
Real wage	0.00	2.75	0.00	3.94
Aggregate Capital Stock	0.00	2.11	0.00	2.52
GDP Price Index	0.65	-3.91	0.12	-0.64
Export Price Index	0.36	-3.16	-0.01	-0.67

Source: authors' estimations.

Notes: results are expressed in real percentage changes from initial levels.

Under the foreign borrowing scenario, it is assumed that borrowing is available immediately for public spending without affecting domestic consumption and investment decisions. When the government implements foreign borrowing measures to fund its investments, the increase in government demand raises prices and imports become relatively more attractive. The balance of trade (as a share of GDP) deteriorates in the short run due to an increase in imports (0.61%) and a decline in exports (-0.72%). This is partly attributed to an increase in the export price index (0.36%), but also to the specific characteristics of the U.S. economy[34]. An analogous short run macroeconomic adjustment was experienced during the Global Financial Crisis, in which the domestic increase of construction investment generated a negative effect on the trade balance (Levchenko et al., 2010). Regarding GDP, it sees a growth of 0.22%, driven by the increase in government consumption (i.e., the increase in public investment), which increases economic activity and creates job opportunities. The 0.43% aggregate employment increase (approximately 680,000 jobs per year) falls short of the White House (2021d) projection of 2 million jobs annually over the next decade. However, our results are in line with early estimations carried out by external agencies, who projected employment increases ranging from 420,000 to 800,000 new jobs created (Kane, 2022).

The competitiveness loss observed in the short run is reversed in the long run as the initial deficit increase needs to be financed, and infrastructure investments contribute to the growth of the capital stock. Consequently, in the long run, imports decrease by 2.47% while exports increase by 6.64%, resulting in an overall reduction of the trade deficit by $41.7 billion compared to initial levels. This indicates improved competitiveness in the international market, bolstering export-oriented industries (i.e., goods' industries), such as Machinery or Transportation Equipment, which increase output in the long run by 2.83%

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[34] Makin and Ratnasiri (2022) examine the effect of expenditure shocks on trade balances in deficit-prone advances economies, including the U.S. They provide strong evidence that changes in domestic expenditure, such as increased government spending, primarily influence the trade deficit rather than GDP in these economies. They suggest that an increase in domestic expenditure in the U.S. leads to higher imports and spending on goods and services that would have otherwise been exported. Consequently, this leads to a widening of the trade deficit.

and 1.57% respectively[35]. The increase in capital stocks and productivity enhances the productive capacity of the economy, leading to a 1.19% rise in GDP. Workers benefit from the increased capital available for production, which makes them more productive and, in turn, leads to a 2.76% increase in wages.

Under national borrowing, exports and imports maintain the baseline balance of trade as share of GDP, i.e., export and import variations follow the GDP increase and not the shocks. Real GDP sees a growth of 0.19%, and aggregate employment increases by 0.38% (approximately 600,000 jobs). The increase in real GDP and employment is slightly lower than in the foreign borrowing scenario. Foreign borrowing provides slightly higher short run impacts on GDP and employment than national borrowing due to the immediate increased expenses funded from abroad. Even though the difference is relatively small, the macroeconomic adjustment is completely different. Under national borrowing the government competes with private borrowers for available funds in capital markets. It discourages private investment and reduces private consumption. The effects are similar as if the government raises interest rates on government bonds to attract investors[36]. With private consumption being a vital driver of the nation's economic activity any reduction in consumer spending due to concerns about future taxes from increased government borrowing can have broader implications for the overall economic performance.

[35] These output results appear in Table 14 below in which it is evident that there is an export push for agriculture and manufactures.

[36] As explained above, this mechanism is not explicitly modelled in TERM, which does not include interest rates. But the outcomes are consistent with the idea that an increase in government spending which is funded with domestic savings reduces investment and/or private consumption. This effect is particularly significant in the U.S., where private consumption constitutes a substantial portion of the GDP (68%), while it tends to be closer to 60% in other advanced economies.

With national borrowing, in the long run there is no debt to be repaid, in contrast to the case of foreign borrowing. In both cases, national borrowing leads to an expansionary trend driven by a larger capital stock and productivity increases, which in turn boosts consumption and investment. However, with national borrowing the expansionary trend is larger than with foreign borrowing. This contrasts with the impact in the short run, in which the sacrifices in consumption and investment necessary to nationally finance the increase in government spending slightly reduce the positive impact of national borrowing.

We compare our results with two relevant analyses, which used an econometric methodology. Both studies offer valuable insights but have a different scope. Although macro-econometric models and CGEs are both based on a core input-output structure and on a national accounting framework, they offer a different approach to phenomena. Macro-econometric models do not include optimizing behavior as they are based on uncertainty conditions (Pollitt et al., 2019; Latorre et al., 2020b). Unlike econometric models, in which parameters are based on time-series data, CGE's are based on microeconomic behavioral equations that capture the links between the different agents in an economy.

The results provided by Zandi & Yaros (2021) are shown as an add-on to the American Rescue Plan (ARP) (The White House, 2021c), comparing a scenario in which only ARP is contemplated with a scenario in which ARP and IIJA are combined. Therefore, it makes it challenging to attribute outcomes solely to the IIJA as our analysis does[37]. The study carried out by Bonakdarpour et al. (2021) only considers the highway, bridge and public transit spending provisions included in the IIJA. In contrast, our analysis directly assesses the impact of all the expenses contained in the IIJA.

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[37] The only change we introduce in our simulations is the shock related to the IIJA while the rest of parameters and variables remain the same. Therefore, the results only reflect changes arising from the policy shock.

6. Sectoral and distributional impact

Job creation, and specifically jobs in the manufacturing sectors, is an important target of the IIJA investments, and it is mentioned several times by the White House (2021a). Our model allows us to provide a rich set of estimates across different types of workers and identify whether Biden's act would help to counteract inequality issues that have been identified in the U.S. economy (Lawrence, 2023; Lawrence, 2015).

Table 14 provides the evolution of production and employment across sectors and Table 15 presents the impact on the distribution of workers and wages across occupations. In both cases we consider the short and long run impacts of both national and foreign borrowing. Analyzing the effects for sectoral output and employment is important to understand the impact across worker categories[38].

Tables 14 and 15 show that the plan unleashes a general expansion of both employment (short run) and wages (long run) across the majority of workers' categories, with only a few exceptions remaining nearly unaffected. In the short run, the evolution of job creation is very similar under both national and foreign borrowing. Following the increase in government investment demand, most of the initial impact concentrates in the constructions sector. As is well known, this sector has significant spillover effects. Thus, the process unleashes strong spillover effects on other sectors primarily in manufacturing. Employment goes in parallel with production.

[38] An interesting possible extension of this analysis is to study the differential impact of the IIJA across U.S. regions. Appendix II shows that government spending allocation varies depending on the regions and is based on the CNBC (2021) and U.S. Census Bureau (2021), so regional outcomes will necessarily be different.

Table 14. Impact on sectoral production and employment

(% change with respect to initial levels)

Sector	Foreign borrowing				National borrowing			
	Short run		Long run		Short run		Long run	
	Prod.	Empl.	Prod.	Empl.	Prod.	Empl.	Prod.	Empl.
Total Agriculture	**-0.03**	**-0.11**	**1.09**	**0.64**	**0.01**	**0.03**	**0.87**	**-0.31**
Crops	-0.03	-0.23	1.03	0.32	-0.01	-0.09	0.95	-0.35
Livestock	-0.02	-0.24	0.35	-0.48	-0.03	-0.40	0.99	-0.30
Forestry & Fishery products	-0.01	-0.02	1.64	1.05	0.10	0.18	0.45	-0.27
Total Manufacturing	**0.93**	**1.76**	**2.09**	**0.64**	**0.91**	**1.88**	**1.56**	**-0.06**
Energy minerals	-0.01	-0.08	6.24	5.56	0.02	0.11	4.34	2.76
Other mining	0.44	1.38	2.61	2.17	0.48	1.52	1.28	0.14
Utilities	0.01	0.07	8.77	-3.05	-0.01	-0.05	9.08	-2.14
Construction	3.66	6.52	-0.74	-0.85	3.34	5.94	0.37	-0.33
Food, Drinks, Tobacco	-0.09	-0.18	0.49	-0.30	-0.11	-0.21	0.97	0.27
Fabrics, textiles, clothing	-0.18	-0.29	1.48	0.73	-0.09	-0.15	1.20	0.60
Wood products, paper	0.15	0.26	1.38	0.67	0.22	0.39	0.80	0.15
Petroleum & Chemicals	0.00	-0.01	1.78	0.68	0.04	0.16	1.11	-0.01
Rubber & Plastic	0.13	0.28	1.73	1.08	0.23	0.49	0.73	0.07
Non-metallic mineral products n.e.c.	0.84	1.96	1.19	0.42	0.85	1.97	0.96	0.16
Metal products	0.16	0.30	2.77	1.88	0.35	0.64	0.72	-0.02
Machinery & Equipment n.e.c.	-0.08	-0.11	2.83	2.47	0.15	0.20	0.50	0.09
Transportation equipment	0.10	0.14	1.57	1.00	0.21	0.29	0.34	-0.17
Miscellaneous manufacturing	-0.10	-0.19	1.43	0.79	-0.04	-0.07	0.66	-0.06
Total Services	**0.03**	**0.07**	**0.74**	**-0.16**	**0.01**	**0.02**	**1.14**	**0.02**
Trade services	0.13	0.22	0.49	0.07	0.04	0.07	0.90	0.29
Transport services	0.07	0.12	2.77	-1.96	0.10	0.17	2.36	-2.61
Information services	0.04	0.12	5.18	-5.67	0.00	0.01	5.19	-5.66
Business & Professional services	0.06	0.10	1.09	0.55	0.07	0.12	0.74	-0.06
Education	-0.02	-0.03	-0.18	-0.30	-0.15	-0.18	0.58	0.37
Health & Social services	-0.01	-0.01	-0.50	-0.64	-0.16	-0.22	0.35	-0.14
Other services	-0.07	-0.10	1.34	1.00	-0.04	-0.07	1.06	0.56
Government & Defence	0.00	0.00	-0.08	-0.12	0.00	0.00	1.23	1.12
Owner-occupied dwellings	0.00	0.05	-0.61	-1.27	0.00	-0.13	0.74	-0.25
Total	**0.22**	**0.43**	**1.18**	**0.00**	**0.19**	**0.38**	**1.39**	**0.00**

Source: authors' estimations.

Notes: results are expressed in percentage change from initial levels.

In the long run, the differences in the financing method are more important than in the short run. In this phase, the economy moves to its long run equilibrium and restores the natural level of employment. However, employment is flexible across sectors. Consequently, although the net result of long-term employment is zero, at the sectoral level, the workforce experiences increases or reductions. Under foreign borrowing most of the jobs are created in manufacturing and agricultural sectors, while with national borrowing these sectors slightly reduce jobs that are created in services.

Recall that under foreign borrowing in the long run the debt has to be paid back. Thus, national demand is sluggish, and the evolution of prices favors a boost in export competitiveness. Consequently, goods sectors (agriculture and manufactures) increase their output and employment. Additionally, through foreign borrowing there is a reduction in output in the construction sector that is absent with national borrowing. With the latter, there is no need to pay back the accumulated amount of debt. Growing (private and public) consumption and investment increase aggregate with less favorable prices and export evolution than in the foreign borrowing case. This explains worse outcomes for agriculture and manufactures. However, with national borrowing there is no reduction in the output of construction and a stronger overall output increase is experienced (see the "Total" in the last row of Table 14, 1.39% with national borrowing compared to 1.18% with foreign borrowing). The positive impact of this stronger push for overall production in the economy will be more evident in the stronger increases in wages that result from it (presented in Table 15 below). Wages do experience considerably stronger increases in the long run under national borrowing than under foreign borrowing.

Employment mirrors the production trends in all sectors, except those directly impacted by the IIJA in the long run. In these specific sectors (Utilities, Transport services, and Information services), the outcomes manifest an opposing pattern, leading to reductions in employment.

There are several reasons behind these particular results in the long run. Firstly, following the strong capital stock increases in the IIJA sectors in the long run, the rental rate of capital in these sectors decreases significantly. This fall in the rental rate of capital relative to wages drives a decline in employment demand in these sectors in line with the literature analyzing the effects of increases in capital stocks (e.g., Zhou and Latorre, 2021 and Gomez-Plana and Latorre, 2019). Secondly, these results are intensified by the fact that these three industries increase their output productivity. Therefore, the exogenous capital stock increase is followed by a reduction in demand for labor.

Table 16 reveals the actual unequal relationship between the shares of workers (column 1) and wages (column 2). Skilled workers represent 35.3% of the total workforce but receive 53.4% of the total wage, while unskilled workers constitute 64.7% of the workforce but account for only 46.6% of the total compensation[39]. This disparity emphasizes the need to investigate how infrastructure investments can influence these dynamics.

As already noted, in the short run, the increase in government spending causes a rise in the demand in the sector of construction (Table 14). Output (employment) in this sector rises by 3.66% (6.52%) and 3.34% (5.94%) under foreign and national borrowing, respectively. Construction workers account for the 63.6%[40] of the total labor in this industry, and therefore it is the occupation that benefits the most (with 4.19% and 3.84% job increases under foreign and national borrowing, respectively). Additionally, Craft and related trade

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[39] The TERM-USA model incorporates the proportions of the labor force and labor income for different industries relying on the statistics behind the input-output tables that underlie the model database. This implies that the model captures the composition of the labor force by considering wage remunerations across different occupations and industries (as in input-output tables). For our estimations we have updated the information on wage remunerations and used the number of jobs behind those occupations, using Bureau of Labor Statistics information for year 2019 to make it compatible with the rest of data underlying the model (U.S. Bureau of Labor Statistics, 2020).

[40] Data not included in the table.

workers experience an employment increase of over 0.74% (foreign borrowing) or 0.68% (national borrowing), largely due to the spillover effects of the construction industry.

The IIJA would also benefit wages across all occupations in the long run, no matter how it is financed. Under foreign borrowing, there are larger wage increases for unskilled occupations than for skilled ones. The reason for this is that under foreign borrowing the construction sector and a few services sectors would contract, following stagnant private consumption and private investment in the economy. The latter translates in uneven increases in wages across occupations.

By contrast, with national borrowing there is no need to pay back an accumulated amount of debt. Consequently, the economy receives a larger stimulus with national borrowing than with foreign borrowing in the long run and no output reductions in the sector of construction appear (in contrast with foreign financing of the IIJA). This stronger output expansion with national borrowing explains (Table 14) why wage increases tend to be larger and more evenly distributed among all occupations than under national borrowing (Table 15).

Table 15. Initial share of total wage remuneration by skill level and impact on jobs (Short run) and wages (Long run) by occupation and skill level under the two simulation scenarios

(% share and % change with respect to initial levels)

Skill level	Occupation	1. Initial share of total workers by skill	2. Initial share of total wage remuneration by skill level	Foreign borrowing						National borrowing					
				Short run (jobs)			Long run (wages)			Short run (jobs)			Long run (wages)		
				3. Occupation level	4. Skill level	5. New share of total workers	6. Occupation level	7. Skill level	8. New share of total wage remuneration	9. Occupation level	10. Skill level	11. New share of total workers	12. Occupation level	13. Skill level	14. New share of total wage remuneration
Skilled	Managers	35.3	53.4	0.40	0.20	35.2	2.97	2.21	53.2	0.38	0.17	35.2	4.19	3.94	53.4
	Professionals			0.06			1.65			0.01			3.77		
Unskilled	Construction	64.7	46.6	4.19	0.52	64.8	1.36	2.99	46.8	3.84	0.47	64.8	4.08	3.94	46.6
	Craft & related trade			0.74			1.76			0.68			2.83		
	Sales			0.13			3.61			0.09			4.14		
	Office workers			0.23			2.35			0.19			4.00		
	Transport			0.27			1.92			0.27			1.82		
	Production			0.15			7.00			0.28			3.88		
	Agricultural & fishery			-0.05			4.64			0.04			3.91		
	Service			0.01			1.64			-0.06			6.16		
	Total	**100.00**	**100.00**	**0.43**		**100.00**	**2.76**		**100.0**	**0.38**		**100.00**	**3.94**		**100.0**

Source: authors' estimations.

Notes: results are expressed in percentage change from initial levels.

We now deepen into the impact that this plan would have on workers by income level deciles[41]. Table 16 shows the percentage of total remuneration for each decile in the baseline (second column), while the following columns show the share in the long term under each scenario. Currently, the top 10% of workers (i.e., the 10th decile) earns 17.8% of total compensation, while the lowest decile earns only 5.7%.

Table 16. Long run impact on the shares and cumulative shares of total wage remuneration by decile of annual average wage (%)

Decile	Share of total wage remuneration		
	Baseline	**Foreign borrowing (long run)**	**National borrowing (long run)**
0-10	5.7%	5.7%	**5.9%**
10-20	6.2%	6.2%	**6.3%**
20-30	7.0%	**7.1%**	**6.9%**
30-40	7.3%	7.3%	**7.2%**
40-50	7.6%	7.6%	7.6%
50-60	8.3%	**8.4%**	**8.2%**
60-70	11.6%	11.5%	11.6%
70-80	13.5%	**13.4%**	13.5%
80-90	15.0%	**14.9%**	15.0%
90-100	17.8%	17.8%	17.8%
-	100.0%	100.0%	100.0%

Source: authors' estimations.

Notes: Deciles are defined by the percentage of workers. Results in green (red) indicate an increase (decrease) from the initial share of total wage remuneration.

The analysis reveals a very small impact on the distribution across deciles. Nevertheless, as we have just seen (Tables 14 and 15), most workers will be better off after the IIJA, since they experience wage increases (in the long run) and more jobs will be created (in

[41] Sorted from lowest to highest average annual wage, i.e., the 1st decile corresponds to workers with the lowest wage.

the short run). Thus, we should bear in mind that the overall amount of labor remuneration has been increased, and the total remuneration distributed across workers is larger than before.

Table 16 also shows that under national borrowing the wage share of the poorest deciles (1st and 2nd) increases slightly[42]. Similarly, under foreign borrowing there are slight decreases in the income of the richest deciles (9th and 10th). This means that the impact of the package goes in the right direction. However, the investment is not large enough so as to profoundly transform the deciles distribution.

Tables 15 and 16 also indicate that wages increase more under national borrowing, which makes it more desirable for most categories of workers. This should lead us to conclude that national borrowing benefits more workers than foreign borrowing in the long run[43]. However, in the short run, there is a slightly higher job creation with foreign borrowing than with national borrowing (see the "Total" in the last row of Table 14, 0.43% versus 0.38% respectively).

We finally analyze the impact on the income of factors labor, capital and land (Table 17)[44]. Under both scenarios there is a slightly increase in the share of labor income, at the cost of capital income (with land income remaining unaffected). Our results are a real example of what Lawrence (2015) highlights related to the substitution elasticity between capital and labor: "paradoxically, with a substitution elasticity under one, policies that increase investment and the supply of capital could achieve more equal

[42] However, this comes at a cost for the shares of some intermediate workers in total labor remuneration (3rd, 4th and 6th deciles), which go down slightly.

[43] Only the wages of workers in production (Plant and machine operators and assemblers) benefit considerably more with foreign borrowing than with national borrowing, but they only represent 2.5% of the labor force.

[44] In certain analyses, land is directly incorporated into capital. However, we have separated it from capital in the present one, given its distinct nature.

distributions of income." This is paradoxical because an elasticity below 1 indicates a small capacity to substitute between workers and capital. Therefore, no big changes in their shares in GDP should be expected. All in all, this plan would help to change the U.S. declining trend of the labor-capital ratio, although only slightly.

Table 17. Long run impact on primary factor income shares

Scenario	Labor	Capital	Land	Total
Initial data	54.38%	45.47%	0.15%	100%
Foreign borrowing (long run)	**55.33%**	**44.52%**	0.15%	100%
National borrowing (long run)	**55.52%**	**44.33%**	0.15%	100%

Source: authors' estimations.

Notes: Results in green (red) indicate an increase (decrease) from the initial share.

Both our analysis of deciles and of the shares of primary factors in GDP lead us to conclude that the stimulus provided by the IIJA goes in the right direction but is not large enough to generate a strong push for a more equitable wage distribution.

7. Sensitivity analysis

We carry out a sensitivity analysis to check the robustness of our results following the approach of Latorre et al. (2020b) and Latorre (2012). To do so, we double and halve the values of several elasticities (primary factor substitution elasticity, skill type substitution elasticity and domestic/imported Armington substitution elasticity), as well as the value of increase in the output productivity. Table 18 shows how the effects for GDP and labor (wages or employment) of the IIJA are affected by each parameter. We change parameters one by one, while we keep all the others unchanged. Additionally, we run a long run sensitivity analysis in which we isolate the IIJA, i.e., without the long run endogenous capital adjustment (see last row). This implies we keep fixed the capital stock in all industries, except the ones directly affected by the IIJA (Utilities, Transport, Information). The latter do experience the capital stock increases explained above. We run this shock because in the last decades capital stock increases have been scarce and the long run endogenous capital adjustment may not take place in a mature economy like the U.S.

Table 18. Sensitivity analysis: impact of the IIJA on the U.S.

	Foreign borrowing				National borrowing			
	Short run		Long run		Short run		Long run	
	GDP	Employment	GDP	Wages	GDP	Employment	GDP	Wages
Base results	0.22	0.43	1.18	2.76	0.19	0.38	1.39	3.94
CES substitution, primary factors (σ_P)								
σ_P * 2	0.25	0.48	1.28	1.63	0.23	0.46	1.61	2.42
σ_P * 0.5	0.19	0.36	1.02	4.10	0.15	0.3	1.17	5.08
CES substitution between skill types (σ_L)								
σ_L * 2	0.22	0.43	1.19	2.81	0.19	0.38	1.38	3.90
σ_L * 0.5	0.22	0.43	1.18	2.69	0.19	0.38	1.40	4.02
Armington Substitution between dom/imp (σ_{ei})								
σ_{di} * 2	0.21	0.41	1.24	2.99	0.19	0.38	1.39	3.94
σ_{di} * 0.5	0.22	0.44	1.14	2.55	0.19	0.39	1.38	3.90
Output productivity (atot)								
atot * 2			1.46	3.17			1.72	4.67
atot * 0.5			1.04	2.56			1.22	3.58
IIJA in isolation (no endogenous long run capital adjustment)			0.74	2.01			0.74	2.19

Source: authors' estimations.

The first row of Table 18 presents the impacts described above. Regarding short run results, GDP increases are quite robust for any elasticity. Short run outcomes are nearly the same except for the primary factors' elasticity, whose impact is slightly larger. This is the parameter that has the strongest interdependence with GDP and labor results. Long run results show slightly higher differences and due to the same parameter (primary factors elasticity), but small enough to continue to demonstrate that GDP and wages will always go up vigorously. Our shock is an expansionary one and it creates new jobs in the short run or increases wages in the long run. When the elasticity of substitution between primary factors is larger (lower), and labor and capital are more (less) substitutable than in the reference scenario, more jobs are created after the increase in demand in construction. In the long run, with a larger (lower) elasticity the wages increase, which are necessary to move workers across sectors, are lower (larger) after the increase in the capital stock.

Additionally, we perform a sensitivity analysis of the productivity shocks, by doubling and halving the ones introduced in our study. Obviously, larger productivity effects result in much better outcomes for GDP and wages.

Finally, as for the long-term simulations in which we isolate the effect of the Biden plan, the difference with the initial scenario lies in the mobility of the capital stock of those sectors in which we do not exogenously increase it. That is, if the simulation is based only on the exogenous increase in the capital stock in Utilities, Transport and Information, this increase represents approximately a 1% increase in aggregate capital stock, while in the initial results of our analysis the increase is above 2% in both scenarios. The reasons for carrying out this simulation are mainly two: firstly, because in this way we are able to estimate the importance of the sectors in which we introduce the shock (Utilities, Transport and Information) in the results. Secondly, although intuitively/theoretically the capital stock increases in the long run in almost all sectors, in the U.S. the capital stock has not increased significantly in recent years[45] (Bennett et al., 2020). Therefore, it may seem optimistic to increase the capital stock by more than 2% solely due to the IIJA.

In the case of foreign borrowing, although the aggregate increase in capital is halved in this simulation, the increases in GDP and wages remain above 60% from initial results. With this scenario we rule out that the greatest weight of economic growth comes from other sectors that do not benefit from this plan. In the case of national borrowing, we reach the same conclusion although the impact compared to the endogenous mechanism is less intense. In any case, we still derive that this way of financing the plan benefits more the workers than in the case of foreign borrowing.

[45] Real basic infrastructure investment has been between $280 and $320 billion since the early 2000's.

In sum, our sensitivity analysis shows that our previous results are robust to changes in the elasticities and other assumptions. The primary factors elasticity may change the size but not the direction of the adjustment. In the long run, the IIJA considered in isolation brings about important GDP and wage increases for the U.S. economy. The impact could be more sizeable still if the plan results in larger productivity impacts than what has been assumed based on the literature.

8. Conclusions

Our Computable General Equilibrium approach allows us to analyze a comprehensive and consistent set of results within the same modelling exercise. The results suggest that the Infrastructure Investment and Jobs Act (IIJA) will have positive impacts on the U.S. economy, including increased GDP, employment, and wages, regardless of the financing method chosen. However, it also highlights key differences between short- and long-term debt maturity (proxied by foreign and national borrowing, respectively).

Firstly, the short-term effects represent the construction phase, in which the stimulus is based on a government demand increase for construction and results show the approximate effects after one year (in 2023). When the deficit is financed through foreign (national) borrowing in the short run, the initial stimulus raises GDP by 0.22% (0.19%) and employment by 0.43% or approximately 680,000 jobs (0.38% or approximately 600,000 jobs). The increase in government spending is the main force driving these GDP and employment outcomes and the way in which it is financed is not very relevant. Under the foreign borrowing scenario, it is assumed that the funding is available immediately for public spending, without affecting domestic consumption and investment decisions. By contrast, private consumption and private investment are slightly reduced under national borrowing. Thus, foreign borrowing slightly boosts GDP and employment more than national borrowing in the short term. The evolution of output (and job creation, which follows the output pattern) is similar under both financing strategies, since it is the expansion of the construction sector and its significant spillover effects, what drives national and foreign borrowing.

Secondly, in the long term, infrastructures are fully functional, and increase physical capital in Utilities, Transport services and Information services sectors. In the long run the increase in government demand ceases but its effects work through a larger and better infrastructure. The study emphasizes debt service considerations providing evidence of the consequences of the accumulation of long-term debt maturity periods. The main messages for the policy maker are as follows. In the long run the two alternatives to financing yield contrasting results. National borrowing (more evenly distributed short term debt maturity) brings about stronger positive outcomes than the ones of foreign borrowing (accumulation of long-term debt maturity). In the long run under national borrowing, GDP rises by 1.39% and wages rise by more than 3.9%, compared to 1.19% and 2.75% increases in GDP and wages, respectively, under foreign borrowing. What is more, national borrowing causes a stronger boost for production across sectors and wage increases tend to be larger and more evenly distributed across all occupations. By contrast, accumulating significant debt that needs to be repaid in the future can lead to abrupt production adjustments and output contractions and job destruction in some sectors, as observed in the construction sector under foreign borrowing.

Thirdly, an important goal of the IIJA is to promote inclusive economic growth and reduce income inequality. Importantly, we find that the IIJA has the potential to create significant employment and wage opportunities across various sectors, which should not be overlooked. Additionally, we find that changes in the distribution of wages across deciles go in the right direction but are very small. Under national borrowing, the poorest deciles (1st and 2nd) increase their wage shares very slightly, while under foreign borrowing the richest deciles (9 and 10) experience a very mild reduction in their shares. Similarly, under both scenarios there is a very tiny increase in the share of labor income at the cost of capital income in GDP. Again, it is a bit more favorable for workers in the case of national borrowing than foreign borrowing. It seems that the amounts invested are not large enough to profoundly change the income distribution and would have to be complemented with other policies. It remains to be analyzed how other investment spending initiatives in the U.S. such as the Inflation Reduction Act (IRA) affect inequality.

The study provides quantitative evidence and insights for policymakers and government leaders. It can guide government decision-making when considering the timing and short- and long-term economic stimulus associated with different borrowing alternatives. In a nutshell, it suggests that foreign borrowing slightly boosts short term GDP and employment more than national borrowing, due to the increased expenses funded from abroad. However, foreign borrowing also involves distinct macroeconomic and microeconomic adjustments and accumulating debt constrains long term growth and wages. In any case, by prioritizing infrastructure investments and ensuring a sustainable debt repayment plan, governments can effectively stimulate the economy, promote sectoral growth, and enhance the well-being of all workers.

Chapter 6. Challenges in greening the economies: a computable general equilibrium analysis of the Inflation Reduction Act (IRA)

Abstract

We use a dynamic Computable General Equilibrium (CGE) model to analyze the effects of the Inflation Reduction Act on the U.S. Our analysis focuses on the green incentives of this policy, in particular the tax credits for climate-related industries. We identify that on the whole the green investments promoted by this Act have a rather low multiplier (i.e., ratio of the change in GDP to the amount of government incentives provided by the IRA). This indicates that IRA's spending results in less than proportional increases in GDP. However, when we look at the different sectors for which the IRA provides green incentives, the differences in their multipliers are striking. Motor vehicles and Electric Equipment exhibit considerably high multipliers, while Utilities, which receives around 50% of the tax credits, has a very low multiplier. Our analysis, thus, offers particular recommendations on the importance of targeted investments. We also cover other macro and microeconomic effects throughout the 2024-2031 period, running three additional scenarios to estimate the uncapped effect of the tax credits, finding different efficiencies when comparing macro and sectoral results.

1. Introduction

The federal policy measures that the United States (U.S.) has taken in recent years show evidence of a commitment that this country is making towards an energy transition. The Biden administration, following the return to the Paris commitments, has positioned the country as a leader by pledging to achieve a 50% carbon emissions reduction by 2035 and net-zero carbon emissions by 2050, with respect to 2005 levels (The White House, 2021a). In this context, the government signed the 2022 Inflation Reduction Act (IRA), legislation that promotes clean manufacturing production and investment in green energy addressing different areas and sectors of the economy. Among some of the motivations of the law, the U.S. aims to reduce the dependance on external sources of energy and reduce costs in the medium-long run and in turn reduce inflation.

The IRA includes a $457 billion increase in federal funding and represents the third legislative stride in U.S. economic reform since late 2021, after the Infrastructure

Investment and Jobs Act[46] (IIJA) ($550 billion) and the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act[47] of 2022 ($278 billion). The three of them include energy-related investments, with the IRA standing out as the highest clean energy related plan in U.S. history. It allocates $393 billion to this purpose. The remaining amount up to $456 billion corresponds to increased government spending on healthcare through an extension of the Affordable Care Act of $64 billion), while the IIJA and the CHIPS and Science act include approximately $110 billion and $53 billion, respectively.

The bulk of the $393 billion in energy and climate funding from the IRA manifests as tax credits, with corporations expected to be the primary beneficiaries to incentivize private investment in clean energy, transport, and manufacturing. The impact of these tax credits is the main focus of our analysis in this paper. The IRA especially synergizes with the Infrastructure Investment and Jobs Act (IIJA), potentially amplifying federal funding for clean-energy projects to an estimated $370 billion over the 2022-2027 period (Suárez-Cuesta & Latorre, 2023). To offset the augmented spending, the Act introduces measures such as raising the minimum tax on large corporations to 15 percent, imposing a 1 percent excise tax on stock buybacks, and enhancing Internal Revenue Service (IRS) collection efforts, resulting in an initially projected reduction of government deficits by $237 billion over the next decade[48], as estimated by the Congressional Budget Office (2022).

In examining the green provisions of the Inflation Reduction Act's impact on the U.S. economy, several questions arise: (1) how will the IRA affect the economic growth and main macro variables in the next decade? Does it generate jobs? (2) what is going to be the impact at a sectoral level? Is the current allocation across sectors the most efficient?

[46] Signed into law in November, 2021, also known as Bipartisan Infrastructure Law (The White House, 2021b).

[47] Signed into law in August, 2022, also known as CHIPS & Science Act (The White House, 2022).

[48] The CBO initial estimation is the result of the increase in revenues or costs reductions ($694 billion) minus the increase in outlays ($457 billion).

and finally (3) what could be the impact considering an upsurge in demands for tax credits?

To address these questions, we employ a dynamic Computable General Equilibrium (CGE) model of the U.S. economy, namely the USAGE model. We isolate the effects of the green incentives of the Inflation Reduction Act (IRA) throughout the 2024-2031 period and run three policy scenarios. First, we run a scenario in which we consider the Congressional Budget Office (2022) initial estimations regarding the outlays and revenues associated with the IRA. Given the uncapped nature of the production and investment tax credits intended to fund this legislation, we estimate the impact of scenarios in which we double, triple and quintuple the energy-related investments. We estimate the "multiplier effect" of the IRA across the different green sectors considered in the Act throughout the period 2024-2031. In other words, we estimate the ratio of the change in sectoral output to the change in government incentives provided for that particular sector. While a multiplier below one may suggest limited effectiveness in boosting economic activity, it does not automatically imply a reduction in social welfare. Our comprehensive CGE analysis allows us to offer a wide range of results to better put in context the multiplier effects. It also underscores the importance of targeted investments.

The remainder of the paper is structured as follows: Section 2 looks at some of the background and literature about the impact assessment of major climate-related investments. Section 3 describes the CGE methodology and specific model used in this paper. Section 4 details the design of the policy simulation and Section 5 gives an analysis and interpretation of the results obtained. Section 6 concludes the study with a brief overview of the findings and relevant policy implications.

2. Literature review

We analyze the current literature on the impact of government spending on climate-related sectors, avoiding a financial perspective. Moreover, we delve into economic impact analyses on the IRA since it was signed into law.

Marcuse & Gronki (1980) and Sterman (1982) were among the pioneers in analyzing the macroeconomic impact of energy transition in the U.S. through renewable energy technologies. The former use an input-output model combined with an econometric model to explore the consequences of renewable energy financing in the U.S. Counteracting the assumed thinking of that time, they concluded that a transition to solar energy would not lead to a significant increase in employment nor a shift towards manufacturing jobs. Sterman (1982) developed a system dynamic model to assess the effects of government subsidies for energy technologies, in the context of an energy transition from nonrenewable energy sources to renewable energy sources (solar, biomass, hydropower) and nonrenewable energy sources drawing on very large resource bases (shale oil, coal synthetics and nuclear power). This study found that government subsidies were much more effective when applied to the development of backstop energy sources.

Auerbach and Gorodnichenko (2012) empirically analyze the determinants of public spending multipliers in the U.S. They conclude that fiscal multipliers vary depending on the economic environment, finding higher multipliers in climate-related spending compared to other sectors in times of economic crisis. Specifically, they find multipliers around 1.5 in climate-related sectors during recessions compared to 0.5 in economic expansions. The study carried out by Batini et al. (2022) examines the impact of investing in green initiatives and other investments on economic growth considering multiple countries and using panel vector-autoregressive (VAR) models. It estimates output multipliers for spending on clean energy and biodiversity conservation, comparing them with multipliers for non-ecofriendly activities. The study finds that green spending, particularly on carbon-neutral or carbon-sink activities, generates more economic activity (over a dollar) than non-green spending. In categories like renewable versus fossil fuel energy, the multipliers for green spending are about twice as large (ranging from 1.1 to 1.7 for renewable energy investment and 0.4 to 0.7 for fossil fuel energy investment). These results support the idea that efforts to stabilize climate and reverse biodiversity loss align with economic prosperity.

A study carried out by Schreiner and Madlener (2021) examine the multiplier effects of grid infrastructure investments in Germany using a static input-output analysis. In particular, they find that each euro invested in grid infrastructure generates between 1.3 and 1.5 euros of output. However, they also observed adverse multiplier effects on value added, employment and tax revenues. The reasons behind these negative effects lie in the high proportion of materials and technology imported into the country in the process, the temporary short-term shift of employment to construction and the reduction of tax revenues as a consequence of the previous effects. Kristkova et al. (2022) analyze the long-term effects of green investments in the EU using a CGE approach and obtain cumulative GDP multipliers of around 0.6 and 1.1 for mid- and long-term, similar to the ones obtained by Batini et al. (2022).

In terms of fiscal multipliers for green investments in the U.S., Mustea (2015) provides a comparison between recent estimations of fiscal multipliers in the U.S. It emphazises that the literature is unconclusive, as several factors influence the multipliers. The scope is large, as there is a difference between taxes and spending multipliers, between periods of economic recessions or expansions, and between estimating the multiplier in the short, medium or long run.

Previous analyses on the impact of the IRA

Several studies have analyzed the broader macroeconomic effects of the IRA. Zandi et al. (2022) are the first to assess the macroeconomic consequences of the IRA, estimating that the legislation will create approximately 1.5 million jobs by 2030, primarily in the clean energy and manufacturing sectors. Using a structural macroeconomic model, they isolate the effect of the IRA and obtain forecast values for GDP and CPI throughout the 2022-2031 period, obtaining cumulative results of 0.2% and -0.33% by 2031.

The extensive study on the IRA carried out by Bistline et al. (2023) focuses on the fiscal effects of the Act, especially in terms of investments directed towards the clean energy sector, and how these might influence costs and prices within that sector. Although they discuss the broader economic trends brought about by the policy, they do not provide numerical results for macroeconomic variables. However, they note that the impact on key macroeconomic indicators, such as GDP and employment, appears to be minimal.

Rusch et al. (2023) corroborate these findings, emphasizing the positive impact on economic stability. They analyze the macroeconomic effects of the IRA's renewable energy and energy efficiency provisions. Their results indicate a reduction in energy prices in the long run that will reduce inflation. This reduction in energy costs is expected to enhance household disposable income and consumption, further boosting GDP growth on average 0.1 to 0.3 percentage points per year in the 2022-2030 period. In a report from the EU Commission JRC, Barrios et al. (2023) estimate the macroeconomic impact of the climate-related spending under IRA for the EU and the U.S. By using a multiregional CGE model, they obtain a 21.5% investment increase in U.S. green sectors, an output increase for these of 6.5% and a GDP increase of 0.3% (cumulative results). However, the model used is set to one-sector. Sectoral results are wage-weighted estimates of the economy-wide results.

As of the time of writing this paper, we have come across only one comparable study on the impact analysis of the IRA in the U.S. relying on CGE modeling conducted by Foster et al. (2023). They employ a combination of an energy market simulation model, a carbon tax assessment model, and a dynamic Computable General Equilibrium (CGE) model. They demonstrate that energy investments, particularly when coupled with supportive public policies, have a significant impact on modern industrial economies. The results suggest that the IRA could generate an additional 1.5 million jobs in the U.S. by 2030, along with a substantial 37% reduction in greenhouse gas emissions compared to 2005 levels. Moreover, the IRA is projected to decrease overall energy demand by almost 6% between 2021 and 2032, leading to reduced energy costs, increased disposable income, and a notable 0.9% increase in annual GDP to $28.7 trillion by 2030. Differently from our analysis, which considers the uncapped effect of tax credits included in the IRA, Foster et al. (2023) rely exclusively on the CBO estimates published in August 2022. We also derive the impact of those CBO estimates, obtaining much more limited positive outcomes on the U.S. economy. A reason behind the different additional difference with our study is their definition of the baseline scenario for running the CGE simulations. While our analysis isolates the effect of the IRA, Foster et al. (2023) includes additional public spending from the IIJA and the CHIPS and Science Act.

Although there is a rich literature on that evaluates the economic implications of climate-related investments, we find a gap in the literature regarding the detailed evaluation of the multiplier effects and efficiency of the sectoral incentives, and more specifically for the IRA. Existing research primarily focuses on overall macroeconomic impacts and broad sectoral trends without delving into the specific multipliers for different sectors or the cost-effectiveness of various incentives. We aim to fill this gap by using a dynamic computable general equilibrium (CGE) model to evaluate these effects, providing insights into the specific multiplier effects and efficiency of sectoral incentives and informing more targeted and effective policy design. Moreover, this analysis is centered on the IRA, for which, to the best of our knowledge, none of the previous analyses have evaluated its sectoral efficiency.

3. Methodology

We base our analysis on the single-country (U.S.) version of the USAGE model to analyze the dynamic impacts of the Inflation Reduction Act of 2022 on the U.S. economy. The USAGE is a dynamic computable general equilibrium model based on the MONASH model for the Australian economy developed by the Centre of Policy Studies (CoPS) (for an exhaustive model formulation including the detail of the equations see Dixon et al., 2013).

The Monash-style Computable General Equilibrium (CGE) models stand out as a preferred methodology for economic policy analysis, owing to their unique ability to comprehensively represent an entire economy and the behaviors of diverse agents within it. They provide a holistic view, capturing the interplay between various economic sectors and the decisions made by different entities such as households, industries, and government. The CGE approach provides a comprehensive representation that enables policymakers and researchers to assess the broad-ranging impacts of economic policies, considering how changes in one sector or behavior ripple through the entire economic landscape (Latorre 2012; Latorre., 2013). Based on the standard flow of the economy (including production, income distribution, and domestic and foreign demand), CGE models explain the balance in goods, factor markets, and the foreign sector. In essence, the Monash-style CGE models offer a powerful analytical tool that mirrors the complexity and interconnectedness inherent in real-world economies (Dixon et al., 2013). The results reported were obtained using the GEMPACK economic modelling software (Horridge et al., 2018).

The specific version used in this analysis is set to one region (U.S.) and 74 industries. Within the USAGE model, industries are designed to produce a variety of goods by blending domestic and imported items, coupled with diverse forms of labor, capital, and land. The equations determining what goods an industry produces are shaped by a CET function, while the functions managing industry inputs are established through CES nests. At the model's top tier, a Leontief or fixed-proportions production function combines intermediate commodity composites and a primary-factor composite. This structural arrangement implies that these factors are directly demanded in proportion to industry output. The concept behind each composite of goods is straightforward: it represents a blend of a domestic item and its imported counterpart, in line with Armington's notion that these items are not perfect substitutes based on their production origin (Armington, 1969). The primary-factor composite is configured as a CES aggregate, incorporating composite labor, capital, and land (within primary sector industries). While the USAGE model features a unified production structure across all industries, the specific proportions of inputs and behavioral parameters diverge among industries.

The USAGE model's demand and supply equations originate from solutions to optimization problems, presupposing that private sector agents' conduct aligns with established principles of neoclassical microeconomics. In the model, every sector endeavors to reduce costs considering input prices and operates under a production framework with constant returns to scale, while assuming the absence of pure profits across all industries. Household behavior in the model is driven by the utility-maximization equations subject to a budget constraint.

The USAGE model captures recursive-dynamic patterns through formulations delineating the accumulation of physical capital. Capital stock is industry-specific, and its growth is determined by the industry-specific investments in the preceding year. The expected rate of return on capital determines the investment in each industry.

In terms of government consumption, it sets an exogenous variation for the baseline simulation[49]. Although the IRA contemplates a series of tax reforms to finance tax incentives, we are isolating the effects of the latter. Thus, we allow public deficit to vary, while we set government demands to follow the baseline. The export demand for domestically produced commodities in the USAGE exhibits an inverse correlation with their foreign-currency prices. In policy simulations, the labor market undergoes a lagged adjustment path, with wage rates responding over time to gaps between labor demand and supply across various occupation groups.

A final reflection grounded in microeconomic theory seems appropriate. As is well known, green investments and production in green sectors exemplify what economists' term "an external benefit"—a benefit that an individual or firm provides to others without compensation. Like all positive externalities, the market, if left to itself, tends to produce too little of the goods or activities that generate positive externalities. This occurs because the marginal social benefit exceeds any individual's firm marginal benefit, leading no individual firm to provide the efficient quantity. When a good or activity yields positive externalities, a Pigouvian subsidy to producers serves as a tool to align the market with the socially optimal quantity of production. A significant portion of the IRA focuses on enforcing tax credits, which function as these Pigouvian subsidies.

In practice, one challenge with Pigouvian subsidies is that government officials often struggle to determine the appropriate amount of tax credits to set. Setting too few credits could result in insufficient deployment of green technologies, while setting too many could lead to economic inefficiency. The uncapped nature of tax credits in the IRA

[49] Explained in detail in the following section.

reflects the recognition that substantial investments are necessary to address climate challenges. However, even in environmentally conscious societies, it is important to acknowledge that tax credits come with a cost, utilizing scarce public resources that could otherwise be allocated to produce other goods and services. This issue is particularly pronounced when tax credits are uncapped and therefore not directly controllable.

The positive externalities associated with increases in green investments and production imply an additional benefit not captured in the prices we are about to analyze or in our quantitative estimations of various micro and macro variables. Thus, the IRA generates an intangible benefit not only for the U.S. economy but also for global warming as a whole, the quantification of which surpasses the scope of this paper. Consequently, part of the IRA's impact is challenging to quantify. Our aim is to provide policymakers with a more comprehensive understanding, providing quantitative estimations, to support their decision-making process with greater confidence.

A benefit of dynamic CGE models is that they allow for updating of the model's database structure by including historical information in the baseline. Since the USAGE database represents 2011 data, exogenous forecast values imposed for 2011–2023 represent available historical on GDP, private consumption, investment, trade, wages, exchange rate and consumer price index. Baseline data for both updating the database and running the baseline scenario data sourced from the U.S. Bureau of Labor Statistics (2023), Organization for Economic Co-operation and Development (2023), The World Bank (2023), Bureau of Economic Analysis (2023), and Federal Reserve Bank of St Louis (2023). The initial solution in the model is solved with data from the base year (2023), as is common in CoPS-style models. This data, along with the theoretical framework of the model embedded through the model equations shows us how different agents of the U.S. economy interact. After defining the scenario through the model closure, the values in the database vary over time as a consequence of the shock that has been introduced.

The definition of closure involves determining which variables will be exogenous (fixed or subjected to shocks throughout the simulation) and which will be endogenous (solved in the model as a result of introducing shocks).

4. Simulations

The USAGE model has been designed to gauge the repercussions of policy shifts or external shocks on the U.S. economy over a designated period. Following Dixon et al. (2013), to quantify the effects of a policy change we run two scenarios: one where the shock has taken place (policy simulation) and another where the particular shock under study did not unfold (baseline or "business as usual" scenario). The findings are then articulated as percentage variations between the policy and the baseline scenarios. The nominal exchange rate is established as the numeraire in the policy run, i.e., we fix this variable throughout the simulations. The numeraire serves as the selected fixed price variable against which the changes in all other prices are measured. Hence, the selection of the numeraire is inconsequential in terms of real variables.

5.1. Baseline forecast scenario

The baseline forecast establishes a business-as-usual baseline path for the economy. We set specific values to a number of variables in the model, which is solved on a year-on-year basis. The forecast values imposed for the baseline simulation correspond to the 2024-2031 period and are sourced from official forecasts from the Bureau of Economic Analysis (2023). These include a detailed projection of the expected percentage change (real percentage change for updating the database to 2021) in the following variables: employment, Consumer Price Index, exchange rate, population, imports, exports, private consumption, government consumption and tax on labor income.

5.2. Policy scenarios

What the IRA intends through its different incentives is to encourage production and investment in certain sectors of the U.S. economy. These incentives are mainly tax credits (more than 65%), grants and loans. Given the high share of tax credits in the total, plus the fact that loans and grants ultimately seek to stimulate production and investment, we assume in our analysis the $396 billion as tax credits. We model these tax credits as subsidies (i.e., production tax reductions). To do so, we define a policy closure in which we set as exogenous the production tax revenues variable at the sector level. We then introduce year-on-year sectoral tax revenue decreases (negative shocks) following the sectoral distribution from Table 19. The production taxes (in percentage) are solved in the model as a consequence of these shocks. For the remaining 65 industries, the production taxes are not affected, and thus follow the baseline.

Table 19 shows the sectoral allocation of climate-related incentives under the IRA over the 2024-2031 period, sorted by size. We base this sectoral distribution by identifying the NAICS 4-digit codes within each provision under the IRA (Internal Revenue Service, 2024) in which the USAGE sectors are based.

The IRA funds dedicated to clean electricity generation account for more than 50% ($191) of the total clean-energy funds, followed by Miscellaneous professional, scientific and technical services (12%). These services are provided to all the remaining 8 sectors benefiting from the IRA funds. The Construction, Forestry, fishing and related activities, Electrical equipment, appliances, and components and Motor vehicles, bodies and trailers, and parts industries receive similar-size incentives (between 6%-8% each). The Chemicals industry receives $13 billion due to the clean hydrogen promotion, and finally the Warehousing and storage and Non-metallic Mineral Products are stimulated as the result of specific programs on pollution reduction at ports and the use of low carbon materials, respectively.

The IRA introduces a high level of difficulty for researchers and policymakers to measure its real dimension, as the tax credits under the IRA are uncapped, i.e., we do not know in advance the total that the fiscal cost will represent (the total reduction in tax revenues). However, several studies (Jiang, 2022; Goldman Sachs, 2023; Bistline et al., 2023; Committee for a Responsible Federal Budget, 2024) estimate a total reduction in tax revenues (fiscal cost) between $780 billion and $1,200 billion, i.e., doubling and tripling the initial CBO estimate as a consequence of the uncapped tax credits.

Table 19. Climate-related IRA spending by USAGE industry ($US billion)

Sector	2024	2025	2026	2027	2028	2029	2030	2031	Total
Utilities	11.2	17.5	23.3	28.1	29.7	28.3	27.2	26.7	191.9
Miscellaneous professional, scientific, and technical services	2.7	4.2	5.6	6.8	7.2	6.8	6.6	6.4	46.3
Construction	2.1	3.3	4.3	5.2	5.5	5.3	5.1	5.0	35.7
Forestry, fishing, and related activities	1.9	3.1	4.1	4.9	5.2	4.9	4.8	4.7	33.5
Electrical equipment, appliances, and components	1.7	2.7	3.6	4.3	4.6	4.4	4.2	4.1	29.6
Motor vehicles, bodies and trailers, and parts	1.4	2.2	3.0	3.6	3.8	3.6	3.5	3.4	24.5
Chemical products	0.8	1.2	1.6	1.9	2.0	1.9	1.8	1.8	13.0
Warehousing and storage	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	2.9
Nonmetallic mineral products	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.3	2.1
Total	**22.0**	**34.6**	**46.1**	**55.5**	**58.7**	**56.0**	**53.8**	**52.7**	**379.4**

Source: authors' own elaboration based on Congressional Budget Office (2022) and Internal Revenue Service (2022).

Considering the abovementioned estimates we define 4 scenarios. In Scenario 1 we use the CBO initial estimations ($379 billion[50]) and in Scenarios 2 and 3 we double ($758 billion) and triple ($1,137 billion) these (following the estimations from abovementioned analyses). Finally, we add Scenario 4 in which the total decrease in tax revenues quintuples those from Scenario 1 ($1,895 billion). By setting this very-high tax

[50] The total outlays corresponding to climate related spending adds up to $393 billion in the 2022-2031 decade. The simulations are carried out for the 2024-2031 period; thus we extract the funds allocated in 2022 and 2023 from the total, as their effect is embedded in the historical data from those years.

demand increase we shed light on the behavior of the tax stimulus and its sectoral efficiency.

5. Results

The CGE approach allows us to analyze and differentiate between the macro and sectoral results. We start by explaining the macroeconomic impact in GDP, investment, capital Stock, employment, CPI, exports and imports, which are expressed in percentage change in Table 20. The stimulus of certain sectors of the economy has an expansionary impact effect on the economy. The first effect of the subsidy reduction in production taxes is an effective cost reduction for industries. This cost reduction pulls down the price of goods produced by these industries, thus fostering the demand for them. This increases output and investment and generates economic growth that reaches its maximum value in the form of an increase in GDP of 0.24% in 2029. To produce more, these sectors increase the demand for primary factors, i.e. increased capital stock and increased employment (equivalent to 490,000 workers).

This domestic stimulus has a price-increasing effect, and the CPI rises throughout the decade, reaching by 2031 its highest levels. This, along with the GDP increase that augments imports, affects negatively the trade balance. As prices rise, demand for exports falls towards the end of the decade and imports increase in a country (U.S.) with an already high import dependency.

Table 20. Macroeconomic impact of the Inflation Reduction Act (% change)

	2024	2025	2026	2027	2028	2029	2030	2031
GDP								
CBO	0.03	0.08	0.13	0.18	0.22	0.24	0.23	0.22
CBOx2	0.07	0.15	0.25	0.34	0.40	0.42	0.41	0.37
CBOx3	0.10	0.22	0.36	0.48	0.56	0.58	0.55	0.49
CBOx5	0.16	0.35	0.56	0.72	0.83	0.85	0.78	0.67
Investment								
CBO	0.05	0.15	0.28	0.41	0.54	0.66	0.76	0.83
CBOx2	0.11	0.30	0.56	0.81	1.08	1.32	1.52	1.67
CBOx3	0.16	0.45	0.84	1.22	1.62	1.98	2.27	2.50
CBOx5	0.23	0.69	1.30	1.94	2.62	3.24	3.76	4.19

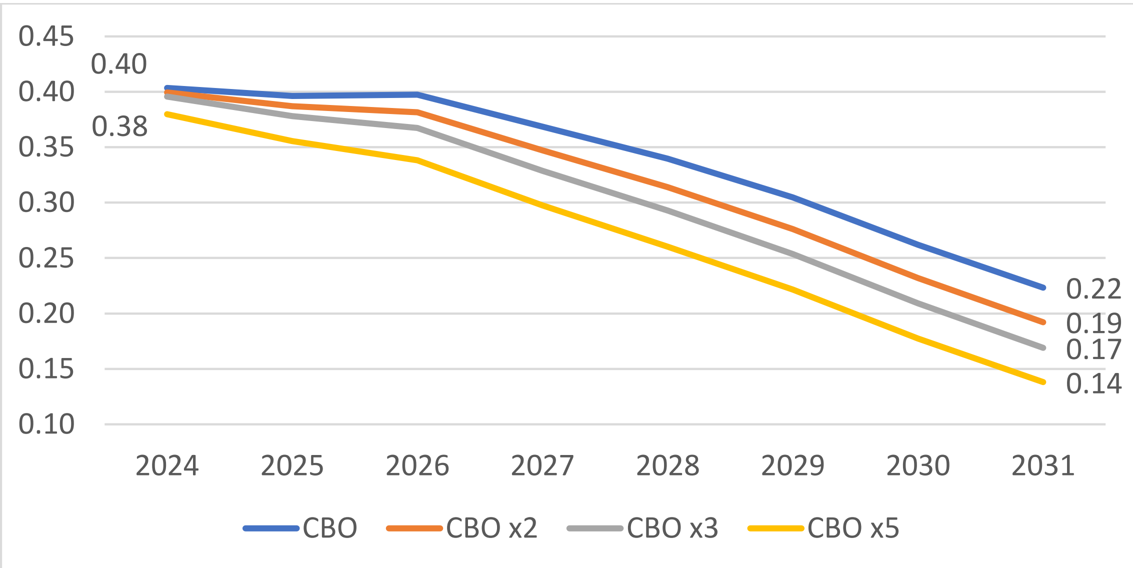
Capital stock								
CBO	0.00	0.00	0.02	0.04	0.08	0.12	0.17	0.22
CBOx2	0.00	0.01	0.04	0.09	0.15	0.24	0.33	0.43
CBOx3	0.00	0.01	0.05	0.13	0.23	0.35	0.50	0.65
CBOx5	0.00	0.02	0.08	0.20	0.36	0.56	0.80	1.05
Employment								
CBO	0.05	0.11	0.19	0.25	0.30	0.32	0.31	0.29
CBOx2	0.10	0.22	0.36	0.48	0.57	0.60	0.59	0.55
CBOx3	0.15	0.33	0.53	0.70	0.82	0.87	0.84	0.79
CBOx5	0.23	0.53	0.85	1.11	1.30	1.37	1.34	1.26
CPI								
CBO	0.02	0.06	0.12	0.17	0.23	0.28	0.34	0.38
CBOx2	0.04	0.12	0.25	0.36	0.48	0.60	0.71	0.80
CBOx3	0.06	0.19	0.38	0.56	0.76	0.94	1.10	1.23
CBOx5	0.09	0.30	0.63	0.96	1.31	1.63	1.93	2.16
Exports								
CBO	0.01	0.02	0.02	0.02	0.00	-0.03	-0.08	-0.15
CBOx2	0.02	0.04	0.04	0.01	-0.04	-0.13	-0.25	-0.39
CBOx3	0.04	0.05	0.04	-0.02	-0.12	-0.27	-0.47	-0.70
CBOx5	0.06	0.10	0.06	-0.07	-0.28	-0.59	-0.97	-1.40
Imports								
CBO	0.00	0.00	0.02	0.04	0.08	0.12	0.17	0.22
CBOx2	0.00	0.01	0.04	0.09	0.15	0.24	0.33	0.43
CBOx3	0.00	0.01	0.05	0.13	0.23	0.35	0.50	0.65
CBOx5	0.00	0.02	0.08	0.20	0.36	0.56	0.80	1.05
Wages								
CBO	0.02	0.08	0.17	0.29	0.43	0.58	0.73	0.86
CBOx2	0.05	0.16	0.33	0.56	0.83	1.12	1.39	1.65
CBOx3	0.07	0.23	0.49	0.83	1.22	1.63	2.02	2.39
CBOx5	0.11	0.37	0.78	1.32	1.94	2.59	3.22	3.80

Source: authors' estimations.

In terms of the difference between the four scenarios, several conclusions emerge. Regarding GDP, the results show a decreasing multiplier effect as fiscal cost levels increase. For example, GDP increases by 0.22% until 2031 in the CBO scenario and by 0.37% in the CBOx2 scenario, representing an increase of 70% after doubling the subsidies. The results for the CBOx5 show that, to increase GDP by 3 times as much as in the CBO scenario in the year 2031, tax incentives would have to increase five times as much as in the CBO scenario. These results show that different GDP multipliers are obtained when considering different levels of tax incentives.

Figure 1 displays the different GDP multipliers we derive. The multiplier results are close to 0.4 in 2024, implying that one $US dollar spent by the government increases GDP only by $0.4 dollars and indicating an inefficiency of the funds. Secondly, although the multipliers are similar across the four scenarios in 2024, the declines become more pronounced as the total incentives increase. By 2031, in the most extreme scenario, the multiplier of 0.14 is 36% lower than the 0.22 seen in the CBO scenario, indicating that the efficiency of the incentives declines as the incentives increase. The results for employment show a similar pattern. In the CBOx2 scenario employment increases by 90% more than in the CBO scenario. However, although the stimulus in the CBOx5 scenario is five times the initial one, employment grows proportionally less. Our analysis of the sectoral outcomes will help to understand these results.

Figure 1. Evolution of GDP multipliers (ratio) across scenarios (2024-2031)



Source: authors' own elaboration

The use of the CGE methodology allows us to draw conclusions that are not apparent at the macro level. In particular, the sectoral results show that the sectors benefiting from the IRA follow a different behavior than what most of the macro variables indicate for the economy as a whole. Table 21 shows the results in % change and at the sectoral level for Domestic output price, Private consumption, Output, Capital Stock, Exports and Imports.

Table 21. Cumulative sectoral results (Year 2031) for IRA-related industries for all scenarios (% change)

Sector, Scenario	Domestic output price	Private consumption	Output	Capital stock	Exports	Imports
Utilities						
CBO	-7.18	7.14	8.69	0.01	12.71	-14.37
CBOx2	-12.43	15.69	15.67	0.02	22.59	-23.83
CBOx3	-16.65	18.39	21.72	0.02	30.76	-30.84
CBOx5	-23.34	35.60	32.25	0.04	44.04	-40.97
Miscellaneous professional, scientific, and technical services						
CBO	-0.87	0.96	1.20	0.00	1.13	-0.60
CBOx2	-1.76	1.58	2.34	0.00	2.23	-1.22
CBOx3	-2.66	2.80	3.43	0.00	3.32	-1.84
CBOx5	-4.45	3.86	5.52	0.01	5.52	-3.12
Construction						
CBO	-0.17	0.21	0.55	0.00	-0.33	0.00
CBOx2	-0.37	0.24	1.11	0.00	-0.71	0.00
CBOx3	-0.57	0.49	1.66	0.00	-1.10	0.00
CBOx5	-0.98	0.33	2.77	0.00	-1.90	0.00
Forestry, fishing, and related activities						
CBO	-17.23	48.61	19.47	0.02	31.81	-8.34
CBOx2	-30.13	110.88	35.66	0.03	59.88	-14.95
CBOx3	-40.50	170.12	50.30	0.04	85.11	-20.82
CBOx5	-55.65	347.80	77.48	0.06	128.15	-31.46
Electrical equipment, appliances, and components						
CBO	-6.78	8.05	13.12	0.01	11.17	-2.45
CBOx2	-12.25	15.02	25.23	0.02	20.88	-4.40
CBOx3	-16.85	21.30	36.70	0.03	29.52	-6.02
CBOx5	-24.25	32.23	58.46	0.05	44.39	-8.54
Motor vehicles, bodies and trailers, and parts						
CBO	-2.39	4.19	4.54	0.00	3.43	-0.15
CBOx2	-4.63	7.91	8.93	0.01	6.66	-0.27
CBOx3	-6.73	12.08	13.21	0.01	9.71	-0.35
CBOx5	-10.54	18.76	21.50	0.02	15.38	-0.47
Chemical products						
CBO	-0.79	0.61	0.89	0.00	0.51	0.36
CBOx2	-1.58	0.85	1.72	0.00	0.97	0.72
CBOx3	-2.37	1.69	2.52	0.00	1.41	1.07
CBOx5	-3.92	1.94	4.10	0.00	2.28	1.73

Warehousing and storage						
CBO	-0.91	1.00	0.24	0.00	1.30	0.00
CBOx2	-1.85	1.59	0.46	0.00	2.58	0.00
CBOx3	-2.82	2.97	0.66	0.00	3.87	0.00
CBOx5	-4.77	4.00	1.07	0.00	6.55	0.00
Nonmetallic mineral products						
CBO	-0.36	-0.02	0.47	0.00	-0.37	0.60
CBOx2	-0.73	-0.37	0.91	0.00	-0.76	1.21
CBOx3	-1.11	-0.16	1.35	0.00	-1.16	1.81
CBOx5	-1.86	-1.06	2.20	0.00	-1.93	2.96

Source: authors' estimations.

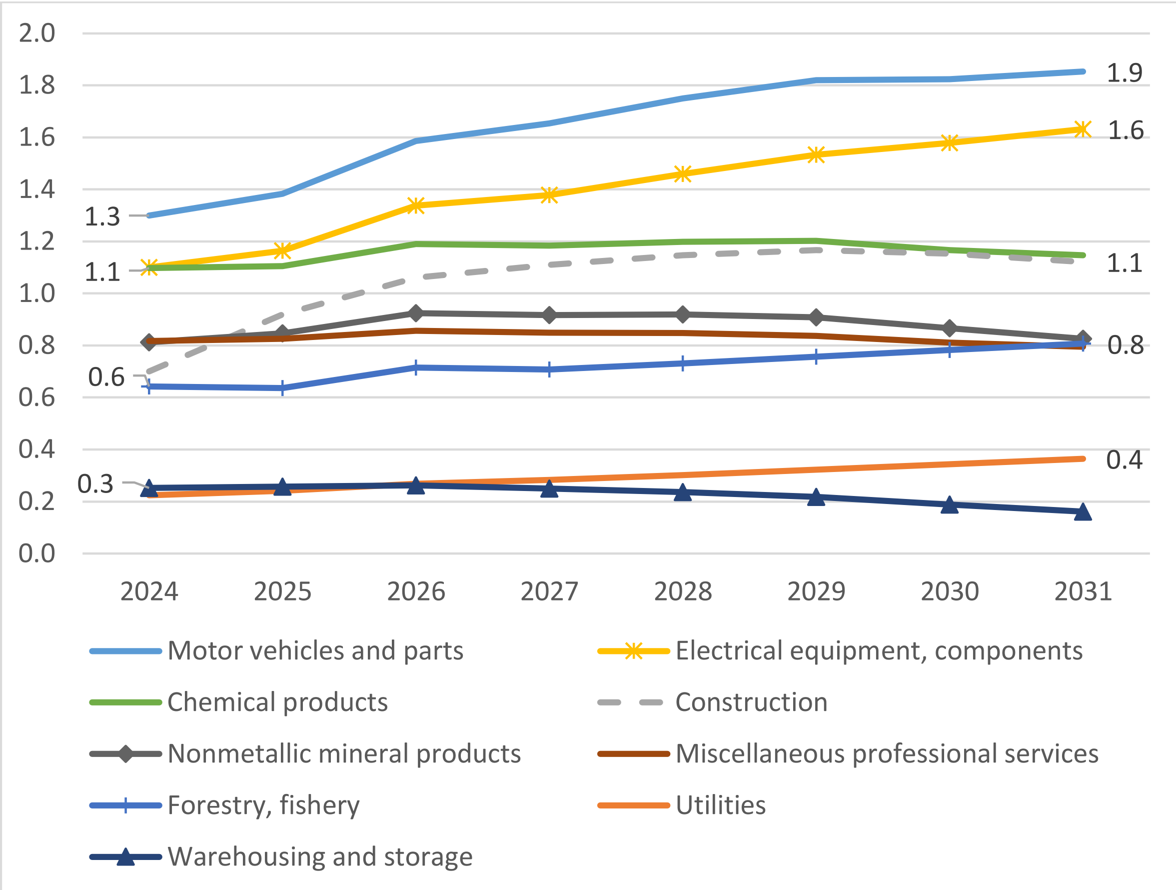
Special attention should be paid to the results of the increase in demand for domestic goods and services. The results obtained here show a clear increase in domestic demand as opposed to imports, which is not the case at the macroeconomic level. This is an effect sought by the authorities when signing this law, as they seek to increase the country's energy security by strengthening its domestic industry. Indeed, one of the long-term objectives of the law is to reduce inflation. Through the domestic industry incentive, our results show that this objective is achieved only at the level of the sectors subsidized by the IRA, but not at the macroeconomic level (see results in the second column from Table 21).

At first, we can deduce that the size of the shocks introduced is a reason behind the results. In the case of Utilities, more than half of the incentives go to this sector (51%), while in the second and third cases the size of the sectors is smaller with respect to the shock than in the case of Utilities. However, these results are not sufficient reason to assess whether the impact on these industries is larger and more efficient than in the other industries.

In order to compare the sectoral results in terms of efficiency, we calculate the increased output per $US dollar with which the sector is incentivized. The results are shown in Figure 2.

Three are the main conclusions extracted from Figure 2. First, in some sectors the multiplier exceeds unity, i.e., each dollar of tax revenue decrease generates more than one dollar of output increase. This is the case for Motor Vehicles and Parts, Electrical equipment, appliances and components, Chemical products and Construction. In these cases, the return on incentives exceeds the increase in public spending. In the rest of the sectors, the multiplier never exceeds unity, and even decreases. The extreme cases are Utilities and Warehousing and storage, which increase output by less than 20% and 40% of the incentive applied at the end of the period, respectively.

Figure 2. Evolution of output multipliers (ratio) in each sector (2024-2031)



Source: authors' own elaboration

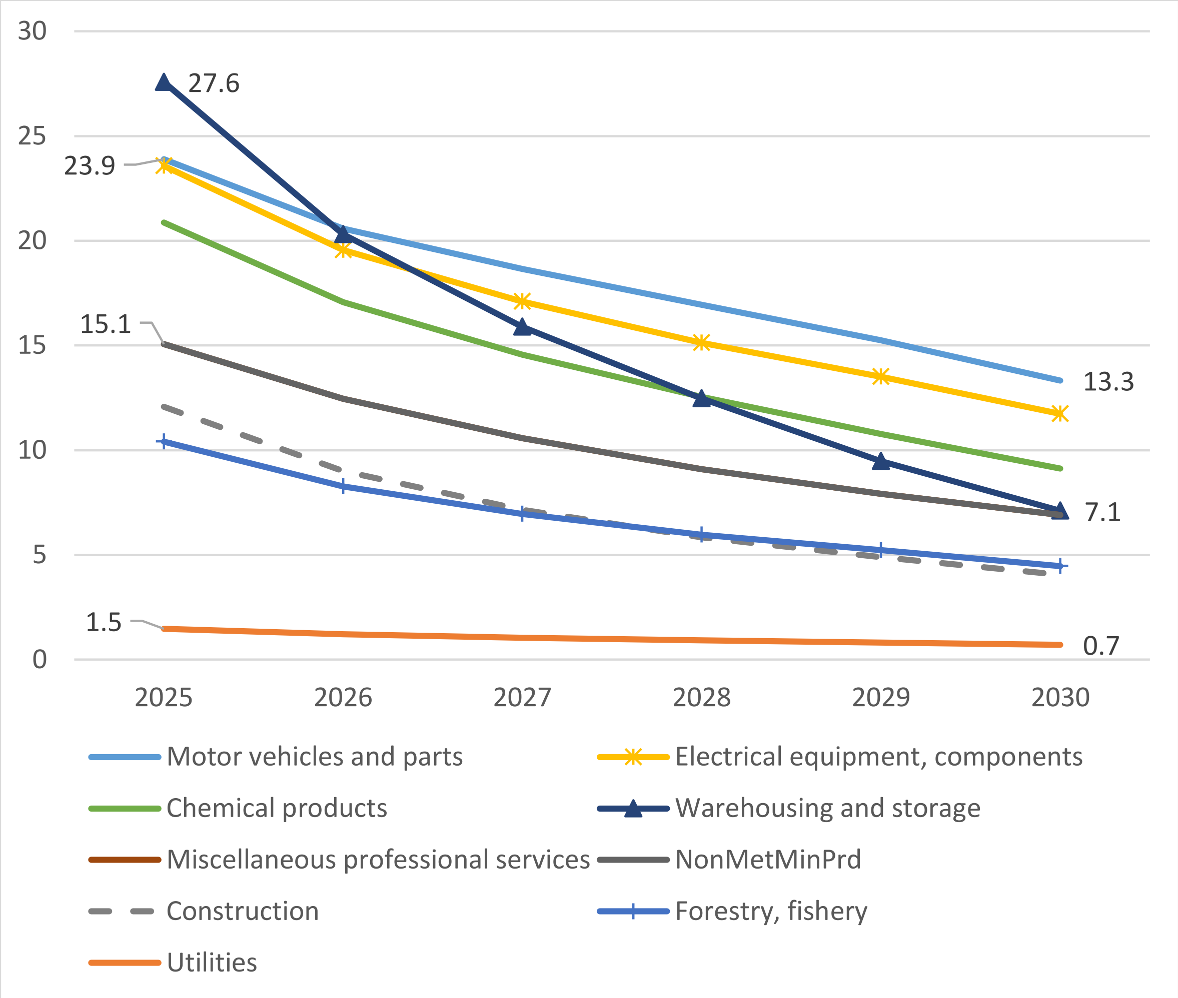
Secondly, the results of the dynamic model allow us to differentiate two patterns of sectors. First, there are sectors that reach an optimal performance point and then reduce their efficiency. This is the case of Chemical products, Construction, Nonmetallic mineral products, Miscellaneous professional services and Forestry, fishing and related activities. In these cases, from a given year onwards, the increase of $1 dollar of incentive in the form of a tax credit generates a lower increase in output than in the previous year. Second, in the Motor Vehicles and Parts, Electrical equipment, appliances and components and Utilities there is an improvement in efficiency over the whole period.

In summary, in Motor Vehicles and Parts and Electrical equipment, appliances and components the multiplier rises from 1.3 and 1.1 to 1.9 and 1.6, respectively. It should be recalled that the time distribution of shocks at the sectoral level follows the time distribution of total climate-related spending estimated by the CBO. That is, the annual increase in incentives is proportional across sectors, and therefore differences in efficiency are not caused by unequal distributions of incentives.

There are two main reasons behind these results, i.e., diminishing returns to capital and trade exposure. To show the effect of diminishing returns to capital, Figure 2 shows the time evolution of the capital/shock ratio for the different sectors benefiting from climate-related investments.

The evolution of the output/shock multiplier shown in Figure 2 has a parallel with the evolution of capital/shock shown in Figure 3. Firstly, those sectors with the highest multipliers in Figure 2 are the ones with the highest return on capital (Figure 3) over the whole period, i.e. Motor Vehicles and Parts and Electrical equipment, appliances and components.

Figure 3.Evolution of capital multipliers (ratio) in each sector (2024-2031)



Source: authors' own elaboration.

Secondly, the Figure 3 shows that sectors with the highest multiplier are also the ones with the slowest reduction in returns on capital, with the exception of Utilities which shows a somewhat slower reduction but starts from the lowest capital/shock multiplier of all the sectors analyzed. The Warehousing and Storage sector starts from the highest multiplier in 2024, but experiences faster diminishing returns on capital than the other sectors.

The second reason behind these results is trade exposure. Table 22 shows the sales of domestic commodities by IRA sector.

Table 22. Destination of sectoral production for IRA-related industries.

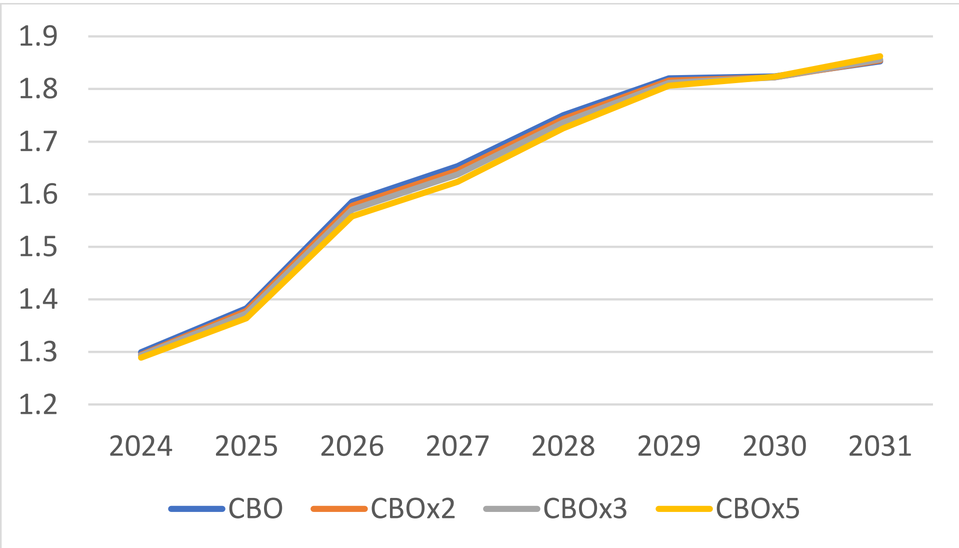
Sector	Demand for intermediates	Demand for Investment	Private consumption	Exports	Government demand	Total
Forestry, Fishery and related activities	77%	0%	4%	19%	0%	100%
Utilities	38%	0%	61%	1%	0%	100%
Construction	8%	92%	0%	0%	0%	100%
Nonmetallic mineral products	85%	0%	3%	12%	0%	100%
Electrical equipment, appilances and components	39%	12%	9%	41%	0%	100%
Motor Vehicles and Parts	24%	28%	13%	35%	0%	100%
Chemical Products	41%	1%	17%	42%	0%	100%
Warehousing and storage	94%	0%	1%	6%	0%	100%
Miscellaneous professional, scientific, and technical services	88%	3%	5%	4%	0%	100%

Source: authors' own elaboration based on data from Bureau of Economic Analysis (2023).

The results in the last two columns of Table 21 show the impact on trade in IRA-related industries. The price reduction in the IRA sectors, as a consequence of the incentives, raises the demand for domestic goods to the detriment of imports. This is an objective of the IRA, which aims to strengthen the so-called energy security in the country. On the other hand, the results show a clear increase (in % change) in exports in these sectors. However, in order to interpret these results, we need to analyze the sales destination of their goods or services to know the extent of the impact on exports. Table 22 shows this information for IRA-related industries. More than 80% of the goods or services produced by sectors such as Utilities, Construction, Warehousing and storage, Miscellaneous Services, Nonmineral metal products or Forestry, fishing and related activities are sold in the domestic market (as intermediates, for investment or for private consumption).

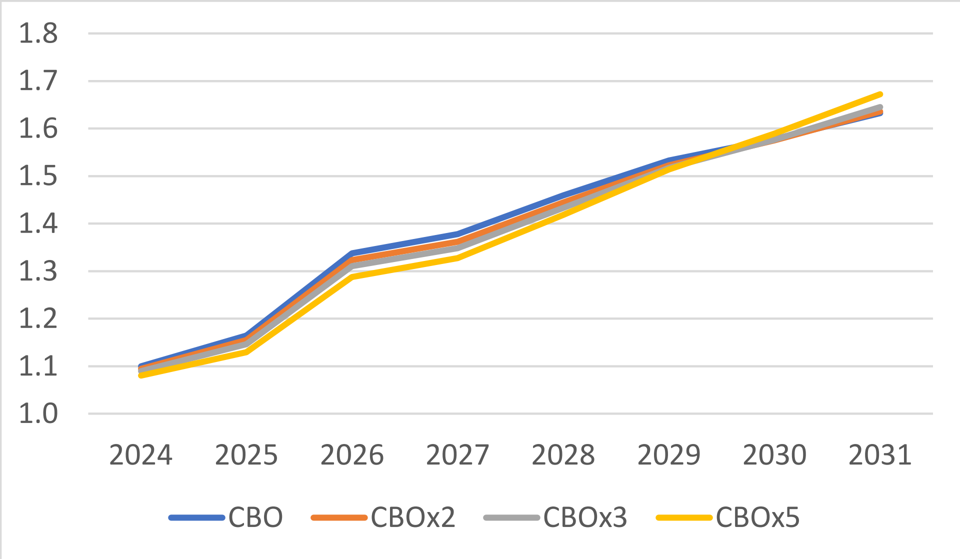
By contrast, the share of exports in the Motor Vehicles and Parts, Electrical equipment, appliances and components and Chemical products sectors is 35%, 41% and 42% respectively. Therefore, for these sectors, demand is increasing both domestically and abroad, which represents a competitive advantage with respect to the rest of the IRA sectors. All these forces result in very different sectoral multipliers. We illustrate the 3 most extreme cases which offer a clear policy recommendation. As can be seen in Figures 4, 5 and 6, the sectoral multipliers for Motor vehicles and parts and Electrical equipment, components and appliances are both above 1 in 2024 (1.3 and 1.1 in 2024, respectively). Moreover, they both increase their results throughout the period (they reach 1.85 and 1.65 respectively) and efficiency is maintained even when incentives are quintupled. The Utilities sector receives a 51% of total incentives, but shows much lower multipliers. Starting from a multiplier result of 0.22 in 2024 and 0.36 in 2031, this sector reduces its efficiency as incentive increases, as can be seen from Figure 6. These results indicate that there is room for both a better redistribution of funds and an increase in Motor vehicles and parts and Electrical equipment, components and appliances, as seen by the multipliers results.

Figure 4. Evolution of output multipliers (ratio) in Motor vehicles and parts across scenarios (2024-2031)



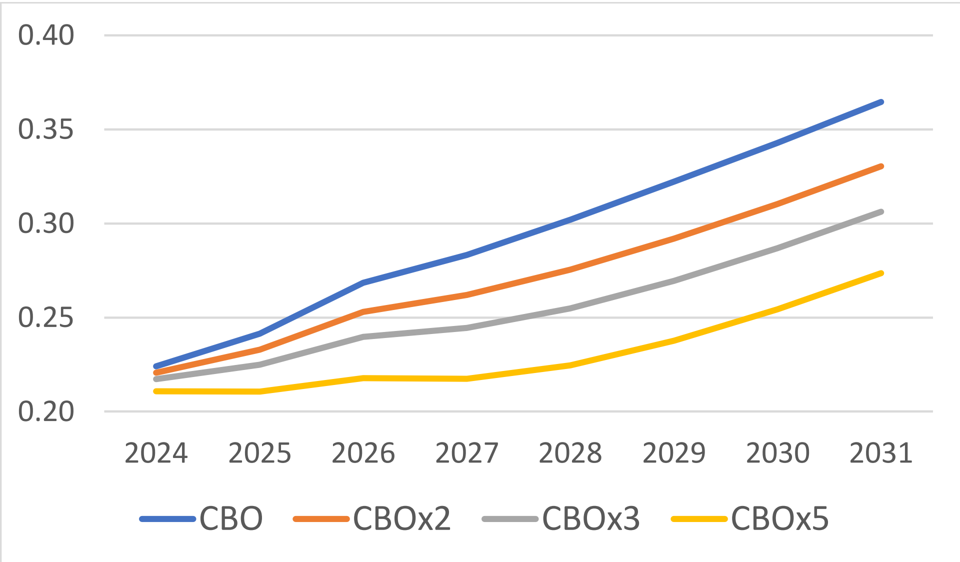
Source: authors' own estimations.

Figure 5. Evolution of output multipliers (ratio) in Electrical equipment, components and appliances across scenarios (2024-2031)



Source: authors' own estimations.

Figure 6.Evolution of output multipliers (ratio) in Utilities across scenarios (2024-2031)



Source: authors' own estimations.

6. Conclusions and policy implications

In this study we provide an ex-ante impact evaluation of the climate-related spending under the 2022 Inflation Reduction Act (IRA). To this aim, we use a dynamic Computable General Equilibrium (CGE) approach. The federal policy measures taken by the United States in recent years, particularly through the IRA, reveals a commitment towards energy transition and economic reform. The dynamic Computable General Equilibrium (CGE) model analysis presented in this study reveals significant macroeconomic and sectoral impacts, with policy-oriented implications.

We derive that green incentives from the IRA are projected to generate economic growth and jobs (approximately 490,000 workers[51]) in the U.S. economy by reducing costs through tax incentives, which stimulate output and investment. With the initial CBO estimations of green incentives our dynamic results show a cumulative GDP growth increase of 0.22% over the 2024-2031 period, reaching a peak of 0.24% in 2029. Cost reductions generate output increases in IRA-related industries and other industries related to them and reduce industry prices. To produce more, these industries increase their demands for intermediates and primary factors. Consequently, investment experiments important increases among these industries and drives aggregate investment to reach 0.83% by 2031. The rise in demand form primary factors causes employment to peak a cumulative increase of 0.32% in 2029.

However, the increased domestic demand resulting from more jobs and capital available for production leads to inflationary pressures, and the Consumer Price Index (CPI) rises by 0.38% by 2031. Inflation reduces export competitiveness, resulting in a projected decrease in aggregate export demand by 0.15%, together with an imports increase of 0.22% by 2031. We account for the uncapped effect of tax credit from the IRA by defining three additional scenarios. Based on several fiscal cost estimations of

[51] Deviation from baseline, in which we use projections data from Bureau of Labor Statistics (Bureau of Labor Statistics, 2023)

the IRA, we double, triple and quintuple the initial CBO estimations. The different scenarios highlight a diminishing return on GDP growth and employment with increased tax incentives, showing that while doubling and tripling the initial outlays yield higher growth rates, the efficiency of these increases diminishes. For example, Scenario 4, which quintuples the tax incentives, only results in a 0.67% GDP growth by 2031, indicating diminishing returns. Thus, at the aggregate level, we find room for efficiency of the uncapped tax credits and going beyond the initial CBO estimates, but there is a limit.

The sectoral analysis yields two policy insights that cannot be revealed through macroeconomic evaluation of the IRA. Our results demonstrate that certain stimulated industries benefit more significantly from the IRA incentives. The Utilities sector, receiving 51% of the climate-related funds, shows the most substantial output increases, with a cumulative output increase of 32.25% by 2031 in the CBOx5 scenario. Other sectors such as Forestry, Fishing, and related activities, and Electrical Equipment, Appliances, and Components also exhibit significant growth, with output increases of 77.48% and 58.46% respectively under the same scenario. However, percentage change results could lead to misleading conclusions, as the efficiency of these incentives varies across sectors. We estimate output multipliers that indicate that sectors like Motor Vehicles and Parts, Electrical Equipment, Appliances, and Components, and Chemical Products have high efficiency, with each dollar of tax incentive generating more than one dollar of output increase. Conversely, sectors like Utilities and Warehousing and Storage exhibit lower efficiency, with lower output increases than the incentives applied.

The findings of this study indicate several key policy implications for maximizing the effectiveness of the Inflation Reduction Act (IRA). Although the Utilities sector receives 51% of the IRA’s climate-related funds, results show a low efficiency of this sector, suggesting a need for more balanced incentive distribution to enhance overall economic efficiency. Shifting some incentives to more efficient sectors such as Motor Vehicles and Parts, and Electrical Equipment could yield higher returns. These sectors benefit from a high return to capital in general and lower diminishing returns to capital, meaning that additional investments continue to yield substantial output increases. In the Motor Vehicles and Parts sector, the output multiplier rises from 1.3 to 1.9 over the analysis period. Similarly, the Electrical Equipment sector shows a significant increase in output multipliers, starting at 1.1 and increasing to 1.6 by 2031. These high multipliers indicate that every dollar of tax incentive in these sectors generates more than a dollar of output, reflecting their efficiency and potential for growth.

The output destination of these sectors also plays an important role in these efficiency results. In the set of sectors incentivized by the IRA there are two distinct groups: those with a high share of their production destined for exports (Motor Vehicles and Parts, Electrical equipment, appliances and components, Chemical products and, to a lesser extent, Forestry, fishery and related activities) and those with a low or very low share of their production destined for the foreign market (Utilities, Construction, Warehousing and storage, Nonmetallic mineral products and Miscellaneous professional, scientific and technical services). The combination of high returns on capital and robust export growth underscores the potential for greater economic gains by reallocating some of the IRA's funds from the Utilities sector to these more efficient sectors. This strategic reallocation would not only enhance economic efficiency but also maximize the overall impact of the IRA on the U.S. economy.

Pigouvian subsidies (tax credits) can be efficient instruments for dealing with positive externalities. However, in practice, they require striking a balance between being insufficient for the deployment of green technologies and becoming economically inefficient. Nevertheless, the positive externalities associated with increases in green investments and production, facilitated by the IRA, imply that there are external benefits not fully captured in the micro and macroeconomic effects on the US economy that we have presented. Thus, the IRA promotes an intangible benefit not only to the US economy but also to global warming as a whole, the quantification of which is particularly challenging and exceeds the scope of this paper.

Chapter 7. Conclusions

This doctoral thesis provides a comprehensive analysis of the economic impact of several trade and investment policies in the United States. It uses a computable general equilibrium (CGE) approach, employing three different CGEs, to integrate detailed sector-specific analyses with broader economic impacts. This work provides insights on the understanding of how several national and international policy initiatives affect various aspects of the U.S. economic landscape.

Chapter 1 introduces the topic, and Chapter 2 delves into the methodology used for the impact analyses carried out in the following chapters. The third chapter addresses how the EU-Mercosur trade agreement could impact signatory regions and third-party countries whose commercial presence in both regions is significant, especially the U.S. The analysis is based on the widely used, publicly available, and transparent GTAP model, aggregated into 9 regions and 36 sectors encompassing all industries of the economy (including agriculture, manufacturing, and services). The regions analyzed include the four Mercosur alliance countries (Argentina, Brazil, Paraguay, Uruguay), the European Union (27 members combined into a single signatory region), the United States (U.S.), China, and Canada. The reductions on tariffs and the quotas are based at the HS 8-digit level ones negotiated in the agreement. Additionally, we simulate the effect of non-tariff measures reductions (including Services sectors and public procurement).

Our results show that, if finally ratified, the impact of this agreement on non-signatory regions would be limited. For instance, the welfare loss in the U.S. would be 1.3 $US billion, which represents only a 0.01% over GDP. However sectoral results show some larger export reductions. Exports to Mercosur are particularly affected, especially those directed to Brazil and Argentina. These results are largely due to the reduction of manufacturing exports to Mercosur in favor of the EU. For instance, U.S. exports of manufactures to Mercosur would be reduced by $4.7 billion (8.6% decrease), while EU would increase its manufacturing exports to the Mercosur region $38 billion (74% increase).

The EU presence in service sectors in Mercosur is much higher than in the case of the U.S. (more than double). Through the EU-Mercosur agreement this difference would be accentuated. As a result of NTMs in the Mercosur countries, the EU would increase its service exports to the region by 10% ($3.5 billion) mainly driven by exports increases from the Communications, Insurance and Other business services. The U.S. would reduce its exports of these sectors to the Mercosur region in favor of EU. Unlike the Mercosur countries, the EU's scope in reducing NTMs is extremely low. According to our estimates, the U.S. service exports to the EU would even increase, albeit with very small impacts (below 1%).

Given the differences in size between the EU and Mercosur regions, the scope for gains is higher (in percentage terms) in the Mercosur countries. However, although the four Mercosur countries reduce tariffs in the same way (Common External Tariff), the commitments in terms of NTM reduction and government procurement are different. The openness of a region like the EU through tariff reductions represents a very important stimulus for Mercosur economies. The country that gains the most is Uruguay, which is a rather small country with the most open regime. It would increase its GDP by 0.61%, wages by 2.31%. Exports to the EU would increase significantly due to the tariffs reduction, although to the detriment of exports to other regions. The reason behind relies on the high increases in factor production prices (wages and capital remuneration), resulting from a strong process of factors' reallocation.

In contrast, Paraguay, which is also small but has been less ambitious in the negotiations, gains less from the agreement. Argentina and Brazil would benefit greatly from improved access to the EU market, mainly due to reduced tariffs and increased quotas. GDP increases by 0.26% and 0.13%, and wages by 0.1% and 0.4%, respectively. Brazil would experience production increases of 2.2% ($0.73 billion) in its Vegetables, Fruits and Nuts sector. In Argentina, the Bovine and other ruminants' meats sector would increase its production by 4% ($0.77 billion). A 9.72% ($0.45 billion) increase in exports of Bovine and other ruminants' meats would pull up exports of Mercosur agriculture products (0.84% or $0.66 billion). Approximately half of this figure is attributed to the 32.45% ($450 million) increase recorded by Argentina in this particular sector. On the other hand, Mercosur is expected to increase its agricultural production by 0.75% ($3.1 billion), mainly driven by an increase in exports to the EU by 19.2% ($1.8 billion). Although agricultural exports from the EU to Mercosur would increase, the price increases in the EU pulls down intra-regional demand and agricultural production by 0.47% ($3.8 billion). Thus, the balance of global dynamics would tilt much more in favor of Mercosur's agricultural trade, taking into account the greater access to the EU market.

In short, our tailor-made sectoral and regional analysis shows that gains for Mercosur countries depend largely on their degree of commitment to trade liberalization. Both tariffs and NTMs are higher in Mercosur than in the EU, and their impact on the latter yields interesting conclusions. Through in-depth simulations of tariffs, NTMs and open government procurement policies, our research lays the groundwork for assessing the multiple impacts of trade agreements, including the impact on Services sectors. We enrich the existing literature by delving into interconnections and potential spillovers beyond the regions involved and affected third parties.

Chapters 4 and 5 address the impact of the Infrastructure Investment and Jobs Act (IIJA) from different perspectives. In both chapters we use a multi-regional, multi-sector, static CGE model, which enables to analyze both macroeconomic and sectoral results and the interconnections among them. The IIJA was signed into law in 2021 and provides for $550 billion in new public spending to modernize U.S. infrastructure (mainly from the Transport, Utilities and Information industries). In order to reflect recent economic conditions, we made a major effort to update the original TERM database using a program developed by the Centre of Policy Studies (Centre of Policy Studies, 2019). The CGE model itself is calibrated to respond to specific exogenous shocks defined as changes in public infrastructure spending in various sectors and regions. These shocks represent the direct injection of funds stipulated by the IIJA directed primarily to the transportation, utilities and information services sectors. Each shock is carefully quantified using official Congressional Budget Office estimates.

In the simulations carried out in Chapter 4 we first differentiate between short-term (during the construction phase) and long-term (once these infrastructures are fully functional) outcomes. In the construction phase, the 0.24% ($55 billion) increase in GDP primarily stems from heightened construction activities which require substantial labor input, leading to a 0.44% increase in employment (approximately 650,000 jobs).

However, the GDP price index and the Consumer Price Index increase by 2.33% and 1.88%. These results showcase the direct stimulative effect of government infrastructure spending but a simultaneous inflationary pressure that reduces household purchasing power.

Our results show a 1.39% ($292 billion) rise in GDP once the new infrastructures are fully functional in the long-term. The productivity increase stemming from the new infrastructure would also generate a wage increase of 3.94%. Moreover, the analysis also points to an improvement in the trade balance, shifting from the short-term deficit, as the new infrastructure enhances the global competitiveness of U.S. goods and services.

To understand the efficiency of the current estimations on the distribution of the IIJA funds, we explore and compare three scenarios in which the $550 billion are fully directed to the Transport, Utilities and Information sectors. The only scenario showing a higher GDP outcome than the original simulation is the one devoting the funds to the Transport sector. Results show that such a focused investment could potentially yield a long run GDP growth of 1.42%, which is only slightly higher than in the original simulation. However, this sector-specific strategy would result in smaller wage increases due to the sector's lower capital intensity compared to utilities and information services.

Building upon the findings presented in Chapter 4, Chapter 5 extends the scope of the analysis of the IIJA. It delves deeper into the implications of different financing strategies for the investments contemplated in the plan. We run different simulations by means of the forementioned TERM-USA model. This chapter extends the literature by providing insights in understanding how the choice of financing—either through national or foreign borrowing—affects the economic outcomes of such substantial public spending. We compare two scenarios: one where the public spending increase is financed through foreign borrowing and another through national borrowing. Under foreign borrowing we assume that the debt increase from higher public spending will be serviced in the long run. Therefore, funds are immediately available for increased spending without impacting domestic financial conditions. On the other side, national borrowing assumes that debt is serviced in the short term. Funds are sourced domestically, potentially leading to a crowding-out effect where government borrowing competes with private sector investment. We run short-run simulations (one year after implementation in 2023) and long-run simulations (beyond the construction phase) under each financing scenario.

In the short term, the immediate government expenditure on construction activities drives economic growth and job creation. Results assemble to those shown in Chapter 4, and the source of financing – whether foreign or national borrowing – has a minimal differential impact. Foreign borrowing slightly shows higher outcomes due to its immediacy and negligible influence on domestic consumption and investment. This generates a slightly higher GDP and employment increase over the national borrowing scenario. In the longer term the infrastructure becomes fully operational. The physical capital stock within the Transport, Utilities and Information sectors grows. At this point in time, the financing approach plays an important role. National borrowing, which spreads debt maturity in the short term, delivers stronger economic outcomes compared to foreign borrowing. The latter tends to accumulate long-term debt, resulting in lower GDP, production and wage increases.

Our IIJA analysis in Chapter 5 examines if this plan will foster inclusive growth and reduce income inequality. We find that the IIJA will create significant long-run employment opportunities and wages increases in various sectors such as Energy minerals, Metal Products and Machinery & Equipment. Additionally, we find that the IIJA will impact the distribution of wages across deciles in the correct direction but in a very soft way. Under national borrowing, the poorest deciles slightly increase wages, while under foreign borrowing the richest ones experience a slight decrease. Under both scenarios we also found a small increase in the share of labor income at the cost of capital income in GDP, but national borrowing shows again better results for workers than foreign borrowing. Our results show that the scale of the investments is not large enough to impact largely on the income distribution and would need to be complemented with other policies.

In summary, Chapter 5 extends the conclusions made in Chapter 4 by presenting deeper understanding of how investment under the IIJA, facilitated by selected financing strategies, manifests across different sectors and income deciles. The insights from Chapter 4 suggest that while foreign borrowing can provide an immediate boost to the economy, it is national borrowing that offers more sustainable and broad-based economic growth over the long term. This has implications for policymakers, who must balance the immediate economic benefits of quick fund availability against the long-term benefits of sustainable economic growth and stability. The choice of financing strategy not only affects macroeconomic indicators like GDP and employment but also has differentiated impacts across various sectors and income deciles.

Finally, Chapter 6 examines the economic implications of public climate-related investments under the Inflation Reduction Act (IRA) of 2022. The IRA represents an important step towards the achievement of net-zero emissions in the U.S. Through incentivizing domestic production of clean energy, it aims to foster the country's energy security and reduce energy prices in the longer term. To do so, the law contemplates a series of incentives on specific energy-related industries. The main vehicle used to increase private investment and production is through tax credits. The law allocates these incentives across climate related sectors, being the Utilities sector the one receiving more than half of total incentives (51%).

Considering initial estimations from the CBO, our dynamic CGE results show a cumulative GDP growth of 0.22% by 2031. Cost reductions lead to reduced prices and increased production from IRA-related industries. To produce more, these industries demand more primary factors (i.e., labor and capital), leading to wage and capital rental increases. By 2031, employment rises by 0.29% and wages by 0.86%. This positive effect in primary factor income increases private consumption and investment in the country, and GDP grows a cumulative 0,22% by 2031[52]. However, the inflationary pressures lead to a reduction in overall exports in the U.S. (-0.15% by 2031). The combined effect of

[52] Private consumption represents more than 67% of the U.S. GDP (St. Louis Federal Reserve, 2024).

increased intermediate demand from IRA-related industries, larger private consumption and this increase in inflation results in higher import demand (0.22% by 2031), causing a negative effect in the U.S. trade balance.

The law does not contemplate any limit regarding tax credits. This means that, the impact that tax credits may have on the economy is unknown in advance. To address this challenge and provide data-driven policy insights, we expanded the scope of analysis by adding three scenarios. To account for increased demand of tax credits, we double, triple and quintuple the initial Congressional Budget Office (CBO) estimates. At a macro level, results show diminishing multiplier effects in GDP and employment as fiscal cost levels increase. For instance, GDP increases by 0.37% in the CBOx2 scenario (fiscal costs are doubled), representing a 70% increase with respect to the initial scenario (0.22% GDP increase). In 2024, for the GDP we derive an aggregate multiplier of this law of 0.4 and 0.38 under the CBO and CBOx5 scenarios. The diminishing efficiency of capital lowers these GDP multipliers, and results show that at the end of the period the difference across scenarios is wider. By this time, under the CBO scenario the multiplier is 0.22, while if incentives are quintupled the result is 0.14 (36% lower), respectively, i.e., showing a decrease in efficiency when the incentives are higher.

The sectoral detail of the CGE model allows explain the macro results and compare the efficiency among IRA-related sectors. To this aim, we analyze the output multiplier, i.e., how many $US dollars of increased output increase from each $US dollar from tax credits devoted to each industry. Starting from 2024, results for the initial scenario range from 0.25 in the Utilities sector to 1.3 in Motor Vehicles and Parts. Moreover, the year-on-year results demonstrate that Motor Vehicles and Parts, and Electrical Equipment, components and appliances are the most efficient (with multiplier results over 1) and the only ones that increase their efficiency throughout the whole period. The only exception is Utilities, which slightly increases its efficiency, but it has the lowest multiplier (it reaches a maximum of 0.4 by 2031). The three additional scenarios show different behaviors of the two industries with the highest multipliers, Motor Vehicles and parts and Electrical equipment, components and appliances. In the rest of the sectors, the multiplier decreases as we increase incentives, meaning a gradual reduction in efficiency. However, in these two cases the multiplier remains almost equal in all scenarios, implying room for increasing those incentives in these two sectors.

We find two reasons behind these results related to (1) diminishing returns to capital and (2) trade exposure. By calculating a capital stock multiplier (capital over stimulus), we find that capital is more efficient in these industries. Results are not only higher for Motor vehicles and parts and Electrical equipment, components and appliances from the first year (2024), but also decrease at a lower level throughout the period showcasing lower diminishing returns to capital. As of trade, the share of exports in the total demand for Motor vehicles and parts and Electrical equipment, components and appliances sectors represents more than 35% and 41%, respectively. Thus, they have a competitive advantage as demand for these sectors increases both domestically and abroad.

The combination of high returns on capital and strong export growth underscores the potential benefits of strategically reallocating some of the IRA's funds to these more efficient sectors. While Pigouvian subsidies, such as tax credits, are effective in addressing positive externalities, balancing them to avoid economic inefficiency is crucial. Despite the challenges, the positive externalities associated with green investments and production facilitated by the IRA imply significant benefits for both the U.S. economy and global warming mitigation, although these benefits are challenging to be fully quantified.

This doctoral thesis uses several CGE models to provide a thorough, data-driven examination of the impacts of several trade and investment policies in the U.S. Each section of the work offers detailed insights that can help guide effective policy formulation and implementation. By bridging theoretical models with practical applications, this thesis exemplifies the potential of economic research in shaping public policy and advancing economic development. The insights provided can help policymakers, economists, and stakeholders involved in trade, infrastructure investment, and environmental policy, directing the way toward more informed and effective economic decision-making.

Appendixes

Appendix I: Model sectors and correspondence with GTAP 10 sectors

Nº	Description	Equivalent GTAP Sector/s	Type
1	Cereals	1, 2, 3, 5, 23	Agriculture
2	Vegetables, fruits, nuts	4	Agriculture
3	Sugar	6, 24	Agriculture
4	Plant & animal fiber, others	7, 8, 12, 14	Agriculture
5	Bovine and other ruminant meats	9, 19	Agriculture
6	Other animal products	10	Agriculture
7	Dairy products	22	Agriculture
8	Forestry	13	Agriculture
9	Gas, coal, oil extraction or distribution	15, 16, 17, 18, 47	Manufactures
10	Live animals, meat and animal products	20	Manufactures
11	Vegetable oils and fats	21	Manufactures
12	Food products nec	25	Manufactures
13	Beverages and tobacco products	26	Manufactures
14	Textiles	27	Manufactures
15	Wearing apparel	28	Manufactures
16	Leather products	29	Manufactures
17	Wood products	30, 31	Manufactures
18	Petroleum, coal and other chemical products	32, 33	Manufactures
19	Pharmaceutical products	34	Manufactures
20	Rubber and plastic products	35	Manufactures
21	Other manufactures	36, 45	Manufactures
22	Metals and metal products	37, 38, 39	Manufactures
23	Electronic products	40	Manufactures
24	Other machinery	41, 42	Manufactures
25	Motor vehicles and parts	43	Manufactures
26	Transport equipment	44	Manufactures
27	Other services	48,50,52,55,62,63,64,65	Services
28	Construction	49	Services
29	Hotels and Restaurants	51	Services
30	Maritime Transport	53	Services
31	Air Transport	54	Services
32	Communication	56	Services
33	Banking	57	Services
34	Insurance	58	Services
35	Business Services	59, 60	Services
36	Personal Services	61	Services

Source: authors' elaboration based on Aguiar et al. (2019)

Appendix II. TERM-USA model regions and regional fund allocation

Region	States	Total ($US billion)
California	California	57.14
Texas	Texas	45.45
New York	New York	34.52
SouthEast	Tennessee, North Carolina, South Carolina, Alabama, Georgia, Florida	80.64
MISO	Illinois, Indiana, Michigan, Wisconsin, Iowa, Minnesota, Missouri, North Dakota, South Dakota, Mississippi, Arkansas, Louisiana	112.53
PJM	New Jersey, Pennsylvania, Ohio, Delaware, District of Columbia, Maryland, Virginia, West Virginia, Kentuky	99.93
New England	Maine, Conneticut, Massachussets, New Hampshire, Rhode Island, Vermont	31.52
NorthWest	Washington, Oregon, Idaho, Montana, Wyoming, Nevada, Utah	40.29
SouthWest	Colorado, Arizona, New Mexico	22.07
SSP	Kansas, Oklahoma, Nebraska	16.22
AlasHawaii	Alaska, Hawaii	9.68
Total		550.00

Source: authors' elaboration based on The White House (2021c), U.S. Census Bureau (2021)

Appendix III. Detailed TERM Model description

The U.S. version of the Enormous Regional Model (TERM-USA) is a multi-sector and multi-region CGE model for the U.S. based on the generic TERM and developed by the Centre of Policy Studies, from Victoria University (Australia). TERM builds on the ORANI model for the Australian economy and provides a strategy for creating a “bottom-up” multi-regional CGE model used for comparative-static simulations. Along with national constraints, it treats each region as an independent economy. Thus, prices and quantities can vary from one region to another. In each region, the households’ preferences are defined by a representative consumer, and firms produce goods that are consumed by final users (households, government, exports) or by other firms (as intermediate inputs). In this specific U.S. version, the 11 regions are based on an aggregation for modelling electricity generation and distribution (electricity grid regions, see Appendix II). It distinguishes 26 sectors combining goods (17) and services (9), each of them producing a single product or service.

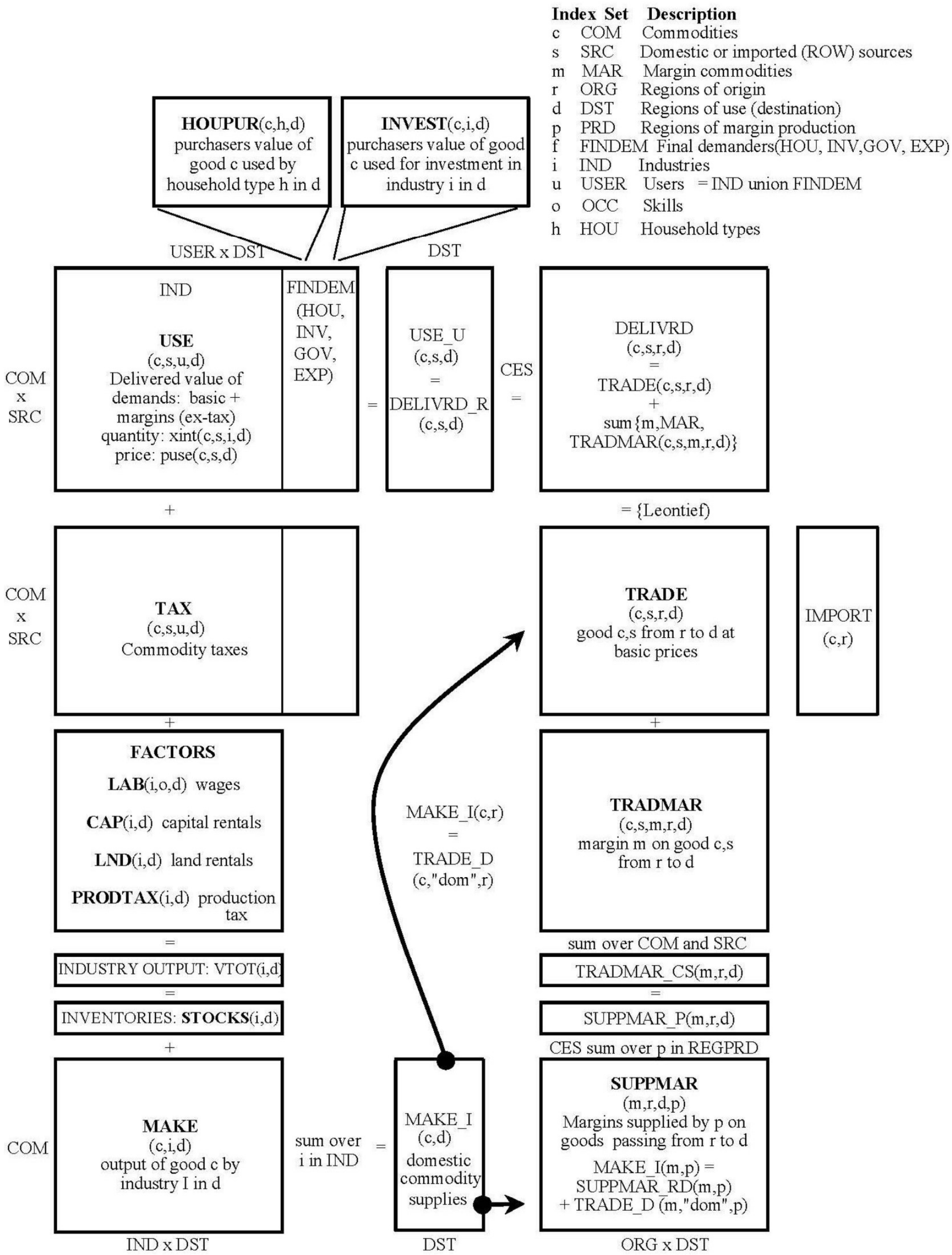
As is well known, CGE models rest on the input-output structure of the economy but assume more flexible functional forms than input-output models. Interestingly, upon national statistics, the database of the TERM-USA model adds a regional dimension based on regional statistics. The original database (Centre of Policy Studies, 2013) was updated to 2019 levels using a program developed by the Centre of Policy Studies (2019).

Figure A1 shows the basic structure of the TERM database. Each rectangle represents a flow matrix whose dimension is defined by the number of set it considers, e.g., the HOUPUR (c,h,d) is a 3 dimensional matrix as it is reflects household demand (h) in region d for commodity c. Sets description is shown at the top right of Figure A1. Price data on each matrix can be expressed as basic, delivered (which includes basic + trade or transport margins) or purchasers (basic + margins + taxes) values.

The left-hand side of Figure A1 shows the production side of each region in the economy, in a manner similar to a conventional input-output database for a region. On the top left, the U.S. E matrix shows industry demand for intermediates (i.e., production costs) and final user demands (households, government, investment, exports). The sum of production costs (industry demand for intermediates), commodity taxes (TAX matrix) and primary factor costs (labor, capital, land and production taxes) is shown in matrix VTOT. The latest is at the same time the sum of the value of domestic industry outputs (MAKE matrix) plus the value of inventories (STOCK matrix). Some balancing requirements are shown in the figure, e.g., the matrix U.S. E summed over users (U.S. E_U) shall be equal to DELIVRD_R, which is the sum of DELIVRD over regional sources (Horridge, 2012). The DELIVRD matrix, in turn, gathers the prices of domestic goods and services including trade and/or transport margins.

The matrices on the right-hand side represent the regional sourcing mechanism of the TERM database. The TRADE matrix shows inter-regional trade of domestic or imported (s) commodity (c) by origin (r) and destination (d). In the case of domestic source (s=domestic), “r” represents region of origin. When the source is imported (s= imported), “r” corresponds to port of entry. Therefore, import data shown in the IMPORT matrix is the result of adding up the imported part of the TRADE matrix over destinations (d). The model recognizes retail trade and road transport (i.e., margin commodities) needed to move the products between producers and final users. TRADMAR shows the margin value needed to facilitate each flow of the TRADE matrix (Horridge, 2012), and SUPPMAR gives information on the region where each margin is produced. TRADMAR does not include information on where the margin is produced, whereas SUPPMAR is not defined for either commodities or sources (the same proportion of margin is supply independently from the commodity). Thus, if we sum TRADMAR over commodities and sources we obtain the same as if we sum SUPPMAR over p (regions where margin is produced).

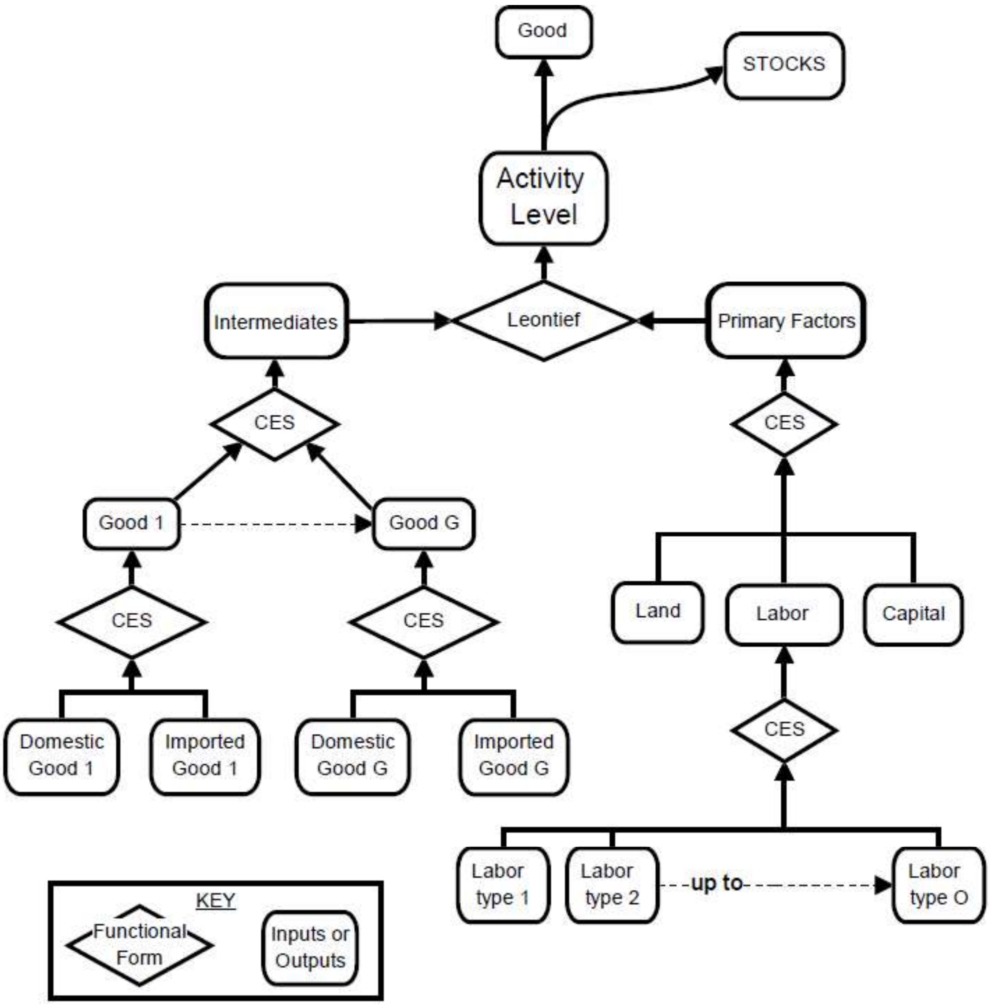
Figure 7. The TERM flows database



Source: Horridge (2012)

As in other CGE models, the TERM model contains thousands of equations that describe the behavior among the different agents in competitive markets (households, investors, government, exporters and importers), using neoclassical assumptions. These equations describe the equilibrium between demands and supplies and between costs and prices. Sectors are perfectly competitive. Thus, they produce undifferentiated goods or services under constant returns to scale technology and price at marginal costs, so that agents are price-takers. Therefore, product differentiation only exists based on the region of origin, following an Armington approach. The production functions are of the nested CES type and producers are assumed to behave in a cost-minimizing manner (refer to Figure A2 for further details).

Figure 8. TERM Production structure



Source: Horridge (2012)

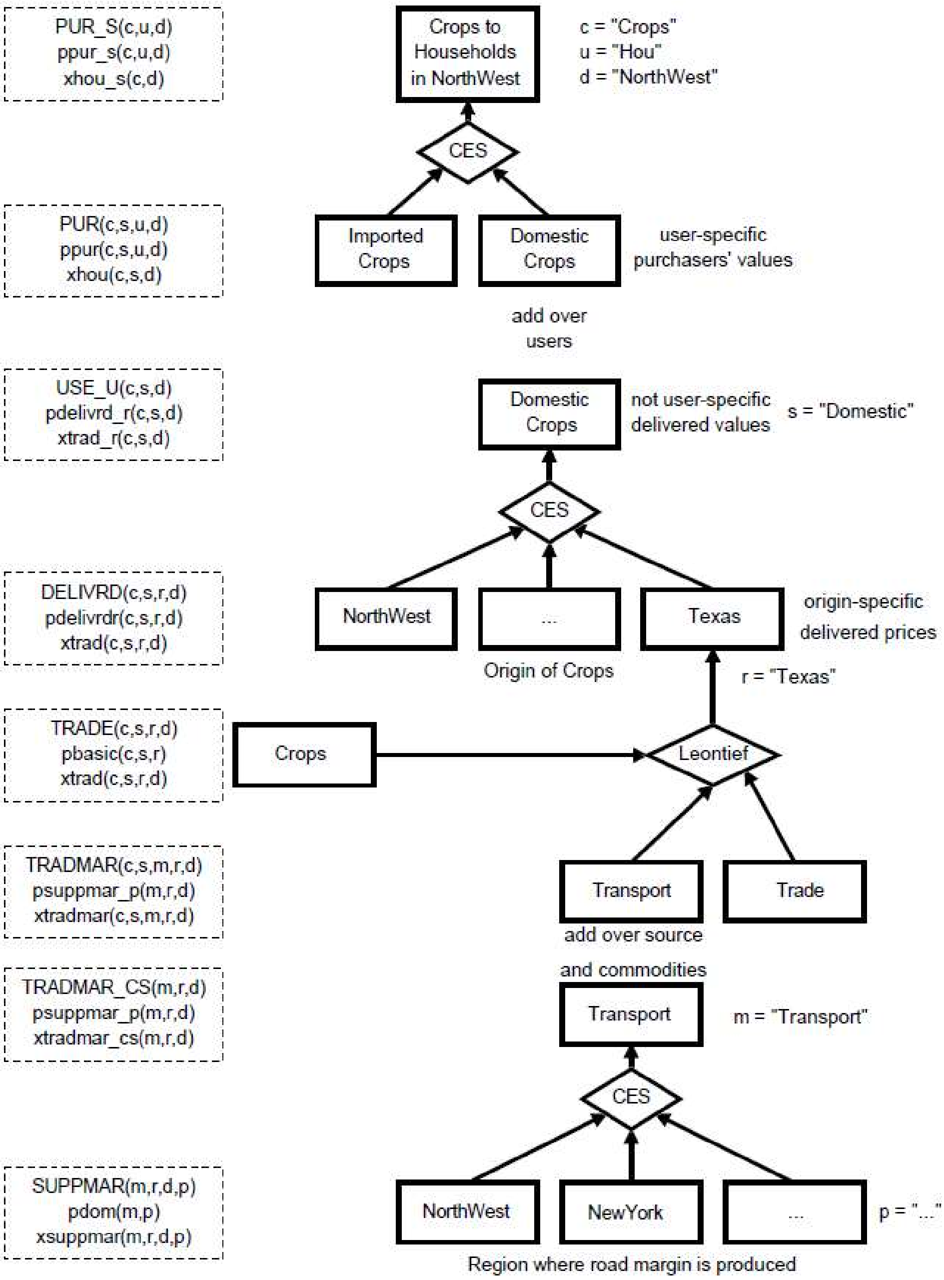
Producers demand both intermediates and primary factors, following a Leontief assumption, i.e., in proportion to industry output (Horridge, 2012). Each of the intermediate inputs' aggregate and primary factors' aggregate come from a CES aggregation of commodities from different regions (intermediates' aggregate) and a combination of land, labor and capital (primary factors' aggregate). Labor is at the same time a CES aggregation of 10 different occupations (2 skilled and 8 unskilled).

Figure A3 represents the TERM system of demand sourcing. The rectangles on the left side of the figure show the corresponding data matrices (shown in Figure A1) expressed as values (uppercase) and percentage change variables of prices (prefix "p") and quantities (prefix "x"). Although the scheme corresponds to a specific user (Household) demand for a specific commodity (Crops) coming from a specific region (NorthWest), this scheme applies to demands of any commodity coming from any region.

As in the production structure, the TERM demand sourcing has a nested structure. At the top nest, households combine domestic or imported varieties following a CES demand function, and data is expressed in purchasers' prices (PUR). In the specific example of Figure A3, the representative household in NorthWest demands imported and domestic Crops based on a CES function. Accordingly, matrix PUR_S is the result of adding up matrix PUR over sources. The rest of matrices shown in the nested structure are not user-specific, i.e., the delivered price of a domestic good or service (DELIVRD matrix) depends on its basic plus margin cost and it is the same for any given user at a given region.

Domestic varieties are differentiated by region of origin under a CES assumption. Following the example, delivered Crops from Texas (or any other region) is a Leontief composite of the basic price of Crops plus trade costs and transport costs. The latter can be differentiated by different circumstances, i.e., transport distance, transport modes, size, weight, etc. Thus, the margin value depends on the combination of origin, destination, commodity and source. As mentioned previously, the model is even more refined and considers that margins may be provided in different regions and considers the transport structure of each region (demand function follows a CES function). All users of a given good in each region have the same sourcing mix.

Figure 9. TERM Sourcing mechanisms



Source: authors' elaboration based on Horridge (2012)

All in all, the TERM model is a suitable tool for analyzing the impact of a specific public policy measure. Based on micro and macro-economic theory, it describes the behavior and interdependencies between the different agents of the economy. Differently from forecasting methodologies, CGE models allow to isolate the impact of a particular policy.

Moreover, the regional component, its distinctive feature, allows shocks to be introduced at the regional level, which cannot be done with other models.

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