

CHALLENGES IN GREENING THE ECONOMIES: A COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS OF THE INFLATION REDUCTION ACT (IRA)

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Abstract

This paper uses a dynamic Computable General Equilibrium model to analyze the macro and microeconomic implications of the Inflation Reduction Act (IRA) on the US economy. The IRA combines expansionary and contractionary policy measures. Its primary objective is to catalyze private investment in clean technologies and boost consumption through tax incentives and grants to households. Simultaneously, it incorporates tax reforms designed to prevent any escalation in the public deficit. Results show that the federal funding increase positively impacts GDP, peaking mid-decade due to the significant role of private consumption in the U.S. economy. However, domestic stimulus raises inflation and export prices, reducing external competitiveness, except in IRA-related sectors like Motor Vehicles, Electrical Equipment, and Other Mining, showing export growth. The stimulus enhances productivity, slightly reducing employment demand but significantly increasing real wages and long-term productive capacity, ultimately curbing inflation by the decade's end. The results indicate that the uncapped effect of the tax credits has a much more positive impact than the negative one in the form of a deficit increase. We examine the impact of an alternative funding approach in which tax increases predominantly fall on workers rather than industries. Results show a greater GDP increase but a significant reduction in household disposable income and savings.

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In addition to Scenarios 1 and 2, where the financing of the Inflation Reduction Act (IRA) is based on increased corporate taxes and other tax enforcements, we introduce Scenario 3, examining the impact of an alternative funding approach. In this scenario, tax credits are funded through elevated taxes on labor and capital income, targeting individuals rather than industries (Scenarios 1 and 2). The fiscal burden in this scenario predominantly falls on workers, given the 4 to 1 ratio between the wage bill and capital rentals in the U.S.

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 dependence on external sources of energy and reduce costs in the medium-long run and in turn reduce inflation.

The IRA includes a \$456 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 Act² (IIJA) (\$550 billion) and the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act³ 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, 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. Noteworthy is the allocation of \$43 billion for consumer incentives, targeting the affordability of cleaner technologies like electric vehicles, energy-efficient appliances, and renewable energy installations. 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 (Suarez-Cuesta & Latorre, 2023).

Beyond its primary focus on energy, the Act extends its impact to healthcare, aiming to curtail prescription drug costs and prolong Affordable Care Act subsidies, with anticipated net savings of \$173 billion through 2031. 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, as estimated by the Congressional Budget Office (2022).

² Signed into law in November, 2021, also known as Bipartisan Infrastructure Law (The White House, 2021b).

³ Signed into law in August, 2022, also known as CHIPS & Science Act (The White House, 2022).

In examining 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? (2) what would be the economic consequences of an unanticipated surge in green energy investment and production stemming from the uncapped tax credits considered? And finally (3) what if an alternative source of revenue is used to finance the investments?

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 Inflation Reduction Act (IRA) throughout the 2022-2031 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 proceed to a second scenario where green energy-related production and investment are increased by 50% compared to the initial CBO estimations. Lastly, in the third scenario we assume the IRA is financed through increases in income tax revenues instead of relying on the corporate tax and tax enforcement initially contemplated in the law.

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

The relationship between green energies and economic growth has evolved over decades, providing a nuanced understanding of the implications of environmentally conscious economic policies. Within the specific context of macroeconomic variables and avoiding a financial perspective, scholars have explored this relationship from various angles. The most prevalent perspectives in literature revolve around green energy consumption (Bhattacharya et al., 2016; Cevik et al., 2021; Chen et al., 2020; Kourtzidis et al., 2018). To a lesser extent, there is attention given to green energy production (Azretbergenova et al., 2021; Schreiner & Madlener, 2021; Bohlmann et al., 2016), and notably, green energy investments, forming the core of this analysis. Although this literature review predominantly focuses on the latter, it incorporates essential references that also encompass consumption and production approaches.

Early studies carried out by Marcuse & Gronki (1980) and Sterman (1982) conducted a macroeconomic impact analysis of energy transition through the implementation of renewable energy technologies in the country. The former combine an input-output model and an econometric model to address the consequences of renewable energy, differentiating between a scenario in which initial costs are financed through government deficit and a scenario in which those costs are financed by the consumers through higher taxes. Counteracting the assumed thinking of that time, they concluded that a transition to solar energy wouldn't significantly increase employment, and that it would not shift it 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 "backstop" energy, i.e., 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.

The closest precedent in U.S. history is the American Clean Energy and Security Act of 2009 (ACES), also known as the Waxman-Markey bill, aimed to establish a clean energy economy, cut greenhouse gas emissions, and boost energy independence. ACES proposed a cap-and-trade system for specific sectors to reduce emissions by at least 83% below 2005 levels by 2050. It also aimed to promote clean energy development through regulations, studies, and grants, creating jobs and reducing reliance on foreign energy. Although the House narrowly passed ACES on June 26, 2009, the bill did not proceed to a Senate vote. However, researchers analyzed how the American Clean Energy and Security Act (ACESA) might have affected the U.S. economy. They used different macro econometric models to predict its potential impact on growth, and their results supported earlier findings. Overall, the research indicated that the proposed shift to a lower-carbon economy under ACESA would not significantly alter the long-term growth path of the U.S. economy (Pollin et al., 2009).

Focusing on job creation, Wei et al. (2010) developed an analytical job creation model for the U.S. and provided insights into the clean energy industry, emphasizing the potential job creation associated with renewable energy. They find that all non-fossil fuel technologies create more jobs per unit energy than coal and natural gas. Recent studies on the U.S. are more focused on the consumption side of the renewables, rather than on the investment side. Cevik et al. (2020), used an econometric approach to examine the relationship between renewable and non-renewable energy consumption and economic growth in the U.S., finding a positive relation in the long run. Dabbousi & Abid (2022) found that the U.S. must exceed a certain threshold of renewable energy consumption for some sectors (electric power, industrial, residential, commercial and transportation) to achieve a positive economic growth from its renewable energy investments.

The study carried out by Batini et al. (2022) examines the impact of investing in green initiatives and other investments on economic growth within a nation 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.

Finally, 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 a dynamic CGE model, and conducted by the Energy Futures Initiative. Foster et al. (2023) employed 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. It's essential to note that this analysis relies exclusively on the CBO estimates published in August 2022. We aim to provide a macroeconomic and sectoral impact update by defining a scenario that considers the uncapped feature of the tax credits, along with an additional scenario considering an alternative means of financing the law.

Green investments have also been a subject of extensive study outside the U.S., with insights emerging from various countries and regions, contributing to a global understanding of the economic consequences of sustainable policies. In the aftermath of the 2008 financial crisis, Naqvi & Stockhammer (2018) explored the impact of green investments in high-income countries. Their findings indicated decreased overall investment levels, necessitating regulatory interventions or state-led investment programs to create favorable conditions for green investments. Barra and Ruggiero (2019) analyzed the employment effects of green energies in some high-income OECD countries. They use a fixed effects model to analyze the effects of green energies on employment and found that a 10% increase in output of green energies was found to determine a 0.3% increase in employment. In terms of energy consumption, Inglesi-Lotz (2016) uses an econometric approach to analyze the relationship between renewable energy consumption and economic growth and finds that a 1% increase of renewable energy consumption will increase GDP by 0.105% and GDP per capita by 0.100% while a 1% increase of the share of renewable energy to the energy mix of the OECD countries will increase GDP by 0.089% and GDP per capita by 0.090%.

Most of the studies analyzing the link between renewable energy and economic growth are European Union (EU) based. Under different assumptions for fossil fuel prices, domestic installations and international trade, Lehr (2012) examined large investments into renewable energies in Germany and found positive net employment effects for all scenarios, with renewable energy expansion reaching around 150 thousand jobs in and gross employment up to 600 thousand for the same year. Kristkova et al. (2022) demonstrated positive effects of green investments on GDP in the EU, providing quantitative cumulative GDP multipliers of around 1.1 for the longer term.

Using an econometric approach, Pimonenko et al. (2022) analyzed the contribution of green investments to sustainable economic prosperity and found that a 1% increase in green investments could lead to a GDP growth from 0.01% to 0.05%. A recent study by Guliyeve & Tatoğlu (2023) investigated the relationship between renewable energy and economic growth in European countries from 1970 to 2019 using panel data analysis and found a 1% in capital stock increase and a 1% increase in renewable energy consumption corresponded to an increase in economic growth (GDP) of 0.613% and 0.055% respectively.

At a country specific level, Schreiner & Madlener (2021) focused on the macroeconomic impacts of power grid infrastructure investments in Germany. They use a static input-output analysis to study how multiplier effects of grid investments impact macroeconomic outcomes. The results indicate that investments in Germany's power grid infrastructure yield beneficial impacts on both national and international economic production. Nonetheless, these investments lead to adverse multiplier consequences for value added, employment, and tax revenues.

Also in 2021, Gelo et al. (2021) added to the literature by focusing on the economic impacts of planned investments in renewable energy sources for electricity production in Croatia. The analysis, spanning from 2021 to 2030, utilized input-output tables for Croatia, revealing relatively modest macroeconomic effects. This study emphasizes the need to revise investment structures for strategic focus on sources with a high domestic component and the development of production capacities for wind and solar energy technologies.

Even though the EU and U.S. had led the green investments in the world in the 1990s, their leadership was shifted to China in 2009. Eyraud et al. (2013) observation of China's leadership in green investments set a global trend. Subsequent studies by Jiang et al. (2022) and Liu et al. (2022) explored the Chinese experience, revealing an inverted U-shaped relationship between the scale of green investment and carbon dioxide emission limitations.

Jiang et al. (2022) analyzed the impact of ecological innovation and green investment on China's CO₂ emissions. The study built a data analysis model and found an inverted U-shaped relationship between the scale of green investment and carbon dioxide emission limitations. Liu et al. (2022) examined the relationship between green energy investment, renewable energy consumption, and carbon neutrality. They found that green energy investment and renewable energy consumption positively contribute to carbon neutrality, which in turn promotes economic growth.

Similarly, Wan & Sheng (2021) conducted a provincial panel analysis in China and found that green investment, clean energy consumption, and economic growth are positively correlated. However, it also found that green investments do not have a significant effect on CO₂ emissions, suggesting that green investments may even contribute to economic benefits even though its environmental benefits could remain low. Finally, focusing on FDI in renewables and using data from 30 Chinese provinces from 2000 to 2019, Wei et al (2022) found that GDP, green energy consumption and foreign direct investment have a strong link only in the long run.

In conclusion, this literature review underscores the evolving understanding of the economic consequences of green investments, offering diverse insights from studies conducted within the U.S., the EU and China. These findings collectively contribute to evidence-based policymaking for sustainable economic development on both national and international scales. However, there is a research gap in the specific context of the U.S., particularly in terms of comprehensive general equilibrium modeling and economy-wide impact assessments. Moreover, in contrast to existing literature that predominantly explores the positive nexus between national-level renewable energy consumption and economic growth in the U.S., our research adopts a distinctive approach by delving into the specific realm of major private investments facilitated by federal tax incentives in the renewable energy sector. Our CGE approach aims to provide a comprehensive understanding of how financial incentives can influence national economic growth dynamics.

3. Methodology

We use 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 USAGE database used for this analysis is based on an updated version from 2011. Relying on the same sources⁴, it has been updated to 2021 using data on GDP, private consumption, investment, trade, wages, exchange rate and consumer price index over the 2011-2021 period. The initial solution in the model is solved with data from the base year (2021), 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 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 intricate interplay between various economic sectors and the decisions made by different entities such as households, industries, and government. The CGE approach provides a comprehensive

⁴ Detailed data sources in Section 4. Simulations

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 2010, chapter 1; 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 maximization of a Klein-Rubin utility function within the constraints of their budget. The model formulates the specific units used by each industry to build capital as a combination of domestic and imported commodities that minimizes costs. In terms of government consumption, it sets an exogenous variation for the baseline simulation, while it links it to the variations in household consumption for the policy simulations. 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.

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 the realm of government fiscal accounts, a similar mechanism governs financial asset/liability accumulation, where changes in public sector debt are tied to debt incurred in a particular year and the interest payable on previous debt. Adjustments to the national net foreign liability position are influenced by the annual investment/savings imbalance and revaluations of assets and liabilities.

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 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.

Due to the specific requirements of this analysis, we have introduced a variable (and the associated equation) into the model related to tax credits. In the case of production, the model does have a defined variable that calculates the variation in revenue from production taxes at the industry level. However, in the case of investments, no such variable is defined. Given that the IRA encompasses both production and investment tax credits that target specific industries, we have modified the model to incorporate this variable and the corresponding equation (more details on Appendix II).

One of the key characteristics of an analysis utilizing the CGE methodology is the definition of closure, which 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). In this context, to introduce specific shocks to target variables we modify the closure in the following terms:

- i. **Investment:** In the model, annual investment considers the rate of return from the previous year, maintaining a fixed investment/capital ratio. However, for sectors categorized as IRA (Utilities, Other Mining, Electrical Equipment, Motor Vehicles and Parts), we fix the investment variable and introduce a positive shock (increase) to it while keeping the investment/capital ratio unfixed. To simulate the effect of tax credits, we introduce a negative shock to the investment tax revenue for IRA industries according to the estimated distribution of public funds among industries shown in Table 1.
- ii. **Production:** To stimulate growth in IRA sectors, we endogenize the technological change variable, assuming a positive impact on productivity. Similar to the previous point, we fix the production tax revenue variable for IRA industries and introduce a negative shock to simulate government spending on production tax credits.
- iii. **Tax Revenues:** Shocks are introduced to the variable mentioned in (ii), but with the opposite sign (+), extending them to all industries listed in the Fortune (2022) list.
- iv. **Direct Transfers:** to incorporate the shock related to the ACA extension, we fix all variables constituting total transfers (grants, unemployment, age, other, net interest) and only shock the grants variable. We assume that increasing grants will not displace others, maintaining government spending in other areas. An assumption regarding the average propensity to consume is made. As households receive additional grants from the IRA, private consumption is expected to be decoupled from real GDP, depending on household disposable income. Post the ACA extension deadline in 2026, we assume private consumption follows GDP in the long run, aligning with macroeconomic evidence, especially in a country like the U.S. where private consumption constitutes approximately 70% of GDP.

4. Simulations

a. Baseline forecast

The baseline forecast is a necessary first step in order to conduct the policy simulation as it establishes a business-as-usual baseline path for the economy. 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 2011–2022 represent available historical 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), U.S. Office of Management and Budget and Federal Reserve Bank of St Louis (2023), while forecast values imposed for the baseline simulation corresponding to the 2023-2031 period are taken from official tables from the Congressional Budget Office (2023). Our baseline forecasts for both updating the database and running the baseline scenario 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.

b. Policy scenarios

Table 1 illustrates the allocation of funds over the period 2022-2031, categorizing between (1) Outlays and (2) Revenues. The difference between the two corresponds to the estimated reduction in the public deficit resulting from this legislation. Regarding Outlays, two significant provisions stand out, being the climate related provisions the higher share. These include the total amount of tax credits allocated to each sector each year, and which is simultaneously divided into investment tax credits (50%) and production tax credits (50%). Additionally, (2) there is an increase in healthcare expenditure directly benefiting households through an extension of the Affordable Care Act until 2026, constituting a direct boost to household disposable income.

Table 1. Official estimates of outlays and revenues derived from the Inflation Reduction Act (\$US billion)

\$US billion	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Total
Outlays	0.1	25.5	45.0	58.6	51.0	55.5	58.7	56.0	53.8	52.7	457.0
Climate related provisions (50% investment; 50% production)*	0.1	13.4	22.0	34.6	46.1	55.5	58.7	56.0	53.8	52.7	393.0
Utilities	0.1	8.6	14.2	22.3	29.7	35.7	37.8	36.1	34.6	33.9	253.0
Electrical Equipment	0.0	1.9	3.2	5.0	6.6	8.0	8.4	8.1	7.7	7.6	56.5
Motor vehicles / and parts	0.0	1.5	2.5	4.0	5.3	6.3	6.7	6.4	6.2	6.0	44.9
Other Mining	0.0	1.3	2.2	3.4	4.5	5.4	5.8	5.5	5.3	5.2	38.5
Affordable Care Act extension	0.0	12.1	23.0	24.0	4.9	0.0	0.0	0.0	0.0	0.0	64.0
Revenues	-0.1	47.7	46.7	46.1	45.9	66.8	92.1	104.3	117.5	127.0	694.0
Corporate minimum tax + IRS tax enf.	-0.1	45.8	43.8	33.6	34.3	39.6	46.6	53.3	58.6	63.3	418.9
Prescription drug pricing reforms	0.0	1.9	2.9	12.5	11.6	27.2	45.5	51.0	58.8	63.7	275.1
Net budget effect	-0.2	22.2	1.7	-12.5	-5.1	11.3	33.5	48.2	63.7	74.3	237.0

Source: authors' own elaboration based on Congressional Budget Office ([2022](#))

Despite the significant differences in objectives, outcomes, and conclusions arising from each scenario, the simulations conducted to estimate the effects of the IRA on the U.S. economy share several features. As mentioned in the preceding section, we run three simulations:

- (1) Climate-related investments and production increases in targeted industries, as estimated by the Congressional Budget Office (CBO, 2022).

(2) Climate-related investments and production increases in targeted industries, considering uncapped tax credits, and

(3) IRA effects considering an alternative funding approach to corporate tax increases⁵.

Table 2. Shocks introduced.

Variable shocked	Sectors targeted	1. CBO Scenario	2. Uncapped scenario	3. Alternative funding scenario
Investment tax revenues (-)	IRA	- \$196.5 bn	- \$295 bn	- \$196.5 bn
Production tax revenues (-)	IRA	- \$196.5 bn	- \$295 bn	- \$196.5 bn
Investment	IRA	\$295 bn	\$440 bn	\$295 bn
Production	IRA	\$295 bn	\$440 bn	\$295 bn
Grants	-	\$60 bn	\$60 bn	\$60 bn
Aggregate indirect tax revenues (+)	All	\$419 bn	\$419 bn	\$419 bn

Table 2 lists the dimensions of the shocks introduced in the analysis. Scenarios 1 and 2 differ in the scale of investment and production increases, and Scenario 3 differs from the previous in that it employs a different avenue of tax revenue generation, i.e., financing of the plan. For a better understanding of the simulations, the following paragraphs elaborate in detail on the common foundation of the three scenarios.

Regarding the climate related provisions within the IRA, we introduce the double effect of investment and production tax credits contemplated in the IRA, i.e., the public spending on tax credits and the private investments and production increase derived from this fiscal stimulus. The allocation of funds across industries follows the Congressional Budget Office (2022) and is shown in Table 1.

The IRA introduces a high level of difficulty for researchers and policymakers to measure its real dimension, as its main provision (climate investments) is based on uncapped tax credits. To address this challenge, we first estimate its impact using CBO (2022) estimates (Scenario 1), and an additional scenario (Scenario 2), in which we assume the investment and production increases will be 50% higher than the expected by CBO. This 50% increase is based on the current performance of the law, which already exceeds the initial estimates from the CBO (2022). According to various sources such as (Bistline et al., 2023; Credit Suisse, 2022) considering the private investment announcements resulting from the IRA in the first year of the law's implementation, the final estimated cost would surpass the initial \$393 billion projected by the CBO, reaching over \$1 trillion. This represents a difference of more than 100%, thus we stay on the conservative side.

To estimate the size of the shocks we rely on the multiplier effects of climate related public spending estimated and analyzed by Batini et al. (2022), Mustea (2013) and Jiang et al. (2022), that conclude that the fiscal multiplier is between 1.1 and 1.7. We assume a fiscal multiplier 1.5, meaning that for each \$1 dollar spent by the government (in the form of tax credits), we expect the private sector to invest \$1.5 dollars. We therefore apply a 1.5 multiplier to the public spending (\$393 billion), i.e., we introduce a

⁵ For this scenario we assume the estimates from Congressional Budget Office (2022), i.e., dimension of the shocks is the same as Scenario 1.

total investment increase of \$295 bn and output increase of \$295 bn (totaling \$590 bn) in the CBO scenario⁶, while in the ambitious scenario the government spending is of \$590 billion and the total investment increase is of \$880 billion (\$440 bn of investment increase and \$440 bn of production increase). Therefore, staying on the conservative side, we consider a second scenario in which both the cost (tax credits) and the investment and production increase by 50% compared to the values estimated by the CBO.

To simulate the double effect of investment and production tax credits⁷, we (1) increase investment and output of the industries directly benefiting from the tax credits and (2) shock the corresponding tax revenue variables (investment tax revenue⁸ and production tax revenue). The subsidies in the form of tax credits (shocks to investment and production tax revenues) are introduced as negative shocks to the variables related to tax revenues.

As shown in Table 1, climate-related investment tax credits are estimated at approximately \$393 billion, distributed over ten years but with a heightened concentration during the second half of the decade. These \$393 billion are allocated to various provisions spanning multiple industries. In the USAGE model, sectors are defined according to NAICS (two and three digits). Drawing from the items included in the Congressional Budget Office (2022), IRA provisions can be grouped into the following USAGE industries (corresponding 3-digit NAICS code in parentheses):

- Utilities (NAICS 221): Includes climate-related funds dedicated to electric power, natural gas, steam supply, water supply, and sewage treatment and disposal.
- Electrical equipment (NAICS 335): Encompasses primary battery manufacturing and charging stations.
- Motor vehicles and motor vehicle parts (NAICS 336): Covers funding for clean commercial vehicles and medium- and heavy-duty electric vehicles.
- Other mining (NAICS 212): Investments in this industry mainly focus on critical minerals (primarily lithium, cobalt, nickel, and copper), crucial for energy transition technologies.

Regarding the extension of the existing Affordable Care Act (ACA), the shock is introduced as an increase in direct transfers from the government to households of \$64 billion through years 2023-2026 (see Table 1). When households receive direct transfers for healthcare, it essentially provides them with financial resources that they can allocate to other aspects of their budget. This additional income can contribute to an increase in disposable income, which is the amount of money available to individuals or households for spending and savings after taxes. Households are assumed to be utility maximizers in the USAGE model and allocate their income across commodities based on their preferences and subject to budget constraints.

In terms of revenue, the CBO not only anticipates funding through tax credits but also foresees a reduction in the public deficit. The increments in tax revenue, as previously mentioned, entail an elevation in corporate taxes and other tax enforcement measures. However, introducing a shock uniformly across all sectors in the model (76) would

⁶ The shares are based on Congressional Budget Office (2022) estimations.

⁷ The share between investment and production tax credits is approximately 50% investment - 50% production, according to information from the CBO (2022).

⁸ This new variable defined across industries is explained in Section 3. Methodology.

distort results for two key reasons. Firstly, the IRA predominantly targets the wealthiest corporations, and not all sectors encompass companies with profits exceeding one billion dollars (the 15% minimum corporate tax applies solely to companies surpassing this profit threshold). Secondly, certain industries exhibit negative production taxes, implying they are subsidized.

To enhance the precision of the shock, we structure its distribution to reflect an unequal sharing of responsibility. This is grounded in the factual sectoral distribution as delineated in the 2022 Fortune 500 list⁹ (Fortune, 2022). The list showcases the largest U.S. companies, each with revenues exceeding \$2 billion, providing a comprehensive overview of their total revenue. Table 3 provides a breakdown of the expected tax burden distribution for each industry under the IRA.

Given that the USAGE model does not explicitly model corporate taxes, we introduced the shocks through production taxes. While production taxes are not identical to corporate taxes, they share similarities in that they are linked to economic activities, such as production and business operations. Both aim to generate revenue for the government from economic transactions. This approach serves as a practical and effective alternative to capture the effects on the economy. By introducing shocks to production taxes, the model accommodates the integrated impact on production activities, considering the direct link between these taxes and the costs associated with producing goods and services. This method is particularly relevant as the primary focus of this study is to comprehend the broad economic implications of alterations in the taxation of production activities.

On the other hand, the IRA allocates \$80 billion to the IRS to enhance tax enforcement, reduce tax evasion, and improve efficiency in tax collection. As a result, it anticipates an increase in revenue over the period 2022-2031 of approximately \$205 billion, yielding a positive balance of about \$125 billion. Summed to the estimated \$294 billion that will be raised through the minimum corporate tax enforcement previously mentioned, the total increase in tax revenue is estimated at \$419 billion (see Table 1). The simulation does not differentiate corporate tax enforcement from the rest of IRS tax enforcements. Thus, we apply the shock at once, assuming the sectoral distribution in Table 3. So, \$419 bn of tax revenue is raised according to the shares displayed in Table 3, which basically resemble the presence of the largest firms (over \$2 billion revenue¹⁰) across U.S. industries.

Lastly, the IRA incorporates an allocation projected to decrease the deficit by \$275 billion (as per CBO estimates), attributed to cost savings in healthcare resulting from a series of reforms. Since the exclusive aim of this allocation is deficit reduction and to maintain the integrity of our simulation results, we opt not to include this provision in our analyses. Introducing this allocation would inevitably impact either prices or demand (depending on the type of shock introduced), inaccurately reflecting reality, as public demand is not anticipated to change due to these reforms. The shock would propagate through the model, leading to distortions in public demand.

5. Results

Table 3 provides a comprehensive overview of the key macroeconomic variables for the three scenarios under consideration. Results are expressed as the cumulative percentage deviations away from the baseline.

5.1. Scenarios 1 and 2.

⁹ See full distribution of shocks in Table A1 (Appendix)

¹⁰ Tax revenue increases to finance the IRA mainly correspond to a minimum corporate tax to corporations with over \$1 billion revenue.

Scenarios 1 and 2 are designed to isolate and measure the economy-wide impact of the Inflation Reduction Act of 2022. Scenario 1 is based on the initial outlays, revenues, and deficit estimations from the Congressional Budget Office (2022), while Scenario 2 includes a larger shock related to the uncapped feature of the tax credits. The items related to revenue increases remain constant in both scenarios. This allows an easy comparison between both scenarios in Table 3.

The GDP outcomes in both Scenarios 1 and 2 are notably modest, a trend that aligns with the findings of the singular¹¹ impact analysis specifically dedicated to the IRA conducted by Foster et al. (2023) and with most of the previous literature on major infrastructure investments (see section on literature review). Although this legislative initiative achieves a noteworthy milestone in clean energy promotion, amounting to \$393 billion and encompassing augmented investment and production, it constitutes only about 2.3% of the total U.S. GDP.

The primary provisions of the IRA, i.e. tax credits, drive a historic surge in domestic investment and production of clean energy, and the extension of the Affordable Care Act (ACA) contributes to a rise in household disposable income. However, in the longer run, the fiscal contraction arising from corporate tax increases and tax enforcement diminish an important part of the positive effects of the stimulus. The results show their most positive outcomes in the mid-term, around the middle of the decade, when the GDP reaches 0.1% in Scenario 1 and 0.27% in Scenario 2. The main reason is found in the distribution of provisions, as it is from the middle of the decade onwards when the CBO (and the IRS) estimate that tax increases for large corporations will take effect.

Two are the key factors affecting GDP growth in the 2022-2031 period. The first comes from the increased production due to production tax credits, making up 50% of total tax credits considered in the IRA. This significant share allocated to production tax credits clearly and directly influences the GDP growth path. On the other hand, the increased purchasing power stemming from the direct transfers from the government increases the purchasing power of households. In the U.S., the most significant share of the GDP corresponds to private consumption (approximately 70%), thus GDP follows private consumption closely.

Table 3. Macroeconomic results.

¹¹ To the best of our knowledge

Scenario 1. CBO	% change deviations with respect to the baseline by year (cumulative)								
Variable	2023	2024	2025	2026	2027	2028	2029	2030	2031
Real household consumption	-0.01	0.07	0.14	0.09	0.10	0.07	0.05	0.03	0.02
Aggregate real investment	0.13	0.28	0.38	0.33	0.44	0.36	0.30	0.25	0.22
Quantity of private investment	0.15	0.31	0.43	0.40	0.51	0.43	0.37	0.31	0.27
Quantity of public investment	-0.08	-0.03	-0.07	-0.13	-0.09	-0.16	-0.16	-0.18	-0.18
Aggregate real government demand	-0.01	0.07	0.14	0.10	0.11	0.07	0.05	0.03	0.03
Export volume index	-0.03	-0.17	-0.32	-0.32	-0.39	-0.41	-0.42	-0.41	-0.39
Import volume index, CIF weights	0.02	0.28	0.44	0.30	0.42	0.33	0.28	0.23	0.20
Real GDP, expenditure Side	0.01	0.05	0.09	0.06	0.08	0.04	0.02	0.00	0.00
Aggregate employment	-0.05	0.03	0.08	0.05	0.06	0.01	-0.02	-0.04	-0.04
Real wage for consumers	-0.02	-0.01	0.04	0.06	0.09	0.09	0.08	0.06	0.04
Consumer price index (CPI)	0.03	0.23	0.31	0.14	0.21	0.16	0.14	0.12	0.09
Scenario 2. Uncapped effect	2023	2024	2025	2026	2027	2028	2029	2030	2031
Real household consumption	-0.03	0.11	0.26	0.25	0.28	0.22	0.13	0.07	0.06
Aggregate real investment	0.21	0.47	0.65	0.66	0.79	0.67	0.55	0.44	0.37
Quantity of private investment	0.24	0.52	0.72	0.76	0.91	0.80	0.66	0.54	0.47
Quantity of public investment	-0.05	0.03	-0.10	-0.09	-0.11	-0.23	-0.29	-0.33	-0.36
Aggregate real government demand	-0.03	0.11	0.27	0.25	0.28	0.22	0.14	0.08	0.06
Export volume index	0.04	-0.12	-0.26	-0.30	-0.39	-0.43	-0.46	-0.46	-0.43
Import volume index, CIF weights	-0.05	0.34	0.55	0.50	0.61	0.50	0.40	0.31	0.24
Real GDP, expenditure Side	0.04	0.13	0.24	0.24	0.27	0.21	0.13	0.07	0.05
Aggregate employment	-0.06	0.07	0.18	0.15	0.16	0.07	-0.01	-0.07	-0.07
Real wage for consumers	-0.03	0.01	0.10	0.17	0.25	0.28	0.27	0.24	0.20
Consumer price index (CPI)	0.02	0.29	0.38	0.26	0.32	0.25	0.22	0.19	0.13
Scenario 3. Alternative funding	2023	2024	2025	2026	2027	2028	2029	2030	2031
Real household consumption	0.10	0.15	0.16	0.11	0.13	0.11	0.08	0.06	0.05
Aggregate real investment	0.32	0.36	0.43	0.37	0.50	0.42	0.38	0.32	0.30
Quantity of private investment	0.33	0.39	0.48	0.44	0.58	0.50	0.45	0.39	0.36
Quantity of public investment	0.22	0.11	-0.02	-0.10	-0.04	-0.12	-0.13	-0.15	-0.16
Aggregate real government demand	0.10	0.15	0.17	0.11	0.13	0.11	0.08	0.06	0.05
Export volume index	-0.12	-0.26	-0.34	-0.27	-0.31	-0.31	-0.31	-0.30	-0.28
Import volume index, CIF weights	0.27	0.39	0.38	0.19	0.33	0.26	0.23	0.19	0.17
Real GDP, expenditure Side	0.08	0.10	0.12	0.11	0.13	0.11	0.08	0.06	0.05
Aggregate employment	0.08	0.08	0.08	0.04	0.06	0.02	0.00	-0.02	-0.02
Real wage for consumers	0.04	0.08	0.12	0.14	0.17	0.18	0.18	0.17	0.15
Consumer price index (CPI)	0.22	0.34	0.30	0.08	0.19	0.14	0.12	0.10	0.08

Source: authors' own estimations.

The upsurge in private investment, catalyzed by the implementation of tax credits, induces a crowding-out effect on public investment. This phenomenon denotes a reduction in public investment levels as a consequence of the stimulus of private investment. Despite the negative impact on public investment (see Table 3), public investment constitutes roughly a 20% of the aggregate investment in the U.S. Consequently, the repercussions on the Gross Domestic Product (GDP) remain marginal.

Fiscal stimulus results in a substantial boost to domestic production and investment, primarily driven by IRA sectors and closely related industries. This surge in domestic production initially lowers the prices of IRA-related commodities, but the increased investment triggers a general rise in both investment demand and prices. Additionally, the higher household disposable income contributes to an overall price increase. These inflationary pressures are notably prominent in sectors not directly benefiting from tax credits, as highlighted in Table 4. However, in the IRA sectors, this dynamic results in a net depreciation of the basic price.

While the output shock initially reduces commodity prices, this effect is counteracted by increased investment and, notably, the rise in tax revenue impacting various sectors, including both IRA and non-IRA industries, propelling prices upward. In the IRA-benefited industries, the net price effect remains negative (falling prices), whereas in the non-benefited IRA industries, the net effect is positive (increasing prices), resulting in inflation increases at an aggregate level. Notably, Scenario 2 exhibits a faster initial rise in inflation, but the economy stands to benefit in the medium term, potentially leading to a complete reduction in inflation in the long run.

Table 4 presents the percentage change impact of the IRA at a sectoral level for a selected set of variables under Scenario 1 (CBO estimations). Starting with production and considering that our simulations isolate the effects of the IRA, the only industries experiencing an output increase are those directly benefiting from this law (Utilities, Other Mining, Electrical Equipment, and Motor Vehicles and Parts), along with industries related to them. Examples of the latter include manufacturing industries such as Mining Services, Construction, Non-metallic mining products, and services industries such as Rail Transport or Pipeline. The commodities produced by these industries represent a high share of intermediate goods demanded by IRA industries. Governmental industries also increase their activity, assuming that government demand follows private consumption, which is positive during the decade.

As mentioned earlier, at the sectoral level, prices increase across the board except in IRA sectors (production increase, unchanged demand, and price decrease). The widespread price increase also raises the price of primary factors, and wages grow by 0.13% in 2031. This growth occurs proportionally across all sectors, assuming that employment is mobile across sectors. Employment demand adjusts with the increase in sectoral production, resulting in increases/decreases similar to production. At the top level of the production nesting structure, intermediate commodity composites and a primary-factor composite are combined using a Leontief or fixed-proportions production function in the USAGE model. Consequently, they are all demanded in direct proportion to industry output or activity.

Table 4. Cumulative sectoral results (Year 2031) for manufacturing industries under Scenario 1.

USAGE Sector	Production	Labor demand	Basic price	Exports	Imports	Priv.Cons. DOM	Priv.Cons. IMP
Farms	-0.19	-0.24	0.07	-0.35	0.10	-0.06	0.18
ForestFish	-0.13	-0.14	0.11	-0.45	-0.03	-0.01	0.01
OilGasExtrac	-0.12	-0.09	0.44	-1.05	0.54	0.10	0.10
OthMining	0.97	0.61	-0.43	2.35	-0.71	0.17	-0.32
MiningServ	0.18	0.21	0.16	-0.08	0.00	0.10	0.10
Utilities	1.99	1.82	-1.69	5.06	-3.79	1.66	-3.11
Construction	0.12	0.05	0.04	-0.39	0.00	0.10	0.10
WoodProd	0.00	-0.01	0.08	-0.45	0.17	-0.07	0.00
NonMetMinPrd	0.02	0.01	0.03	-0.29	0.08	-0.07	0.00
PrimMetals	-0.12	-0.15	0.11	-0.38	0.17	-0.06	0.02
FabMetProds	-0.07	-0.07	0.16	-0.57	0.26	-0.13	0.04
Machinery	-0.07	-0.06	0.23	-0.68	0.58	-0.18	0.04
CompElecPrds	-0.35	-0.35	0.39	-0.96	0.32	-0.28	-0.04
ElectEquip	1.01	0.39	-0.59	1.53	-0.35	0.55	-0.29
MotVehParts	0.29	0.18	-0.14	0.22	-0.04	0.28	-0.04
OthTransEqu	-0.22	-0.23	0.12	-0.45	0.02	-0.05	0.03
Furniture	-0.01	-0.02	0.11	-0.47	0.11	-0.09	0.04
MiscManu	-0.31	-0.32	0.27	-0.80	0.10	-0.20	0.01
FoodBevTob	-0.16	-0.17	0.18	-0.60	0.38	-0.09	0.34
TextMillProd	-0.11	-0.12	0.08	-0.35	0.04	-0.08	0.01
Apparel	-1.06	-1.10	0.75	-1.81	0.01	-0.67	-0.02
PaperPrds	-0.09	-0.10	0.06	-0.34	0.09	-0.01	0.09
Printing	-0.02	-0.03	0.06	-0.35	0.09	-0.07	0.01
PetroCoalPrd	-0.03	-0.06	0.14	-0.43	0.27	-0.03	0.29
ChemicalProd	-0.15	-0.17	0.12	-0.46	0.17	-0.07	0.08
PlastRubPrd	-0.07	-0.08	0.09	-0.43	0.12	-0.09	0.02
WholesaleTrd	-0.03	-0.04	0.14	-0.56	0.00	0.10	0.10
RetailTrd	-0.01	-0.02	0.31	-0.24	0.00	-0.17	0.42

Source: authors' own elaboration.

Note: full table in Appendix

The last five columns of Table 4 reflect sectoral results in trade (exports, imports) and private consumption of domestic and imported commodities. The domestic appreciation phenomenon explained earlier translates into higher export prices and, consequently, a relative reduction in import prices. There is a widespread increase in import demand in most sectors as a consequence, except in sectors where IRA stimuli lower prices and generate a significant increase in domestic demand, reducing imports. Industries with higher external activity, such as Computer and Electronic Products, Machinery, Chemical Products, or Petroleum and Coal products, and services like Rental and Leasing services, Management of Companies and Enterprises, and, to a greater extent, Foreign Holidays and Tourism Exports, are more adversely affected. In contrast, for IRA sectors, the effect is the opposite. The increase in investment slightly raises prices, but the production increase as a consequence of the production tax credits is much more decisive in reducing prices and, consequently, export prices. This benefits the export of Electrical Equipment (primary battery manufacturers, charging

stations), Motor Vehicles and Parts (electric vehicles), and Utilities (including renewable energies) in terms of the foreign market. This raises concerns among European officials who fear a negative impact on their competitiveness due to the IRA (Scheinert, 2023).

In terms of private consumption, the IRA sectors exhibit a divergent pattern compared to other industries. Essentially, U.S. households undergo a noteworthy transition, shifting their consumption preferences from imported goods to domestically produced commodities originating from IRA-related industries. This shift underscores the impact of the Inflation Reduction Act on reshaping consumer behavior and fostering a preference for domestically sourced products.

Regarding the differences between Scenarios 1 and 2, the positive effect of a higher demand for tax credits than expected by the CBO would be considerably greater and would not follow a linear proportion. For instance, despite a 50% difference in the increase in investment in IRA industries between the two scenarios, the fiscal stimulus would result in an almost 100% increase in private investment in Scenario 2 compared to Scenario 1, shifting from a 0.27% to 0.47% increase. In the labor market, a positive effect in the same direction would be observed. While, considering the CBO estimates, the IRA would generate a cumulative effect of -0.04% by the end of the period and an increase in real wages of 0.04%, in the second scenario, employment would only decrease cumulatively by -0.03%, while real wages would increase by 0.20%. Furthermore, another surprising result in this regard is that, despite the significant difference in the outcomes just mentioned, the trade results are practically identical.

The reason for these results is primarily found in the inflationary effect of domestic stimulation and the distribution of funds by industries. In Scenario 2, the price increase effect is much higher throughout the decade, leaving a difference of more than double in the CPI in the year 2031 (0.05% in Scenario 1 and 0.13% in Scenario 2). On the other hand, the Utilities sector gathers 65% of the climate-related funds from the IRA. This sector, as seen, has very limited external demand, and therefore, the negative effect on exports has a significantly reduced impact at an aggregate level. Hence, the trade results are similar, while greater differences occur in other variables.

Finally, although the difference between this scenario and the previous one revolves around the magnitude of shocks related to increased investment and production in industries benefiting from the IRA (Utilities, Other Mining, Motor Vehicles and parts, and Electrical Equipment), in both scenarios, the dimensions of shocks related to increased tax revenue remain constant. The plan does not consider additional measures to finance this law in the event of a higher demand for tax credits. Thus, in Scenario 2, the expected reduction in the public deficit obtained in Scenario 1 (237 billion) is no longer achieved, as the cost of these tax credits increases considerably.

The impact on prices resulting from the Inflation Reduction Act (IRA) holds significant ramifications for foreign trade, contingent upon the unique characteristics of IRA industries. As presented in Table 1, the appreciation of the economy contributes to a reduction in U.S. export demand and a simultaneous increase in imports. This shift translates into a decrease in the country's external competitiveness.

Analyzing the sectoral impact on exports in scenarios 1 and 2, the Utilities sector is expected to undergo the most significant export increases, reaching 5% (\$415 billion) and 13% (\$1170 million) by 2031, respectively. Interestingly, the Utilities sector stands out compared to Motor Vehicles and Parts, Electrical Equipment and Other Mining, with each of the latter experiencing higher export increases than the Utilities industry. Despite these industries collectively representing 35% of climate-related funds under the IRA, those with higher export shares are projected to witness more substantial growth in exports in absolute terms. The Motor Vehicles and Parts sector is predicted

to see a 0.22% (\$570 million) increase and a 1% (\$2600 million) increase by 2031 due to the IRA, while the Electrical Equipment industry is expected to experience a 1.53% (\$1415 million) increase under Scenario 1 and a 5.56% (\$4621 million) increase under Scenario 2. Other Mining is poised to observe the most substantial export increase in absolute terms, raising exports by 2.4% (\$1713 million) and 9.9% (\$7140 million) in 2031.

The overall enhancement of external competitiveness in sectors benefiting from the IRA, validated by the surge in domestic demand, reduced imports, and increased exports, raises concerns for trading partners, particularly the EU. The trade of batteries, electric vehicles, and other climate-related manufactures with Europe is expected to be notably impacted, given the U.S.'s prominent position as the primary destination for these exports from Europe (28%), followed by Norway at 8%. These results underscore the potential consequences for transatlantic trade relationships.

In alignment with one of the initial objectives of the IRA, there is a discernible fulfillment in reducing external dependence on climate-related industries, mitigating reliance on external energy sources, battery imports, and electric vehicles. While this effect may not be immediately apparent in macro-level results, it becomes observable at the micro level, signaling a shift in consumer preferences and trade patterns.

5.2. Scenario 3. Alternative funding

In scenarios 1 and 2, the financing for the CBO's outlined plan primarily involves increased taxes on corporations with higher profits. In scenario 3, we explore the impact of the IRA under a hypothetical scenario where tax credits are funded through increase in taxes on labor and capital income. Consequently, the fiscal burden shifts predominantly to workers, given that, although we also raise the capital income tax rate, the ratio between the wage bill and capital rentals stands at 4 to 1 in the U.S. The results are presented in Table 1, unveiling intriguing insights.

In this scenario, we adopt the conservative approach in terms of the dimension of shocks, akin to that of scenario 1. The difference lies in introducing shocks to the power of tax on capital and labor income, as opposed to production taxes. We evenly distribute the burden for both.

The outcomes in this scenario exhibit significant differences with Scenarios 1 and 2, though they maintain similar dimensions. Starting with GDP, it experiences growth approximately double that of scenario 1 over the decade, resulting in a cumulative GDP growth of 0.04% in 2031.

Scenarios 1 and 3 share dimensions of investment, production, and direct transfers to households. In Scenario 3, the results related to GDP and its components are similar to Scenario 1, albeit with more favorable outcomes. GDP accumulates growth by 0.05% compared to 0% in Scenario 1, and private consumption resiliently withstands the latter half of the decade, resulting in a cumulative growth of 0.05% compared to 0.02% in the first scenario. If the IRA investments are financed through higher taxes on labor and capital income, the absence of a significant increase in production taxes lowers costs for businesses. This fact, coupled with slower price growth, leads to a greater increase in real wages even compared to Scenario 2, which considers a bigger stimulus. Regarding investment, the results are 50% higher than with the current financing plan of the IRA. Trade results are also more favorable, with exports projected to decrease by 0.28% by 2031 compared to the cumulative fall of 0.39% in the first scenario.

While the outcomes thus far are more favorable than in scenario 1, the notable differences lie in the positive impacts on household income and savings. In scenario 1, during the second half of the decade, and once direct transfers cease, the average propensity to consume for households gradually decreases until 2031. With wages

increasing and private consumption following GDP growth, this positively impacts household savings, which cumulatively increase by \$71 billion in 2031. However, in scenario 3, the increase in direct taxes would diminish households' purchasing power taxes, leading to a more than 60% reduction in the growth of household disposable income compared to Scenario 1. As we assume that the average propensity to consume follows GDP in the medium and long-run, this results in a drastic reduction in household savings, turning negative with a -\$3 billion outcome in 2031.

6. Conclusions and policy implications

The Inflation Reduction Act (IRA) of 2022 represents a pivotal element in the United States' commitment to transitioning to net zero emissions. Aligned with the ambitious goals set by the Biden administration, the IRA aims to significantly reduce carbon emissions, foster clean energy investment, and reshape the economic landscape. In this paper, the IRA is subjected to a comprehensive ex-ante impact analysis using a dynamic Computable General Equilibrium (CGE) model.

This study explores three distinct scenarios, each shedding light on potential macroeconomic and sectoral outcomes and trade-offs associated with the IRA. Scenarios 1 and 2 isolate and measure the economy-wide impact of the IRA. The former is based on the Congressional Budget Office (2022) estimations of the dimension of the provisions included in the law. However, the uncapped property of the investment and production tax credits combined with the positive response these tax credits are already receiving, suggests that CBO estimations are likely to be conservatively low. Scenario 2 aims to provide results considering this uncapped effect of the tax credits. Interestingly our results show that a 50% increase in the demand for tax credits would result in a GDP increase two times higher than under Scenario 1.

The stimulating impact of the IRA on private investments and production (coming from tax credits), and on private consumption (coming from direct transfers to households) has a positive impact on GDP that has its highest result through the mid-decade. The unequal distribution of outlays and revenues¹², along with the high share that private consumption represents in the U.S. GDP (more than 70%) partially explain these results. The direct transfers to households cease by 2026, while the tax reforms will become more effective towards the end of the decade (62% of the income expected will occur from 2027 to 2031). In Scenario 1, by 2027, GDP grows by 0.08% and private consumption by 0.10%. However, under Scenario 2, which considers a 50% increase in government outlays in the form of tax credits, these growth rates increase significantly, reaching 0.27% and 0.28% respectively. This demonstrates the substantial multiplying effect of these investments in economic growth.

The increase in production and investment has an expansive effect on the other components of GDP, except for aggregate exports. Domestic stimulus leads to a generalized increase in basic prices and inflation, resulting in higher export prices, especially towards the end of the decade and leading to a loss of external competitiveness. Following the CPI trend, exports decrease continuously throughout the decade, except for a slight rebound in the last two years due to a relative inflation reduction. However, sectoral results show the opposite trend for IRA-related industries. Cumulative results (by 2031) show that the Motor Vehicles and Parts (covers clean commercial vehicles and medium- and heavy-duty electric vehicles) sector would increase its exports by 0.22% (\$0.57 billion) and 1% (\$2.6 billion) under Scenarios 1 and 2, respectively. The Electrical Equipment industry (encompasses primary battery manufacturing and charging stations) is anticipated to see a 1.53% (\$1.3 billion) and 5.56% (\$4.6 billion) export increases, indicating potential alterations in the U.S.'s role

¹² This unequal distribution can be seen in the *Net budget effect* (last row of Table 1).

as battery supplier within the GVC. Other Mining (includes critical minerals, primarily lithium, cobalt, nickel, and copper) is positioned to observe the most substantial absolute export increase, elevating exports by 2.35% (\$1.7 billion) and 9.9% (\$7.1 billion).

The domestic stimulus generates a general increase in productivity, resulting in a small reduction in employment demand but, at the same time, a comparatively significant increase in real wages, especially in Scenario 2, due to higher investment and production levels. Towards the end of the decade, we observe the positive effect of these investments on the long-term increase in the country's productive capacity (due to the increase in the capital stock), which effectively reduces inflation.

In addition to Scenarios 1 and 2, where the financing of the Inflation Reduction Act (IRA) is based on increased corporate taxes and other tax enforcements, we introduce Scenario 3, examining the impact of an alternative funding approach. In this scenario, tax credits are funded through elevated taxes on labor and capital income, targeting individuals rather than industries (Scenarios 1 and 2). The fiscal burden in this scenario predominantly falls on workers, given the 4 to 1 ratio between the wage bill and capital rentals in the U.S.

Although maintaining the dimension of the shocks¹³, results related to GDP and its components in Scenario 3 mirror those of Scenario 1, albeit with more favorable outcomes. By 2027, GDP accumulates growth by 0.13% compared to 0.08% in Scenario 1, with similar results for private consumption. The absence of a significant increase in production taxes in Scenario 3, coupled with slower price growth, leads to a greater increase in real wages compared to the previous Scenarios (even compared to Scenario 2). Private investment demand increases a 50% more than with the current financing plan of the IRA. Trade outcomes are also more favorable, with exports projected to decrease by 0.28% by 2031 compared to the cumulative fall of 0.39% in the first scenario.

However, the notable differences in Scenario 3 lie in household incomes. While Scenario 1 positively impacts household savings through increasing wages and private consumption, in Scenario 3, the rise in direct taxes diminishes household purchasing power, resulting in a more than 60% reduction in the growth of household disposable income compared to Scenario 1. This leads to a drastic reduction in household savings, turning negative with a -\$3 billion outcome in 2031. The exploration of Scenario 3 underscores the nuanced trade-offs associated with alternative funding mechanisms.

The IRA's implications for energy policy are profound. The boost in sectors like Motor Vehicles and Parts, and Electrical Equipment, especially in exports, underlines a potential shift in the U.S.'s global energy market positioning, particularly as a battery supplier. This transition not only supports domestic energy security but also could strengthen the U.S.'s position in the global clean energy supply chain.

However, the domestic stimulus stemming from the IRA leads to inflationary pressures, impacting the country's export competitiveness. This effect is somewhat mitigated by the long-term benefits of increased productive capacity and reduced inflation towards the decade's end.

Scenario 3 shows that, even considering the same investment and production stimulus, the funding mechanism for these can significantly influence household economic well-being and consumption patterns, which are vital for a sustainable energy transition. Moreover, the IRA's impact on energy-intensive sectors suggests a need for targeted

¹³ Scenario 3 uses CBO estimations, as Scenario 1.

support and transition strategies. As the economy shifts towards cleaner energy sources, sectors facing a decline in competitiveness due to higher costs or shifting demand patterns may require assistance to adapt or restructure.

In summary, while the IRA is a significant step towards the U.S.'s climate goals, its economic and energy policy impacts require a nuanced approach that balances economic growth, household well-being, and global energy market dynamics.

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Appendix I

Table 3. Percentage Distribution of Tax Burden by Sector by total revenue (\$ million).

Industry classification		Total revenue (\$US Billion)	Share of total
Fortune	USAGE	17963509.8	100.0%
Financials	SecurInvest	2910251.7	16.20%
Health Care	HopsitNurs	2688237.8	15.00%
Retailing	RetailTrd	2336676.6	13.00%
Food, Beverages & Tobacco	FoodBevTob	617540.7	3.40%
Technology	CompElecPrds	1092064.5	3.05%
Technology	ElectEquip	1092064.5	3.05%
Telecommunications	BroadTelCom	529942.9	3.00%
Industrials	Machinery	507474.6	2.80%
Motor Vehicles & Parts	MotVehParts	470407.9	2.60%
Food & Drug Stores	RetailTrd	446986.5	2.50%
Wholesalers	WholesaleTrd	405322.1	2.30%
Business Services	AdminServ	383672.9	2.10%
Aerospace & Defense	AirTrans	338982	1.90%
Chemicals	ChemicalProd	297776.6	1.70%
Media	InfoDataProc	256759.8	1.40%
Engineering & Construction	Construction	253801	1.40%
Household Products	MiscManu	243560.9	1.40%
Energy	OilGasExtrac	628.183.70	1.17%
Energy	OthMining	628183.7	1.17%
Energy	Utilities	628183.7	1.17%
Hotels, Restaurants & Leisure	Accomodation	188472.8	1.00%

Transportation	WaterTrans	251609.6	0.70%
Transportation	TruckTrans	251609.6	0.70%
Apparel	Apparel	117313.1	0.70%
Materials	PrimMetals	199215.2	0.55%
Materials	FabMetProds	199215.2	0.55%

Notes: In industries that encompass multiple USAGE sectors, we evenly distribute the tax burden among these sectors to ensure a uniform allocation

Table 4 (FULL)

USAGE Sector	Production	Labor demand	Basic price	Exports	Imports	Priv.Cons. DOM	Priv.Cons. IMP
Farms	-0.19	-0.24	0.07	-0.35	0.10	-0.06	0.18
ForestFish	-0.13	-0.14	0.11	-0.45	-0.03	-0.01	0.01
OilGasExtrac	-0.12	-0.09	0.44	-1.05	0.54	0.10	0.10
OthMining	0.97	0.61	-0.43	2.35	-0.71	0.17	-0.32
MiningServ	0.18	0.21	0.16	-0.08	0.00	0.10	0.10
Utilities	1.99	1.82	-1.69	5.06	-3.79	1.66	-3.11
Construction	0.12	0.05	0.04	-0.39	0.00	0.10	0.10
WoodProd	0.00	-0.01	0.08	-0.45	0.17	-0.07	0.00
NonMetMinPrd	0.02	0.01	0.03	-0.29	0.08	-0.07	0.00
PrimMetals	-0.12	-0.15	0.11	-0.38	0.17	-0.06	0.02
FabMetProds	-0.07	-0.07	0.16	-0.57	0.26	-0.13	0.04
Machinery	-0.07	-0.06	0.23	-0.68	0.58	-0.18	0.04
CompElecPrds	-0.35	-0.35	0.39	-0.96	0.32	-0.28	-0.04
ElectEquip	1.01	0.39	-0.59	1.53	-0.35	0.55	-0.29
MotVehParts	0.29	0.18	-0.14	0.22	-0.04	0.28	-0.04
OthTransEqu	-0.22	-0.23	0.12	-0.45	0.02	-0.05	0.03
Furniture	-0.01	-0.02	0.11	-0.47	0.11	-0.09	0.04
MiscManu	-0.31	-0.32	0.27	-0.80	0.10	-0.20	0.01
FoodBevTob	-0.16	-0.17	0.18	-0.60	0.38	-0.09	0.34
TextMillProd	-0.11	-0.12	0.08	-0.35	0.04	-0.08	0.01
Apparel	-1.06	-1.10	0.75	-1.81	0.01	-0.67	-0.02
PaperPrds	-0.09	-0.10	0.06	-0.34	0.09	-0.01	0.09
Printing	-0.02	-0.03	0.06	-0.35	0.09	-0.07	0.01
PetroCoalPrd	-0.03	-0.06	0.14	-0.43	0.27	-0.03	0.29
ChemicalProd	-0.15	-0.17	0.12	-0.46	0.17	-0.07	0.08
PlastRubPrd	-0.07	-0.08	0.09	-0.43	0.12	-0.09	0.02
WholesaleTrd	-0.03	-0.04	0.14	-0.56	0.00	0.10	0.10
RetailTrd	-0.01	-0.02	0.31	-0.24	0.00	-0.17	0.42
AirTrans	-0.09	-0.12	0.56	-0.43	0.00	-0.33	0.54
RailTrans	0.15	0.09	-0.02	-0.86	-0.12	0.10	0.10
WaterTrans	-0.42	-0.47	1.78	-4.66	1.26	-1.51	1.23
TruckTrans	-0.02	-0.03	0.20	-0.74	0.22	-0.06	0.25
TransitGrndP	-0.30	-0.33	0.07	-0.05	0.00	0.03	0.15
Pipeline	0.75	0.46	-0.60	-0.66	0.00	0.10	0.10

OthTransServ	-0.14	-0.17	0.08	-0.39	0.00	0.03	0.16
WareHousStor	-0.06	-0.07	0.10	-0.48	0.00	0.01	0.21
Publishing	0.01	0.00	0.11	-0.51	0.25	-0.05	0.12
MotPicSndRec	-0.11	-0.12	0.12	-0.50	0.21	-0.02	0.23
BroadTelCom	-0.10	-0.15	0.19	-0.67	0.00	-0.07	0.30
InfoDataProc	-0.16	-0.18	0.29	-0.93	0.40	-0.15	0.40
FedResCrdInt	0.04	0.05	0.16	-0.62	0.28	-0.04	0.27
SecurInvest	-0.63	-0.64	0.77	-2.26	0.00	-0.59	0.88
Insurance	-0.07	-0.07	0.14	-0.56	0.16	-0.02	0.25
FundsTrusts	-0.23	-0.25	0.38	-0.30	0.00	-0.24	0.50
RealEstate	0.01	-0.01	0.07	-0.42	0.00	0.04	0.18
RentalLeas	-0.13	-0.18	0.07	-0.33	0.08	0.04	0.18
LegalServ	-0.02	-0.02	0.12	-0.52	0.23	0.00	0.23
CompServ	0.06	0.06	0.12	-0.55	0.24	0.10	0.10
MiscServ	-0.03	-0.03	0.12	-0.53	0.16	0.00	0.23
ManagComEnt	-0.10	-0.11	0.13	-0.57	0.00	0.10	0.10
AdminServ	-0.04	-0.04	0.12	-0.54	0.20	-0.01	0.24
WasteManag	0.01	-0.01	0.07	-0.40	0.09	0.04	0.18
EducatServ	0.01	0.00	0.10	-0.49	0.21	0.01	0.21
AmbHealthCar	-0.01	-0.01	0.12	-0.53	0.00	-0.01	0.23
HopsitNurs	-0.01	-0.01	0.12	-0.53	0.23	0.00	0.23
SocialServ	-0.01	-0.01	0.13	-0.10	0.00	-0.01	0.24
ArtSprtMusem	-0.08	-0.09	0.11	-0.49	0.14	0.00	0.22
AmusGambRec	-0.18	-0.19	0.09	-0.07	0.00	0.02	0.20
Accomodation	-0.06	-0.08	0.06	-0.04	0.00	0.05	0.17
FoodDrink	-0.01	-0.02	0.11	-0.47	0.00	0.01	0.22
OtherServ	-0.02	-0.02	0.12	-0.53	0.18	-0.01	0.18
NatDef	0.03	0.01	0.12	-0.09	0.00	0.10	0.10
NonDef	0.03	0.02	0.11	-0.08	0.00	0.10	0.10
FedGovEnt	-0.77	-0.62	0.29	-0.93	0.00	-0.15	0.41
SLGEduc	0.02	0.01	0.12	-0.09	0.00	0.10	0.10
SLGOth	0.02	0.01	0.11	-0.08	0.00	0.10	0.10
SLGovEnt	-0.62	-0.83	0.15	-0.11	-0.02	0.10	0.10
Vacation	-0.07	-0.13	0.14	-0.11	0.32	-0.07	0.32
FgnVac	0.32	0.27	0.01	0.32	0.00	0.10	0.10
ExpTour	-0.30	-0.35	0.10	-0.30	0.00	0.10	0.10
ExpEdu	-0.36	-0.42	0.12	-0.36	0.00	0.10	0.10
OthNonRes	-0.04	-0.09	0.13	-0.04	0.00	0.10	0.10
AirInt	-0.23	-0.23	0.10	-0.27	0.08	0.10	0.10
WaterInt	-0.30	-0.35	0.07	-0.29	-0.03	0.10	0.10