Oil Prices and Inequality

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October 13, 2025

Abstract

This paper provides a unified framework to understand the effect of oil price changes on the dynamics of consumption, income and wealth inequality. Using data on macroeconomic aggregates, oil prices, and inequality metrics, we first employ a structural vector autoregressive model to show that an increase in oil prices leads to a persistent rise in income and wealth inequality. To understand these dynamics, we then solve an incomplete market model with aggregate oil price shocks, and calibrate the model to the US data. We find that when oil serves as both a consumption good and a production input, positive oil price shocks increase inequality. While the initial rise in inequality is driven by oil-induced stagflation, which forces poorer households to deplete more of their wealth to cover basic consumption, the quicker rebound in interest rates compared to the slower recovery in wages explains why inequality remains persistently elevated.

Keywords: oil price shocks, inequality, heterogeneous agent

JEL Classification Numbers: D31, E10, Q43

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1 Introduction

Energy stands as a vital driver of economic activity in the United States, and is recognized as a critical industry due to its enabling role across various economic sectors. Consequently, fluctuations in oil prices can significantly influence aggregate economic dynamics. It is widely acknowledged that oil price shocks lead to stagflation, characterized by higher inflation and lower aggregate consumption, investment, and output (Hamilton (2008) and Kilian (2009)). However, the distributional effect of oil price shocks remains inadequately explored.

This paper addresses this question by studying the dynamic responses of inequality to oil price changes, both empirically and theoretically. Empirically, we estimate a monthly IV-SVAR for the United States over the recent decades. [1] The macro responses are textbook: output, consumption, wages, and employment fall while the price level rises. Inequality increases meaningfully and persistently following a 10% increase in oil prices: Gini coefficients for total income, labor income, and wealth increase by roughly 0.06 to 0.1 percentage points, with peak effects arriving only gradually, well after the initial macroeconomic contraction. As inequality rises, the share of income and wealth shifts away from the bottom half of the population and toward the rich. The bottom 50 percent loses share in both income and wealth, while gains accrue in the upper tail, including the top 10% and top 1%. The findings are robust across alternative oil instruments and to estimating the VAR in differences for potentially non-stationary series.

This raises the question: What underlying factors could drive this positive relationship between oil prices and inequality? To answer this question, we build and solve a continuous-time heterogeneous agent model with a one-time aggregate oil price shock where oil serves as both a consumption good and a production input. This framework enables us to examine the dynamic impact of oil price fluctuations across the entire spectrum of consumption, income, and wealth distribution within a general equilibrium context. The model is calibrated to the U.S. economy from 1985 to 2019. Following a one-time positive oil price shock, our simulation outcomes indicate a contraction in aggregate economic activities, including output, consumption, and investment, while the general price level increases, which aligns with the literature that typically views oil price shocks as a negative supply-side shock. Moreover, the Gini coefficients of consumption, income, and wealth exhibit an increase and persist above the baseline for a long time.

In the model, an oil price shock generates stagflation by reducing real incomes across the entire distribution. Households in the lower wealth quintiles, with limited asset buffers, are forced to draw down savings to smooth consumption, which erodes their net wealth and raises wealth inequality. These poorer households adjust by reducing labor supply less than wealthier households, but this response is insufficient to offset their disproportionately larger income losses. The inequality effects are further reinforced during the transition. Lower interest rates initially stimulate

[1] We focus on this period when macroeconomic volatility began to significantly decline, documented by Stock and Watson (2003) and Bernanke (2004), among others. In addition, as stated in Blanchard and Riggi (2013), the effects of oil price shocks on the aggregate economy have become significantly different during this period than in 1970s.

a rapid rebound in capital demand, while capital supply adjusts more slowly due to the gradual process of accumulation. To clear the market, the interest rate temporarily overshoots beyond its steady state level. Because lower-wealth households depend primarily on labor income, while higher-wealth households derive a larger share of income from capital, this temporary spike in the interest rate exacerbates both income and wealth inequality before the economy converges back to equilibrium. For quantitative comparison, we scale up the empirical impulse responses proportionally so that both correspond to a 50% change in oil prices. The model then predicts about 0.06-0.18 percentage points increases in income and wealth Gini coefficients, which explains about 36% increases estimated in the data, and captures the persistence of the inequality response as well.

The model further shows that two structural features are crucial for understanding the strength of inequality responses. Allowing for endogenous labor supply enables households to partially offset income losses by adjusting work effort, yet these adjustments are not sufficient to prevent the widening gap in wealth accumulation that emerges after the shock. Moreover, when energy consumption is non-homothetic, poorer households devote a larger share of spending to essential energy goods, making their effective budgets far more sensitive to oil price changes.

Finally, we explore the asymmetric nature of oil price shocks. Negative shocks (oil price declines) stimulate the economy more strongly than positive shocks of equal size, as lower energy costs relax household budgets and fuel faster demand recovery. Yet inequality responds asymmetrically: while oil price cuts modestly reduce inequality, oil price increases generate much larger and more persistent rises. This asymmetry arises precisely from the nonlinear mechanisms embedded in the model: non-homothetic energy demand, constrained households, and uneven income recovery, showing that the distributional cost of oil price hikes exceeds the redistributive gain from price declines.

The remainder of the paper is organized as follows. Section 2 reviews the related literature, and Section 3 presents the empirical evidence from the IV-SVAR. Section 4 introduces the incomplete market model, with Section 5 detailing the general equilibrium conditions. Numerical results, covering transition dynamics, winners and losers, labor supply, and energy heterogeneity appear in Section 6. Section 7 examines the asymmetric effects of positive and negative oil price shocks, and Section 8 concludes. Appendices provide data, robustness checks, numerical methods, and sensitivity analyses.

2 Literature Review

The paper attempts to bridge the gap between two seemingly unrelated pieces of literature. The first is recent literature that focuses on the macroeconomic dynamics of income and wealth inequality. Income and wealth inequality have both been rising significantly worldwide since the 1980s (Piketty and Zucman (2014)). While the topic of wealth inequality was primarily studied within the field of development economics, it has recently gained attention among macroeconomists

(Ahn, Kaplan, Moll, Winberry, and Wolf (2018)). Some strands focuses on taxes and technology (Kaymak and Poschke (2016)), globalization (Azzimonti, De Francisco, and Quadrini (2014)), entrepreneurship (Jones and Kim (2018)), automation (Moll, Rachel, and Restrepo (2022)), some focus on monetary policy (Kaplan, Moll, and Violante (2018)), others examine the heterogeneous return to wealth (Fagereng, Guiso, Malacrino, and Pistaferri (2020)). We fill in the gap of the literature by exploring the relationship between oil price shocks and inequality.

The second literature it relates to is the macroeconomics of energy. It has been documented in the literature that oil price changes serve as one of the most important supply-side disturbances that can generate fluctuations in the aggregate economy. Traditional macroeconomic theory suggests that oil price shocks lead to stagflation, featuring higher price level and lower aggregate demand (Hamilton (1983), Rotemberg and Woodford (1996), Hamilton (2003), Barsky and Kilian (2004), Kilian (2008), Edelstein and Kilian (2009), Herrera, Karaki, and Rangaraju (2019), Koirala and Ma (2020))).

While the inequality literature has expanded rapidly, few studies have connected it to energy shocks. Most empirical work treats oil mainly as a macro supply disturbance, with limited attention to distributional effects. Most existing work focuses on empirical analysis. They either examines the natural resource curse (Brunnschweiler and Bulte (2008), Parcero and Papyrakis (2016), Sebri and Dachraoui (2021)), as well as how oil price shocks affect income or consumption inequality (Parcero and Papyrakis (2016), Kim and Lin (2018), and Edmond, Chisadza, Matthew, and Rangan (2021), Bettarelli, Estefania-Flores, Furceri, Loungani, and Pizzuto (2023), Bhattarai, Chatterjee, and Udupa (2025)). Del Canto, Grigsby, Qian, and Walsh (2023) employs a feasible set approach and found that oil shocks are regressive, operating mainly through the asset price channel. We contribute to the existing literature by presenting a structured theoretical framework along with empirical analysis, highlighting diverse responses to typical oil price shocks.

Among the limited theoretical work in this area, several recent studies are particularly relevant. For instance, Oni (2024) examines the distributional impact of such shocks by comparing steady states outcomes across different oil price levels. Pieroni (2023) and Auclert, Monnery, Rognlie, and Straub (2023) build and solve heterogeneous agent models with nominal rigidity, focusing on short-term fluctuations in aggregate demand through nominal channels. In contrast, our study focuses on the real effects of distributional variables and their long-term dynamics. Another major distinction lies in our incorporation of capital in production, which is essential in understanding how oil prices influence inequality through capital accumulation.

3 Empirical Evidence

We begin by estimating the causal effect of a 10% increase in oil prices on key macroeconomic indicators and inequality using a structural vector autoregression (SVAR) with an internal instrument for oil prices. As instruments for oil prices, we use oil shocks proposed in the literature by Baumeister and Hamilton (2019), Känzig (2021), and Baumeister (2023). Before presenting the empirical model, we briefly justify our choice of an internal-IV approach and the derivation of a formal IV framework to harmonize the different oil shock measures.

Internal vs. external instruments. We adopt an *internal* IV approach, placing the instrument inside the VAR and ordering it first so its innovation propagates through current and lagged dynamics. This is robust if shocks are non-invertible (i.e., reveal themselves with delay), whereas *external* (proxy-SVAR) identification loads on contemporaneous innovations and can misidentify responses under non-invertibility. See Plagborg-Møller and Wolf (2021) for a concise discussion and equivalence results linking internal and external IV approaches across local projections and vector autoregressions.

Why a formal IV framework. Because the different oil shock measures vary in scale and in the *shape* of the oil-price path they induce, we adopt a triangular IV design that treats the *entire* forecast path of the real oil price—not just the contemporaneous price—as the treatment. We renormalize each instrument's first stage to a common unit ("peak 10% oil-price increase"), making IRFs comparable across instruments. This setup also makes identification transparent: the relevance and exclusion restrictions are formulated for path-treatments rather than a single-period price change.

3.1 Econometric Model

The VAR model is specified as:

$$W_t = \gamma_0 + \Gamma_1 W_{t-1} + \cdots + \Gamma_p W_{t-p} + u_t, \quad \text{with } W_t = \begin{bmatrix} Z_t \\ X_t \\ Y_t \\ Q_t \end{bmatrix}, \tag{1}$$

where W_t is an N-dimensional vector of random variables. It includes the instrument Z_t (oil shock), the explanatory variable X_t (real oil price), the dependent variable Y_t (inequality or a macro indicator), and additional controls and state variables Q_t. The VAR residuals u_t have zero mean and no autocorrelation, i.e., $E[u_t] = 0$ and $E[u_t u'_{t-k}] = 0$ for $k \neq 0$.

From the VAR model in (1), we construct the forecast path:

$$\mathcal{X}_t = \begin{bmatrix} X_t \\ E_t X_{t+1} \\ \vdots \\ E_t X_{t+H} \end{bmatrix}, \quad \mathcal{Y}_t = \begin{bmatrix} Y_t \\ E_t Y_{t+1} \\ \vdots \\ E_t Y_{t+H} \end{bmatrix}, \tag{2}$$

where E_t denotes the conditional expectation given the information set $\{W_{t-l}\}_{l \geq 0}$ under the VAR model (1).

We formalize identification using a triangular structural model, which refers to a system of equations where three key components interact in a recursive, one-directional way:

1. an instrument Z_t (oil shock) that shifts
2. an endogenous explanatory variable $\mathcal{X}_t$ (a random vector representing the forecast path of oil prices), which in turn affects
3. the dependent variable $\mathcal{Y}_t$ (e.g., the forecast path of inequality).

This structure is captured in the following recursive system:

$$\begin{aligned} Z_t &= \psi_Z' \mathbf{W}_{t-1} + \zeta_t \\ \mathcal{X}_t &= \alpha Z_t + \Psi_{\mathcal{X}} \mathbf{W}_{t-1} + \xi_t \\ \mathcal{Y}_t &= B\mathcal{X}_t + \Psi_{\mathcal{Y}} \mathbf{W}_{t-1} + \upsilon_t \end{aligned} \tag{3}$$

where $\mathbf{W}_{t-1} = \begin{bmatrix} W_{t-1}' & \cdots & W_{t-p}' \end{bmatrix}'$ denotes the vector of lagged variables, and ζ_t, ξ_t, and υ_t are residuals. The scalar instrument Z_t shifts the explanatory forecast path $\mathcal{X}_t$ via the $(H+1)$-dimensional parameter vector α, which in turn affects the dependent forecast path $\mathcal{Y}_t$ through the $(H+1) \times (H+1)$ coefficient matrix B.

We define a counterfactual perturbation of the treatment as:

$$\begin{aligned} \hat{\mathcal{X}}_t(r, \delta) &= \mathcal{X}_t + \delta r \\ \hat{\mathcal{Y}}_t(r, \delta) &= B(\mathcal{X}_t + \delta r) + \Psi_{\mathcal{Y}} \mathbf{W}_{t-1} + \upsilon_t \end{aligned} \tag{4}$$

for some direction $\delta \in \mathcal{D}$, where $\mathcal{D}$ is the set of $(H+1)$-dimensional vectors with a normalized positive maximum of 0.1:

$$\mathcal{D} = \left\{ v \in \mathbb{R}^{H+1} \middle| \overline{k} := \arg\max_k |v_k|, \ v_{\overline{k}} = 0.1 \right\} \tag{5}$$

In other words, we evaluate counterfactual outcomes in response to a hypothetical change in the forecast path $\mathcal{X}_t$, where the perturbation peaks at 0.1. For example, δ may represent a one-time 10% increase in oil prices at a specific horizon or a more persistent sequence of smaller increases peaking at 10%.[2]

[2] In empirical macroeconomics, it is typically impossible to find an instrument that raises oil prices by exactly 10% for a single period before immediately returning to its steady state. For this reason, the "cause" must be defined more generally—as a perturbation to the forecast path that peaks at 10%.

The objects of interest are the impulse response functions (IRFs):

$$\begin{aligned} IRF^X(\delta) &= \frac{\partial \hat{\mathcal{X}}_t(r,\delta)}{\partial r} = \delta \\ IRF^Y(\delta) &= \frac{\partial \hat{\mathcal{Y}}_t(r,\delta)}{\partial r} = \frac{\partial \mathcal{Y}_t}{\partial \mathcal{X}_t'}\delta = B\delta \end{aligned} \tag{6}$$

A natural choice for δ is the direction $\delta^{IV} \in \mathcal{D}$ implied by the instrument Z_t. It is derived by normalizing the first-stage effect of Z_t on $\mathcal{X}_t$, given by $\alpha = \frac{\partial \mathcal{X}_t}{\partial Z_t}$ in equation (3), so that the largest component of the resulting vector equals 0.1:

$$\delta^{IV} = \frac{0.1}{\alpha_{\overline{k}}} \cdot \alpha, \qquad \overline{k} = \arg\max_k |\alpha_k| \tag{7}$$

The next section shows how to identify the IRFs in equation (6) for the specific direction δ^{IV} in (7). Note that since α, and therefore δ^{IV}, depends on the choice of instrument, each instrument may yield different IRFs.

3.2 Identification

The goal is to identify the causal effect of an oil price increase via an instrumental variable. This requires the following two assumptions:

A1. Relevance Condition. *The non-forecastable component of the instrument Z_t is relevant for predicting the explanatory variable $\mathcal{X}_t$, i.e. $E[\mathcal{X}_t|Z_t, \mathbf{W}_{t-1}] \neq E[\mathcal{X}_t|\mathbf{W}_{t-1}]$.*

A2. Exclusion Restriction. *The instrument Z_t does not affect the dependent variable $\mathcal{Y}_t$, except through its effect on the explanatory variable $\mathcal{X}_t$, i.e., $E[\mathcal{Y}_t|Z_t, \mathcal{X}_t, \mathbf{W}_{t-1}] = E[\mathcal{Y}_t|\mathcal{X}_t, \mathbf{W}_{t-1}]$.*

An ideal instrument satisfying these assumptions is an oil supply shock that arises independently of the business cycle and affects the macroeconomy only through its impact on current and expected future oil prices—for example, a sudden loss of oil production due to the outbreak of the Gulf War in 1990, which led to higher oil prices in the United States. More broadly, any shock specific to the oil sector rather than driven by macroeconomic conditions qualifies, allowing us to use the oil shocks proposed by Baumeister and Hamilton (2019), Känzig (2021), and Baumeister (2023).[3]

We now combine the VAR model (1) with the two identifying assumptions to derive the impulse response functions (IRFs) of each variable with respect to an oil price increase normalized to peak at 10%. The VAR identifies the total derivative of the forecast paths $\mathcal{X}_t$ and $\mathcal{Y}_t$ with respect to

[3] The relevance condition is established by the papers that construct these oil-shock series, which document that their shocks shift oil prices in a statistically and economically significant way; see Baumeister and Hamilton (2019); Känzig (2021); Baumeister (2023). In our estimates, the oil-price impulse responses to Z_t indeed show a clear and economically meaningful increase, consistent with this assumption.

the innovation in Z_t as:

$$\frac{d\mathcal{X}_t}{d\zeta_t} = \begin{bmatrix} e_2'\Psi_0 \\ \vdots \\ e_2'\Psi_H \end{bmatrix} Ae_1, \qquad \frac{d\mathcal{Y}_t}{d\zeta_t} = \begin{bmatrix} e_3'\Psi_0 \\ \vdots \\ e_3'\Psi_H \end{bmatrix} Ae_1, \tag{8}$$

where e_j denotes the jth unit vector, and Ψ_h and A are defined as:

$$\Psi_h = \sum_{k=1}^{p} \Gamma_k \Psi_{h-k}, \qquad A = \mathrm{Chol}(\mathrm{Cov}(u_t)), \tag{9}$$

with initialization $\Psi_0 = I_N$ and $\Psi_l = 0$ for $l < 0$, and A is the lower-triangular Cholesky factor of the VAR residual covariance matrix in (1). Under the two identification assumptions A1 and A2, these derivatives identify α and $B\alpha$ defined in (3):

$$\begin{aligned} \frac{d\mathcal{X}_t}{d\zeta_t} &= \alpha + \Psi_{\mathcal{X}} \underbrace{\frac{d\mathbf{W}_{t-1}}{d\zeta_t}}_{=0} + \underbrace{\frac{d\xi_t}{d\zeta_t}}_{=0} = \alpha \\ \frac{d\mathcal{Y}_t}{d\zeta_t} &= B \underbrace{\frac{d\mathcal{X}_t}{d\zeta_t}}_{=\alpha} + \Psi_{\mathcal{Y}} \underbrace{\frac{d\mathbf{W}_{t-1}}{d\zeta_t}}_{=0} + \underbrace{\frac{dv_t}{d\zeta_t}}_{=0} = B\alpha \end{aligned} \tag{10}$$

which identify the IRFs of interest after rescaling by $\frac{0.1}{\alpha_{\bar{k}}}$, as specified in (6) and (7).

3.3 Data and Estimation

This section describes the dataset used in our IV-SVAR framework. The variables included in the VAR (1) are:

$$W_t = \left[\begin{array}{c} Z_t \\ \hline X_t \\ \hline Y_t \\ \hline Q_t \end{array}\right] = \left[\begin{array}{c} \text{Oil Shock}_t \\ \hline \text{Real Oil Price}_t \\ \hline Y_t \\ \hline \text{Real Rate}_t \\ \text{Real Consumption}_t \\ \text{Real Output}_t \\ \text{Employment}_t \\ \text{Real Wage}_t \end{array}\right] \tag{11}$$

The vector W_t consists of four components. The first element, Z_t, is the internal instrument—an oil shock—placed first to enable structural identification. The second, X_t, is the treatment variable, defined as the real oil price. The third, Y_t, is a placeholder for the outcome of interest. The remaining block, Q_t, includes additional control and state variables used to propagate the impulse response over time. The ordering beyond the instrument Z_t does not affect identification or estimation. For instance, reordering X_t, Y_t, and Q_t—such as placing Q_t before X_t—would yield identical results.

The variable Y_t rotates across a set of over 50 macroeconomic and distributional indicators for which we estimate impulse response functions (IRFs). These include, for example, the Gini coefficients for income and wealth, income and wealth shares by strata, the price level, and other macroeconomic aggregates. Since estimating a single VAR that includes all of these outcomes simultaneously is infeasible, we estimate separate VARs, each tailored to a specific choice of Y_t, while holding the remaining components of the system fixed.[4]

The VAR model is estimated using monthly data from January 1976 to December 2019. This sample period is selected to align with the availability of the *Real-Time Inequality* dataset by Blanchet, Saez, and Zucman (2022) and to avoid capturing the effects of the COVID-19 pandemic.[5] The VAR is estimated with twelve lags, corresponding to $p = 12$ in (1), following the common practice of using one year of monthly data to capture macroeconomic dynamics. When the additional outcome of interest, Y_t, is only available at a quarterly frequency (as with real capital and investment), the monthly series are aggregated to quarterly averages, and the VAR is estimated with $p = 4$ lags to maintain consistency with the one-year lag structure. We provide a detailed description of the macro-financial indicators and oil price instruments used in the IV-SVAR model below, with corresponding time-series plots presented in Appendix A.1.

1. *Oil Shock* refers to the negative oil supply shock series from Baumeister and Hamilton (2019), available at sites.google.com/site/cjsbaumeister. It captures unexpected contractions in crude oil production that lead to increases in oil prices exogenous to the U.S. business cycle. Alternative oil shock measures from Baumeister and Hamilton (2019), Känzig (2021), and Baumeister (2023) are used for robustness (see IRFs in Figure 15). These alternative shocks, available at sites.google.com/site/cjsbaumeister and github.com/dkaenzig, are not shown here but closely resemble the oil shock series in Figure 13, appearing similar to a white noise process. As an alternative instrument for oil price increases, we construct *Hamilton event dummies* that equal one in the month an oil event begins and zero otherwise, following the six episodes in Hamilton (2013, Table 21.1, see IRFs in Figure 16).

2. *Real Oil Price* is defined as the natural logarithm of the WTI spot price divided by the consumer price index. The WTI spot price is compiled by merging data from Dow Jones & Company (before June 2013) and the U.S. Energy Information Administration (from January 1986 onward), as provided by the Federal Reserve Bank of St. Louis. It is available through the Federal Reserve Economic Data (FRED) database at fred.stlouisfed.org under

[4] To ensure that the dimensionality of the system remains constant across specifications, we adopt the following convention: if the outcome of interest already appears among the variables in Q_t, we move that variable into the Y_t position and replace its original position in Q_t with the Gini coefficient of total income.

[5] All IRFs are estimated over this sample period, except for the IRFs in the "1-Month Oil Price Surprises (Baumeister 2023)" column of Figure 15, which use data starting in January 1986 rather than 1976 due to the limited availability of the shock series from Baumeister (2023).

the identifier "WTISPLC." The consumer price index series, sourced from the U.S. Bureau of Labor Statistics, is available in FRED under "CPIAUCSL."

3. *Real Rate* is the ex-post real federal funds rate. It is constructed by subtracting twelve times the monthly log-difference of the consumer price index (available on FRED under "CPIAUCSL") from the nominal federal funds rate ("FEDFUNDS"). The federal funds rate is provided by the Board of Governors of the Federal Reserve System (Release: *H.15 Selected Interest Rates*), and the consumer price index is provided by the U.S. Bureau of Labor Statistics. The transformation annualizes monthly CPI inflation so that both terms are expressed in annualized percentage points.

4. *Real Consumption* is defined as the natural logarithm of personal consumption expenditures ("PCE") divided by the consumer price index ("CPIAUCSL"). The PCE series is provided by the Bureau of Economic Analysis, while the CPI series is provided by the U.S. Bureau of Labor Statistics.

5. *Real Output* is measured by the natural logarithm of the industrial production index ("INDPRO"), which tracks real output in the manufacturing, mining, and utilities sectors. The series is published by the Board of Governors of the Federal Reserve System.

6. *Employment* is defined as the natural logarithm of total nonfarm payroll employment ("PAYEMS"), provided by the Bureau of Labor Statistics.

7. *Real Wage* is defined as the natural logarithm of average hourly earnings of production and nonsupervisory employees ("AHETPI") divided by the consumer price index ("CPIAUCSL"). Both series are published by the Bureau of Labor Statistics.

8. *Price Level* is measured by the natural logarithm of the consumer price index for all urban consumers ("CPIAUCSL"), published by the Bureau of Labor Statistics, reflecting the average price change over time for a basket of goods and services purchased by urban consumers.

While the eight series above are available at a monthly frequency, the following three series are only available at a quarterly frequency:

9. *Real Capital* is defined as the natural logarithm of gross fixed capital formation in chained 2012 U.S. dollars ("USAGFCFQDSNAQ"), sourced from the Organisation for Economic Co-operation and Development (OECD).

10. *Real Investment* is measured by the natural logarithm of real gross private domestic investment ("GPDIC1"), expressed in billions of chained 2017 dollars. The series is provided by the U.S. Bureau of Economic Analysis (Release: *Gross Domestic Product*).

The income, wealth, and inequality measures used in the IV-SVAR model are drawn from the *Real-Time Inequality* dataset by Blanchet, Saez, and Zucman (2022), and summarized in Figure 14 in Appendix A.2. The dataset is available at realtimeinequality.org, and provides high-frequency estimates of the distribution of income and wealth in the United States, combining public data sources to construct harmonized monthly series expressed in real (March 2023) dollars. The relevant measures, shown across rows in Figure 14, are organized into three main categories:

1. *Total Income* is defined as the sum of all factor income before taxes. Factor income corresponds to national income as measured in the national accounts, offering a comprehensive indicator of the income generated by U.S. residents.
2. *Labor Income* is defined as income from wages, salaries, and self-employment, before taxes and transfers.
3. *Wealth* is defined as the net value of all household financial and non-financial assets, excluding vehicles and unfunded pensions, and net of debts.

Each of these three measures is then decomposed into a set of distributional statistics across the U.S. working-age population (ages 20–64), using an equal-split approach for married couples. The corresponding statistics for each measure, displayed across columns in Figure 14, are as follows:

- *Log of Average*: natural logarithm of the average value across individuals.
- *Gini Coefficient*: a standard summary index of inequality. It is computed based on the percentile ranges using a trapezoidal approximation of the Lorenz curve. Specifically, it is calculated as
$$G_t = 1 - \sum_{k=1}^{K}(S_{k,t} - S_{k-1,t})(I_{k,t} + I_{k-1,t}) \tag{12}$$
where $S_{k,t}$ denotes the cumulative population share up to group k at time t, and $I_{k,t}$ the corresponding cumulative share of total income, labor income, or wealth.[6] This approach provides a numerical approximation of the area under the Lorenz curve, allowing inequality measurement even when only grouped data are available. The Gini coefficient ranges from 0 (perfect equality) to 1 (maximum inequality), although values slightly above 1 may occur when variables such as wealth can take negative values.
- *Share of Bottom 50%*: share of the measure held by the bottom half of the distribution.
- *Share of Middle 40%*: share held by the middle 40% (the 50th–90th percentiles).
- *Share of Top 10%-1%*: share held by the 90th–99th percentiles.
- *Share of Top 1%*: share held by the top 1%.

[6] Based on data availability, for labor income, distributional groups are defined as the first, second, and third quartiles, along with the Top 25–10%, Top 10–1%, and Top 1%. For total income and wealth, the groups are Bottom 50%, Middle 40%, Top 10–1%, Top 1–0.1%, Top 0.1–0.01%, and Top 0.01%.

The *Real-Time Inequality* database is available at monthly frequency and updated quarterly following macroeconomic releases and provides consistent measurement of economic growth and inequality in real time. For complete methodological details, see "Real-Time Inequality" by Blanchet, Saez, and Zucman (2022).

3.4 Results

In this section, we presents the main empirical results of the paper. Figure 1 presents the impulse responses of key macroeconomic indicators to a 10% increase in oil prices, identified through the oil supply shock from Baumeister and Hamilton (2019). The solid lines depict the point estimates, while the shaded areas represent 68% confidence bands. In response to a 10% increase in oil prices, the real interest rate declines by 1.26 percentage points after 2 months, consistent with an easing of monetary policy. Real consumption and real output contract gradually, declining by 0.37% and 0.39% after 23 and 25 months, respectively. Employment also declines, reaching a 0.37% reduction after 36 months. Real wages fall by 0.23% within 5 months, while the aggregate price level increases by 0.30% after 14 months, indicating moderate pass-through to inflation. On the investment side, real capital stock declines by 0.53% after 12 quarters, while real investment shows an increase of 0.42% within 5 quarters.

Figure 2 shows the impulse responses of income and wealth inequality to a 10% increase in oil prices, using the oil supply shock from Baumeister and Hamilton (2019) as an instrument. The figure illustrates responses across three main categories—total income, labor income, and wealth—each broken down by average levels, Gini coefficients, and shares held by different income and wealth groups. The Gini coefficients increase gradually and persistently, peaking between 40 and 54 months after the shock. The distributional pattern is clearly regressive: the bottom 50% of households lose shares of both labor income and wealth, while the top of the distribution—especially the top 10% and top 1%—gains. For example, the labor income share of the bottom half declines steadily, while the top 1% records gains within the first year. Wealth inequality responds even more sharply, with middle- and upper-tier households capturing larger shares as poorer households' net worth erodes. In summary, the evidence indicates that oil price shocks redistribute resources upward, amplifying pre-existing disparities rather than dissipating over time.

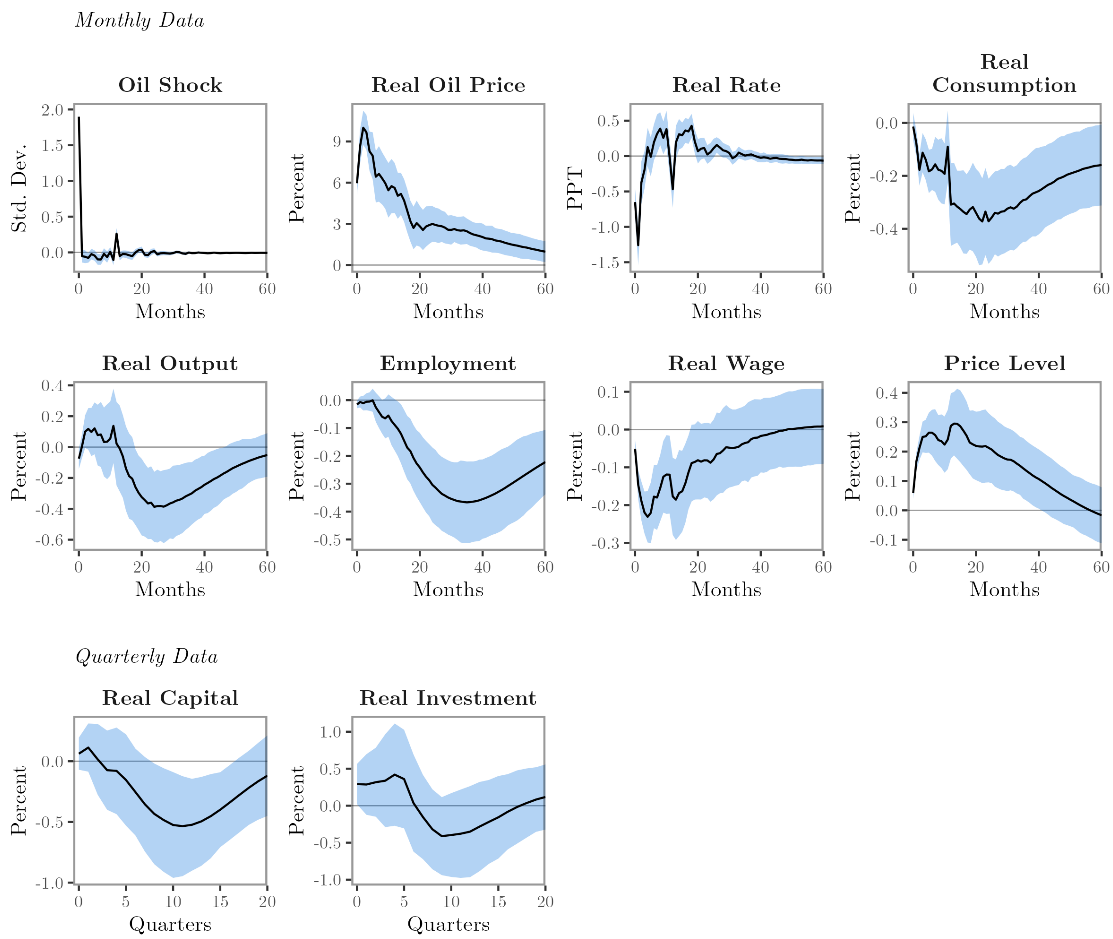

Figure 1: Response of Macro Indicators to a 10% Oil Price Increase.

Notes – Impulse responses of key macroeconomic indicators to a 10% increase in oil prices, using the oil supply shock from Baumeister and Hamilton (2019) as instrument. The solid line is the point estimate and the shaded area is the 68 percent confidence band.

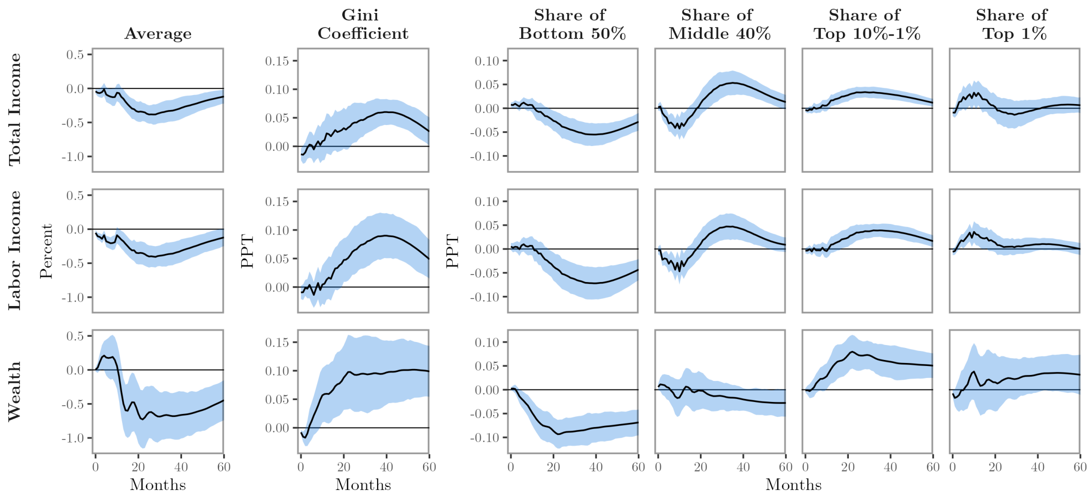

Figure 2: Response of Inequality to a 10% Oil Price Increase.

Notes – Impulse responses of income and wealth measures to a 10% increase in oil prices, using the oil supply shock from Baumeister and Hamilton (2019) as an instrument.The solid line is the point estimate and the shaded area is the 68 percent confidence band.

To assess robustness, Figure 15 in Appendix A.3 shows responses using alternative oil-price instruments from Baumeister and Hamilton (2019), Känzig (2021), and Baumeister (2023), and Figure 16 reports responses when using Hamilton (2013, Table 21.1) event dummies—indicators that equal one in the month an oil event begins and zero otherwise—as instruments. The responses remain broadly consistent across different instruments. Finally, Figure 17 in Appendix A.4 examines robustness to alternative time series transformations. The left panel presents results from a VAR estimated in levels (benchmark specification), while the right panel shows results from a VAR estimated in first differences for variables classified as $I(1)$. The impulse responses are cumulated to recover the original scale. The results remain broadly consistent across specifications, although both the oil price increase and the associated rise in inequality appear more persistent—becoming effectively permanent—when the analysis is based on differenced time series. Overall, the empirical evidence suggests that exogenous increases in oil prices have measurable and robust effects on both macroeconomic activity and inequality. The effects are consistent across different oil price instruments and time series specifications.

4 Model

To account for the above empirical result, we need a model. The model integrates two existing strands of literature. The first strand incorporates oil price shocks in the economy, *a la* Blanchard and Riggi (2013). Given that the U.S. was a net oil importer until 2019, we treat oil as an imported good and abstract from domestic supply. World oil price fluctuations are therefore taken as exogenous, directly shifting U.S. oil demand.[7] Instead, changes in world oil prices result in changes in oil demand. The second strand adopts an incomplete market model featuring idiosyncratic labor income risks as in Aiyagari (1994).

4.1 Households

Time is continuous. The economy consists of a unit mass of infinitely lived households (i.e.:$\bar{N} = 1$). Each household i starts with zero financial wealth. They then work, accumulate capital, and rent their capital out to the firms. They receive labor income and capital income in the form of rental payments. Idiosyncratic labor income shocks contribute to heterogeneity in household income and wealth. Given prices $(p_{E,t}, p_t, w_t, r_t)$, households make labor hour, consumption and savings decisions continuously to solve the following optimization problem:

$$\max_{c_{i,t}} \mathbb{E} \int_0^\infty e^{-\rho t} \left[\frac{c_{i,t}^{1-\phi}}{1-\phi} - \frac{n_{i,t}^{1+\psi}}{1+\psi} \right] dt \tag{13}$$

where

$$c_{i,t} \equiv \left[(1-\xi)^{1-\sigma} c_{Y,i,,t}^{\sigma} + \xi^{1-\sigma} (c_{E,i,t} - \underline{c})^{\sigma} \right]^{\frac{1}{\sigma}} \tag{14}$$

Here, ρ denotes the time discount rate. Agents have CRRA preferences over consumption as well as labor dis-utility. ϕ is the risk aversion coefficient. $c_{i,t}$ is a consumption bundle that consists of both final goods consumption $c_{Y,i,t}$ and energy goods $c_{E,i,t}$. ξ adjusts the weight of energy goods in total consumption and $1/(1-\sigma)$ is the elasticity of substitution between oil and final goods. Agents have non-homothetic preferences in the sense that there exists a minimum level of oil goods consumption $\underline{c}$ for everyone. Further, $n_{i,t}$ denotes hours of labor, and that $1/\psi$ is the Frisch elasticity of labor supply.

Households maximize the consumption bundle by choosing $c_{E,i,t}$ and $c_{Y,i,t}$, given the prices of oil goods $p_{E,t}$ and final goods $p_{Y,t}$, and a certain level of income. Solving this maximization problem yields

$$c_{E,i,t} = \underline{c} + \xi \left(\frac{p_{E,t}}{p_t} \right)^{\frac{1}{\sigma-1}} c_{i,t} \qquad \text{and} \qquad c_{Y,i,t} = (1-\xi) \left(\frac{p_{Y,t}}{p_t} \right)^{\frac{1}{\sigma-1}} c_{i,t} \tag{15}$$

where p_t denotes the aggregate price, which features a combination of $p_{E,t}$ and $p_{Y,t}$ as

$$p_t \equiv \left((1-\xi) p_{Y,t}^{\frac{\sigma}{\sigma-1}} + \xi p_{E,t}^{\frac{\sigma}{\sigma-1}} \right)^{\frac{\sigma-1}{\sigma}} \tag{16}$$

To focus on the relative price between oil goods and final goods, we normalize $p_{Y,t} = p_Y = 1$

[7] According to Bureau of Economic Analysis, the share of oil and gas extraction as a fraction of real GDP in the United States is merely 1.06% in 2019. Therefore, we do not explicitly model the production of oil, and instead assume that the United States can generate export goods at negligible marginal cost (e.g., through the extraction of non-oil natural resources or other low-cost production), sufficient to offset the value of oil imports and maintain trade balance.

so that the aggregate price level is simplified to

$$p_t \equiv \left(1 - \xi + \xi p_{E,t}^{\theta}\right)^{\frac{1}{\theta}} \tag{17}$$

where $\theta = \frac{\sigma}{\sigma-1}$. Let the agent's (real) labor income shock follow an Ornstein–Uhlenbeck process $z_{i,t}$ where

$$dz_{i,t} = \kappa(\bar{z} - z_{i,t})dt + \nu dB_{i,t} \tag{18}$$

Here, κ governs the rate of mean reversion, $\bar{z}$ denotes a constant long-run mean income shock level, ν is the diffusion parameter, and $dB_{i,t}$ denotes a standard Brownian motion, representing the idiosyncratic labor income risk. Notice that the implied long-run variance of $z_{i,t}$ is equal to $\frac{\nu^2}{2\kappa}$. Households' budget constraints then read

$$da_{i,t} = (r_t a_{i,t} - c_{i,t} + z_{i,t} n_{i,t} w_t)dt \tag{19}$$

where $a_{i,t}$ denotes real asset value, r_t and w_t are real rental rate and real wage.

In addition, a borrowing constraint states that

$$a_{i,t} \geq a_{min} \tag{20}$$

Let $V_{i,t}$ denote the value function of the households at time t respectively, the individual Hamilton-Jacobi-Bellman (HJB) equations become

$$\rho V_{i,t} = \max_{c_{i,t}, n_{i,t}} \left[\frac{c_{i,t}^{1-\phi}}{1-\phi} - \frac{n_{i,t}^{1+\psi}}{1+\psi} + \frac{\partial V_{i,t}}{\partial a_{i,t}}(r_t a_{i,t} - c_{i,t} + z_{i,t} n_{i,t} w_t) + \mu(z_{i,t})\frac{\partial V_{i,t}}{\partial z_{i,t}} + \frac{\nu^2}{2}\frac{\partial^2 V_{i,t}}{\partial z_{i,t}^2} \right] \tag{21}$$

The intra-temporal condition linking consumption with labor hours then reads:

$$n_{i,t}^{*\psi} c_{i,t}^{*\phi} = w_t z_{i,t}. \tag{22}$$

Away from the borrowing constraint, agents are able to smooth out consumption through the Euler equation, which reads

$$c_{i,t}^{*} = \left(\frac{\partial V_{i,t}}{\partial a_{i,t}}\right)^{-1/\phi}; \tag{23}$$

However, at the borrowing constraint $a_{i,t} = a_{min}$, agents become hand-to-mouth, and can only consume their current income, i.e.:

$$c_{i,t}^{*}(a_{min}) = r_t a_{min} + z_{i,t} n_{i,t} w_t; \tag{24}$$

Since labor supply and consumption are chosen jointly, labor supply at the borrowing constraint satisfies

$$n_{i,t}^{\psi}(a_{min})\left(w_t z_{i,t} n_{i,t}(a_{min}) + r_t a_{min}\right)^{\phi} = w_t z_{i,t} \tag{25}$$

4.2 Final Goods Firm

The final goods market is competitive. Following Hassler, Krusell, and Olovsson (2021), the final goods firm produces final goods Y_t by combining oil, capital, and labor with a nested CES production function, i.e.:

$$Y_t = A_t\left[(1-\gamma)\left(K_t^{\alpha}N_t^{1-\alpha}\right)^{\chi} + \gamma E_t^{\chi}\right]^{\frac{1}{\chi}} \tag{26}$$

where $\chi = \frac{\epsilon-1}{\epsilon}$, and that ϵ represents the elasticity of substitution between the capital/labor composite and oil, γ denotes the oil income share, and that $\alpha \in (0,1)$. This satisfies constant return to scale, which then ensures zero profit under perfect competition. In the special case where $\epsilon \to 1$ (i.e.: $\chi \to 0$), the production function becomes Cobb-Douglas, and that $Y_t = A_t(K_t^{\alpha}N_t^{1-\alpha})^{1-\gamma}E_t^{\gamma}$.Firms take input cost $(p_{E,t}, p_t, w_t, r_t)$ as given, and optimize over real input demand (E_t, K_t, N_t) to maximize profit. The firm's problem can thus be stated as

$$\max_{E_t,K_t,N_t} p_{Y,t}Y_t - p_{E,t}E_t - r_t p_t K_t - w_t p_t N_t \tag{27}$$

Recall that the price of the final good is normalized to one, $p_Y = 1$. Optimal input decisions then require the firm to equalize the marginal cost for each input. Without loss of generality, we set $A_t = 1$, and the solutions to the above problem read

$$E_t^D = Y_t\gamma\left(\frac{p_t}{p_{E,t}}\right)^{\epsilon} \tag{28}$$

and that

$$N_t^D = Y_t\left(\frac{(1-\gamma)(1-\alpha)}{w_t p_t}\right)^{\epsilon}\left(\frac{\alpha}{1-\alpha}\frac{w_t}{r_t}\right)^{\alpha(\epsilon-1)} \tag{29}$$

$$K_t^D = N_t\left(\frac{\alpha}{1-\alpha}\frac{w_t}{r_t}\right) \tag{30}$$

where the superscript D denotes the optimal demand. Intuitively, the economy tends to enter a recession following an increase in oil prices for two primary reasons. Firstly, when holding the general price level p_t constant, a rise in oil prices directly diminishes the demand for energy inputs, thus decreasing the productivity of both capital and labor. Thus, firms reduce the demand for capital and labor inputs. Secondly, an increase in oil prices also raises the general price level, leading to increased costs for capital and labor. This effect amplifies the reduction in demand for capital and labor inputs, further dampening overall output demand.

4.3 Aggregation

To close the model, we impose market-clearing conditions for oil goods, labor as well as capital. First, given that oil price is assumed to be imported, changes in oil prices determine the total oil demand, which consists of demand for oil consumption and demand for oil input in production, i.e.:

$$E_t^* = E_t^D + \int_0^1 c_{E,i,t} di \tag{31}$$

Next, labor market clearing requires that the total labor demand equals the total labor supply, i.e.:

$$N_t^D = \int_0^1 n_{i,t} di \tag{32}$$

Next, the capital market clearing condition states that total households' savings are equal to total productive capital.

$$K_t^* = K_t^D = \int_0^1 a_{i,t} di \tag{33}$$

Equations (31), (32) and (33), along with equations (28), (30), (29) jointly determine the wage rate, rental rate and equilibrium oil, capital and labor input.

Finally, we abstract from capital depreciation so that investment equals net accumulation. Thus, the goods market clearing condition states that

$$Y_t = \int_i c_{Y,i,t} di + I_t \tag{34}$$

where I_t denotes net investment.

5 Equilibrium

In this section, we start by characterizing the equilibrium of this economy. The system of equations that characterizes the equilibrium requires the coupled Hamilton-Jacobi-Bellman equations and the Kolmogorov-Fokker-Planck equations (HJB-KFP), along with the aggregation conditions. Let $f_t(a,z)$ indicate the joint distribution of income and wealth at time t, we have

$$\rho V_{i,t} = \max_{c_{i,t}, n_{i,t}} \left[\frac{c_{i,t}^{1-\phi}}{1-\phi} - \frac{n_{i,t}^{1+\psi}}{1+\psi} + \frac{\partial V_{i,t}}{\partial a_{i,t}} (r_t a_{i,t} - c_{i,t} + z_{i,t} n_{i,t} w_t) + \mu(z_{i,t}) \frac{\partial V_{i,t}}{\partial z_{i,t}} + \frac{\nu^2}{2} \frac{\partial^2 V_{i,t}}{\partial z_{i,t}^2} \right] \tag{35}$$

$$\frac{\partial f_{i,t}}{\partial t} = -\frac{\partial}{\partial a_{i,t}} \left(f_{i,t} (r_t a_{i,t} - c_{i,t} + z_{i,t} n_{i,t} w_t) \right) - \frac{\partial [\mu(z_{i,t}) f_{i,t}]}{\partial z_{i,t}} + \frac{1}{2} \frac{\partial^2 [\nu^2 f_{i,t}]}{\partial z_{i,t}^2}. \tag{36}$$

$$K_t^* = \int_0^1 a_{i,t} di = \int_{a_{min}}^{\infty} a_t f_t da_t \tag{37}$$

$$E_t^* = E_t^D + \int_0^1 c_{i,t}^E di \tag{38}$$

$$N_t^D = \int_0^1 n_{i,t} di \tag{39}$$

$$Y_t = \int_i c_{Y,i,t} di + I_t \tag{40}$$

$$a_{i,t} \geq a_{min} \qquad \forall i \tag{41}$$

That is, the equilibrium in this model is given by household decisions $(c^*_{E,i,t}, c^*_{Y,i,t})$, a set of aggregate variables of capital, energy, labor, consumption and investment $(K^*_t, E^*_t, N^*_t, C^*_t, I^*_t)$, and prices $(p_{E,t}, p_t, r_t, w_t)$ such that the HJB and the KFP hold, and that the energy market, labor market, goods market and capital market clear. The above system of equations holds both in the steady state as well as during the transition dynamics. In the following section, we will resort to numerical methods to compute the solution of the model. Detailed numerical methods are provided in the Appendix.

6 Numerical Results

This section reports the quantitative effects of oil price shocks. We first show their impact on prices, output, and consumption, then examine how interest rates and wages adjust. We then trace the responses of consumption, income, and wealth inequality, before turning to distributional decompositions across households.

6.1 Energy Price Shocks

We begin by presenting the numerical results using calibrated parameters. To do this, we discretize the continuous time model above into monthly frequency. We then present the steady state results, and the impulse response functions of the economy in response to a one-time positive and temporary oil price shock, modeled as an exponential decay process

$$p_{E,t} = p_E + v_0 e^{-\rho_E t} \tag{42}$$

where $v_0 = 0.5 p_E$ represents a one-time 50% increase of oil prices. We simulate the model's response to a one-time 50% increase in oil prices since such magnitudes are representative of major historical episodes (e.g., the Gulf War, the 2008 spike, the 2014–15 collapse) and make it possible to illustrate the model's dynamics more clearly. The persistence parameter of oil price shock ρ_E is estimated using monthly data on real crude oil prices spanning from 1985 to 2019, sourced from the U.S. Energy Information Administration (EIA). This then implies that the half-life of oil price shocks is determined to be 34 months.

6.2 Benchmark Parameters

Table 1: Benchmark Parameter Values (monthly)

Parameters	Value	Data Source
ϕ	2	Standard value in the literature
α	0.33	Standard value in the literature
κ	0.05	Match annualized labor income persistence
ν	0.55	Match annualized labor income volatility
$\underline{c}$	0.00055	Match bottom group energy expenditure share
ξ	0.023	Match oil consumption share in total consumption
σ	-3.88	Match short-run average elasticity for household
ψ	4	Implied inverse of Frisch elasticity of labor supply
γ	0.017	Match income share of oil in total output
ϵ	0.9	Match short-run output response to oil price
ρ_E	0.02	Estimated using crude oil price data
ρ	0.0217	Match peak timing of interest rate

Table 1 presents the benchmark parameters used for the calibration exercise at monthly frequency. We consider the standard value of $\phi = 2$ and $\alpha = 0.33$ to be the level of risk aversion and capital share. For the labor income process, the monthly rate of mean reversion κ is set to 0.05 and the volatility ν is set to 0.55. These vaules imply a monthly autocorrelation $e^{-\kappa} \approx 0.95$ and a half-life of about 14 months, consistent with the medium estimates of the transitory component of earnings risk in Storesletten, Telmer, and Yaron (2004) and Heathcote, Storesletten, and Violante (2010). Next, since the minimum level of oil goods consumption is mostly relevant to the bottom-income households, we calibrate $\underline{c}$ to match the combined energy expenditure share of the bottom 20%—including gasoline, motor oil, and oil-based residential fuels—amounting to about 11.6% of total consumption (Oni (2024)). This broader definition of energy is consistent with our consumption aggregator, where $c_{E,i,t}$ captures all petroleum-linked household energy use. Following Bodenstein, Erceg, and Guerrieri (2011a), the share of oil consumption out of total consumption composite ξ is set to 2.3%. In contrast to other parameters within the model, the elasticity of energy substitution exhibits a broader spectrum of estimates, ranging from 0.1 to 0.4 across various studies. Here, the parameter σ is chosen so that the elasticity of substitution between oil goods and final goods equals 0.205, which matches the short-run average elasticity for households found in a meta-analysis in Labandeira, Labeaga, and López-Otero (2017). This then implies that $\sigma = -3.88$. [8] The Frisch elasticity of labor $1/\psi$ is calibrated to be 0.25, following the median estimate of a recent meta-analysis Elminejad, Havranek, Horvath, and Irsova (2023). Following the methodology of Blanchard and Riggi (2013), the income share of oil in total output,

[8] In our model, the CES aggregator between oil and non-oil consumption goods implies an elasticity of substitution parameter $\sigma \approx -3.88$, which corresponds to $\eta = 1/(1-\sigma) \approx 0.205$. Using the standard CES relationship, the implied price elasticity of oil demand is approximately $-\eta(1-s_O)$, where s_O is the oil expenditure share. Given an empirical oil expenditure share of 2.3%, this yields a price elasticity of demand near –0.20 as in Labandeira, Labeaga, and López-Otero (2017).

denoted by γ, is set at 1.7%. The substitution elasticity ϵ is calibrated to match the short-run output loss from an oil price increase, estimated at just under 1% by Kilian and Murphy (2014). This then implies that $\epsilon = 0.9$. Further, the steady state of real oil prices in the model is calibrated to match the average household energy consumption expenditure share, which stands at 7.2% based on NIPA and EIA data. We also set the benchmark borrowing constraint at $\underline{a} = 0$, and report in the sensitivity analysis results when a looser borrowing constraint $\underline{a}$ is used. Lastly, we calibrate the monthly discount rate, $\rho = 0.0217$, to align the peak timing of the model's interest rate response with its empirical counterpart.

6.3 Model Fit

We now turn to assessing the model's performance by comparing its key empirical implications. Table 2 presents the main untargeted statistics comparing the model's fit to the data using the calibrated parameters described above. The model produces an average monthly marginal propensity to consume (MPC) of 8.45%, aligning with empirical estimates from Carroll (1997), who find a 5–15% monthly MPC among households facing similar income risk and preferences. [9] Next, the model yields a wealth-to-income ratio of 6.19, aligning well with empirical estimates of 6–8 for private wealth-to-income ratios reported by Castaneda, Diaz-Gimenez, and Rios-Rull (2003) and Piketty and Zucman (2014). The model generates a hand-to-mouth (HTM) share of 11.46% when using a threshold of 3 months' average income to define limited liquid wealth. This broader definition captures agents who may not be strictly liquidity-constrained but still lack meaningful financial buffers. When the threshold is raised to 6 months' average income, the HTM share increases to 48%. These levels are consistent with empirical estimates reported in the literature. For instance, Kaplan, Violante, and Weidner (2014) document that between 30% and 40% of households have insufficient liquid assets to cover three to six months of typical consumption, aligning well with the model's predictions despite its stylized structure. The model also generates a steady-state real monthly interest rate of 0.389%, which implies an annual rate of return of 4.84%, falling within the range of long-run real returns on capital cited by Piketty and Zucman (2014), who estimate that the average real return on wealth (or capital income net of depreciation and inflation) has historically ranged between 4% and 5% in developed countries over the 19th and 20th centuries.

[9] Fagereng, Holm, and Natvik (2021) similarly report monthly MPCs of 5–10% for Norwegian households with moderate liquidity following windfalls.

Table 2: Model Fit (monthly)

	Model	Data (1985-2019)
MPC (monthly)	8.42%	5-15%
Wealth to income ratio	6.09	6-7
Share of HTM agents	11.46-48%	30-40%
Equilibrium interest rate	0.389%	0.327-0.407%
Bottom 20% income	9.02%	3.5%
$20-40\%$ income	14.15%	9.2%
$40-60\%$ income	19.18%	15.3%
$60-80\%$ income	24.37%	24.2%
Top 20% income	32.13%	47.8%

While the model generates slightly less concentration at the top compared to the data—for example, the top 20% of earners receive 32.13% of income in the model versus 47.8% in the data—the overall distribution across quintiles aligns well, capturing key patterns of inequality. As is standard in the Aiyagari type of model, it produces less extreme wealth inequality than observed in the data, largely because we abstract from high-return assets and entrepreneurial risk that drive the right tail in reality. Crucially, this is not a limitation for our analysis. The mechanism by which oil price shocks influence inequality in our framework centers on changes in the savings rate and the division between capital and labor income, rather than movements in the extreme right tail.

6.4 Simulation

Based on the calibrated model, we proceed to simulate the economy under a 50% increase in oil price. Figures 3 and 4 illustrate the impulse response functions of this shock on both aggregate and distributional variables over a span of up to 1200 months, and Figure 5 compares the model with the empirical impulse response functions. [10]

As one can see, the increase in oil price increases the general price level and dampens aggregate output. The reduction in aggregate demand prompts firms to scale back production, leading to a decrease in demand for labor and capital, consistent with the effects of negative aggregate supply shocks. Consumption on both the final goods and oil goods, as well as capital decline. Further, a positive oil price shock also results in an immediate reduction in wages and interest rate. However, interest rate recovers much faster than wages, and temporarily overshoots its steady-state level. This occurs because, when the interest rate initially drops, the supply of capital is low. As a result, the interest rate must rise more quickly to accommodate the recovering demand for capital. Moreover, labor supply declines sharply due to the initial fall in wages and the interest rate. Interestingly, the dynamics of labor supply also exhibit a hump-shaped pattern similar to that

[10] The vertical axis denotes the percentage deviation of the variables of interest from their respective steady-state values, with the exception of interest rate and Gini coefficient, which are expressed as percentage points.

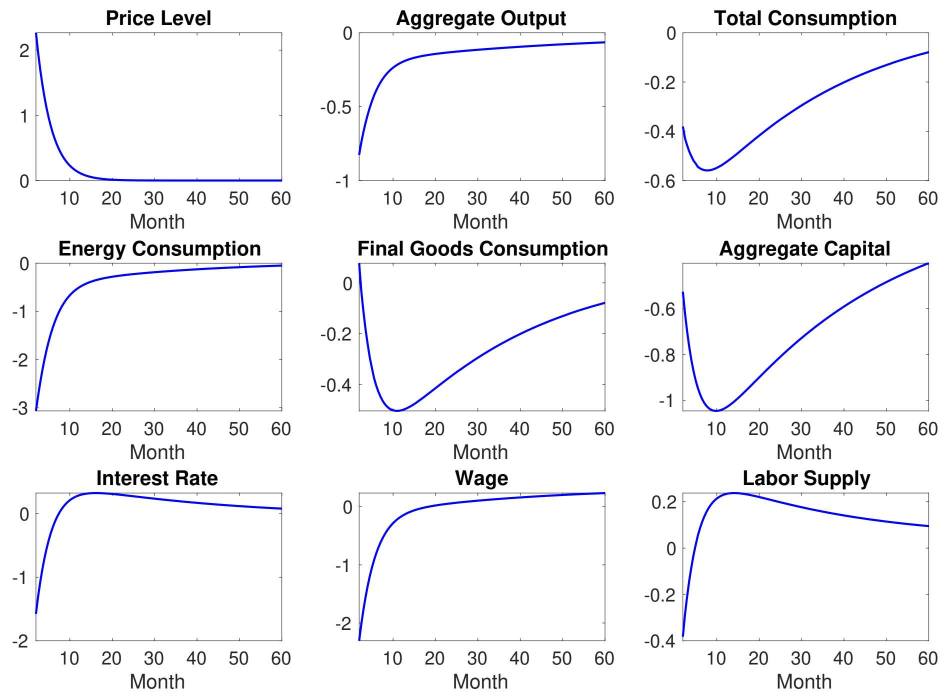

Figure 3: IRFs (Unit: $\Delta\%$ from steady state, except interest rate is expressed as Δ PPT)

of the interest rate. As wages gradually recover and the interest rate temporarily overshoots its steady-state level, the incentive to earn labor income and save strengthens, leading to a temporary increase in labor supply. Eventually, labor supply gradually returns to its baseline level.

Now we turn to the response of the Gini coefficients. First, notice that the initial consumption inequality sees a sudden rise of more than 0.06 percentage points. This occurs because while the wealthy do not need to reduce consumption as much as they have enough buffer stock, many poor agents who were previously operating on the Euler equation now find themselves living hand-to-mouth, eroding their capacity to smooth consumption altogether; thus, consumption inequality jumps. It then decreases rapidly as the economy rebounds, when the poor become less borrowing constrained.

Next, wealth inequality rises and peaks at around almost 0.18 percentage points before gradually converging back to the baseline. Notice that to observe shifts in wealth inequality, variations in wealth growth rates among individuals are necessary. Recall that the flow budget constraint for an individual with wealth $a_{i,t}$ can be written as:

$$\frac{da_{i,t}}{a_{i,t}} = r_t + \frac{w_t z_{i,t} n_{i,t}}{a_{i,t}} - \frac{c_{i,t}}{a_{i,t}} \tag{43}$$

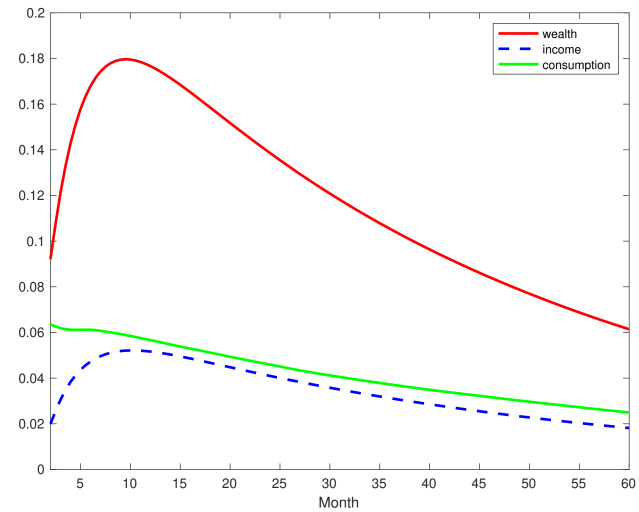

Figure 4: Impulse response functions (Unit: Δ PPT from steady state)

Here, the uniform decrease in r_t for all does not influence wealth growth rates for those on the Euler equation but can help to compress the wealth distribution if many agents are hand-to-mouth. However, since labor income constitutes a smaller fraction of rich individuals' wealth, the second term exacerbates inequality by reducing labor income growth more for the poor. [11]The third term, related to the consumption-to-wealth ratio, rises more for poorer agents because the negative income shock pushes everyone into a higher MPC region. Since the poor already have higher MPCs, they must draw a larger fraction of their wealth to sustain consumption, accelerating their wealth depletion. Thus, both the second and third terms contribute to making the wealth-poor even poorer, with this effect reaching its maximum when the interest rate peaks.

Lastly, income inequality largely mirrors the dynamics of wealth inequality, driven primarily by rising disparities in capital income. As poorer households draw down their wealth, their capital income correspondingly declines. In a later section, we show that lower-income individuals attempt to offset this by reducing labor supply less than wealthier households. However, this response is quantitatively modest and insufficient to counteract the overall rise in income inequality.

To compare with the empirical IV-SVAR results, we scale up the empirical impulse responses proportionally so that both correspond to a 50% change in oil prices. and the results are reported in Figure 5. This implies that a 50% increase in oil prices raises the income and wealth Gini by about 0.06-0.18 percentage points, which explains about 36% of the rise in the empirical estimates.The model also captures well the changes in other macro variables, especially the quick recovery of interest rate and the slow adjustment of wage rate. Further, both the model and the data show that inequality remains elevated long after macroeconomic variables stabilize We also examine

[11]Notice that most of the labor income change is driven by the changes in wage rate, not labor supply.

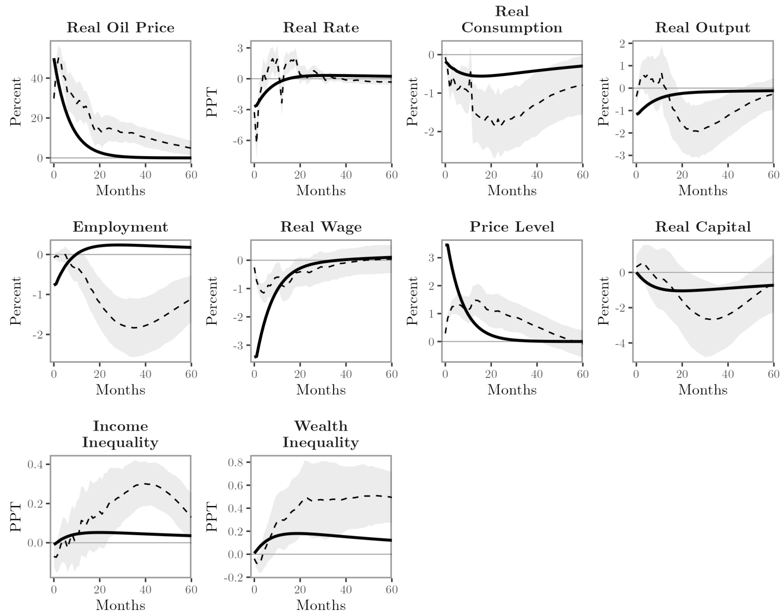

Figure 5: Impulse response functions: Model vs. Data

the sensitivity of these model-based impulse responses to alternative parameterizations, including changes in the oil substitution elasticities, and household borrowing constraints. The qualitative dynamics are broadly robust across these specifications. Detailed robustness exercises are reported in Appendix C.

6.5 Non-Homotheticity in Energy Consumption

The key mechanism through which non-homothetic preferences influence differential exposure to oil price shocks lies in how households shift spending between energy and other goods. To better understand the resulting inequality in energy use, we examine the role of the minimum energy consumption parameter, $\underline{c}$, under the alternative assumption that oil price shocks transmit only to gasoline expenditures, while leaving residential energy costs unaffected. According to the CEX data, the bottom 20% income group allocates about 2.8–2.9% of their total consumption to the category "Gasoline, other fuels, and motor oil." and an additional 0.2% to "Fuel oil and other fuels". Combining these two components, we estimate that the gas-only goods represent roughly 3.1% of total consumption for the bottom quintile. The alternative value of $\underline{c}$ is then based on this combined estimate.

Figure 6 presents the steady-state energy expenditure shares across income quintiles. It shows that lower-income households allocate a larger portion of their budgets to energy when oil price shocks are assumed to affect both gasoline and residential energy, which indicates their greater vulnerability. The degree of non-homotheticity is also stronger in the baseline scenario: the ex-

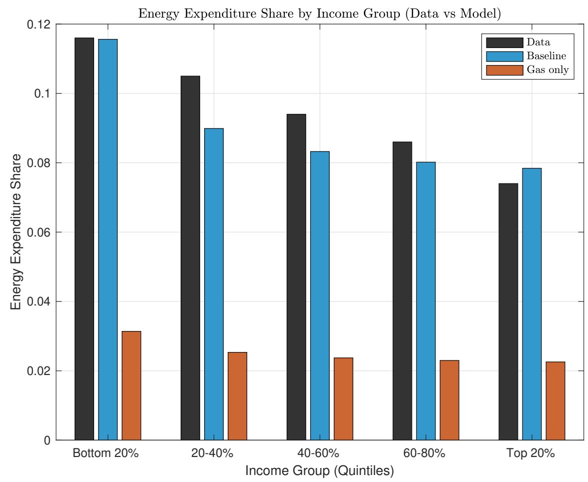

Figure 6: Energy expenditure share by income group

penditure share gap between the bottom and top quintiles is about 1% when only gasoline prices respond to oil shocks, but increases to roughly 3.5% once residential energy is included. Since households' residential energy use such as propane, and other heating sources are all petroleum-based, whose price move closely with crude oil prices, including them provides a more comprehensive measure of households' energy exposure (See Edelstein and Kilian (2009) and Bodenstein, Erceg, and Guerrieri (2011b)).

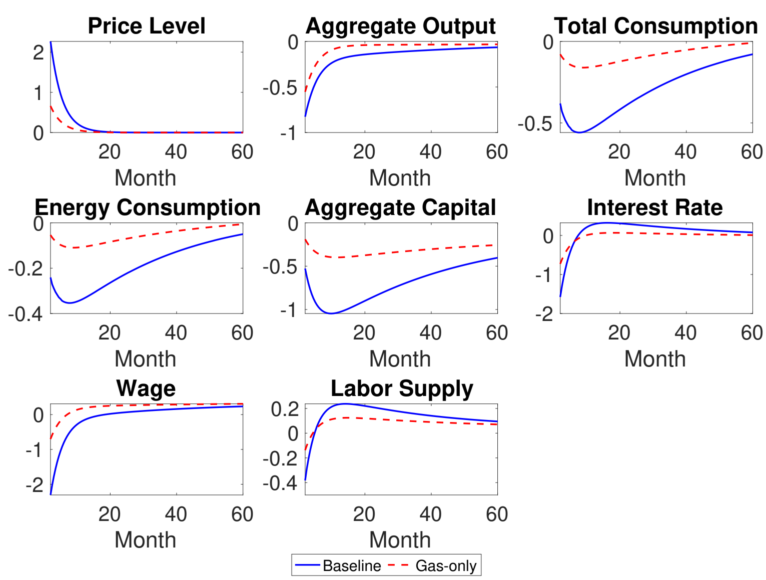

Figure 7: IRFs (Unit: Δ% from steady state, except interest rate is expressed as Δ PPT)

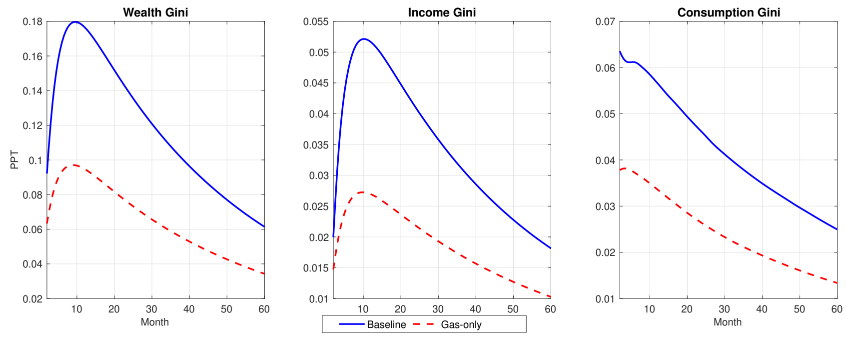

Figure 8: Impulse response functions (Unit: Δ PPT from steady state)

We next compare the impulse responses of aggregate variables and inequality measures between the baseline and the gas-only economy. Figures 7 and 8 show that when $\underline{c}$ includes both gasoline and residential energy, the impact of oil price shocks on aggregate activity and inequality is stronger. A higher minimum energy requirement forces low income households, who spend a larger share of their budget on energy, to cut back disproportionately on other consumption when energy prices rise. This accelerates wealth depletion for poorer households and widens the gap in both income and consumption, leading to larger and more persistent increases in inequality. By contrast, under the gasoline-only calibration, the lower value of $\underline{c}$ reduces the extent of non-homotheticity, leading to a more muted, though still non-negligible distributional effect.

6.6 Winners vs. Losers

To gain deeper insights into winners and losers, we next focus on the change of various quintiles of the distribution in response to oil price shocks.

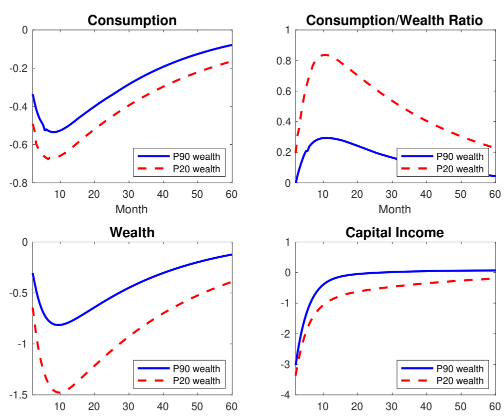

Figure 9: IRFs to P90 wealth group (solid lines) and P20 wealth group (dashed lines) oil price shocks (Unit: Δ% from steady state)

Figure 9 shows the responses of consumption, wealth, capital income, and the consumption-to-wealth ratio for the 90th and 20th wealth percentiles. Both rich and poor households experience sharp declines in consumption, wealth and capital income. However, since poorer households have higher marginal propensities to consume (MPC), they are forced to reduce their savings rates more aggressively. As a result, a larger share of their remaining wealth is used for consumption, leading to a more pronounced increase in their consumption-to-wealth ratio. Therefore, wealth differences increase between the P90 and the P20 wealth group, along with capital income differences.

6.7 The Role of Labor Supply

So far, we have been silent about labor income. In fact, labor income plays an interesting albeit subtle role in the dynamics of income and wealth inequality. Labor supply initially falls in response to a wage decline during a recession, as lower wages reduce the incentive to work. However, in the transition, labor supply recovers fast, and overshoots as the interest rate rises. This higher interest rate incentivizes agents to work more in anticipation of future consumption gains.

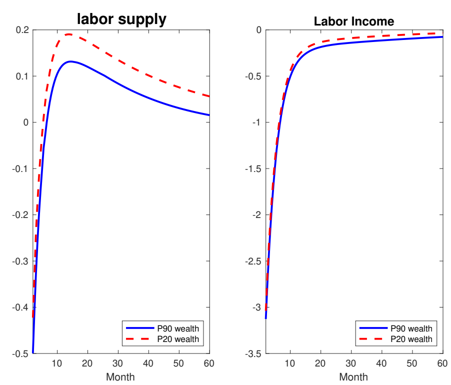

Figure 10: IRFs to P90 wealth group (solid lines) and P20 wealth group (dashed lines) oil price shocks (Unit: $\Delta\%$ from steady state)

However, poorer households reduce their labor supply less than the richer ones in response to the shock. The left panel of Figure 12 shows that individuals in the bottom 20% of the wealth distribution cut back labor supply less compared with the 90%, and work a lot more when the interest rate begins to recover, aiming to offset income losses. However, because the decline in wages is much sharper compared with labor supply response, the impulse response of labor income (shown in the right panel) looks almost identical across wealth groups, and is largely driven by the wage dynamics rather than labor supply effort.

7 Asymmetric Responses to Oil Price Shocks

Finally, we ask ourselves: does inequality decrease with the same magnitude and persistence in response to a negative vs. positive oil price shock? Figure 11 and Figure 12 show the responses of macro variables and Gini coefficients by comparing a 50% increase in oil prices vs a 50% decrease in oil prices under the same baseline parameters. Interestingly, the results indicate that the distributional costs of oil price increases outweigh the redistributive benefits of price declines.

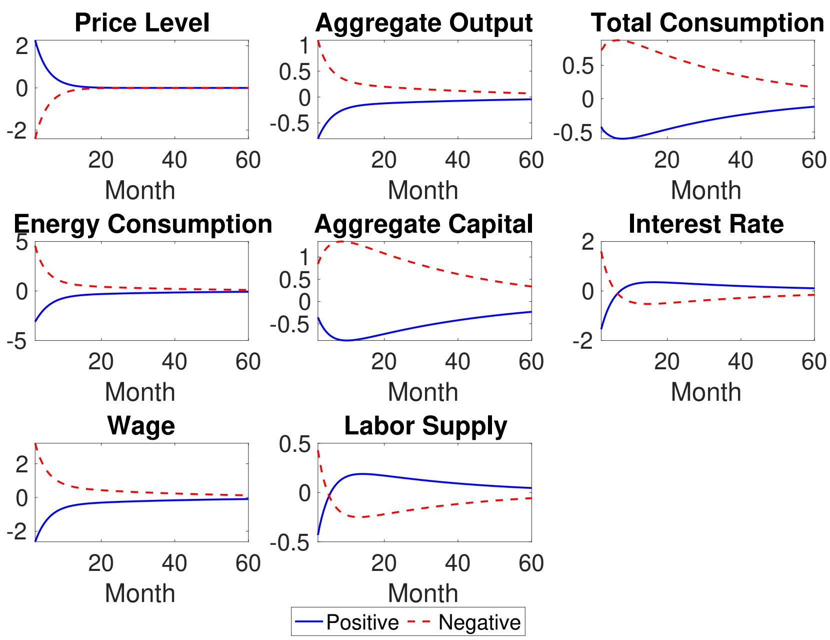

Figure 11: Impulse response functions to positive (solid lines) and negative (dashed lines) oil price shocks (Unit: $\Delta\%$ from steady state), except interest rate is expressed as Δ PPT)

Following a negative oil price shock (a decrease in oil prices), the economy expands much more strongly than it contracts under a positive shock (an increase in oil prices) of equal size. To understand this, notice that a decline in oil prices reduces the relative price of energy and releases expenditure capacity, which quickly translates into higher aggregate demand. By contrast, when oil prices rise, the adjustment in aggregate demand is more muted: the loss of purchasing power from a positive oil price shock pushes households into a higher-MPC region, so total consumption contracts by less than it expands in the opposite case. This asymmetry explains why negative oil price shocks generate a larger boost to aggregate activity than the contraction caused by positive shocks of equal magnitude. In contrast, the distributional effects are more muted under a negative shock. Although inequality decreases when oil becomes cheaper, the reduction is smaller in magnitude than the increase observed during a price hike. This pattern is mainly reflected in the consumption Gini: under a positive oil price shock, many households that were previously optimizing along their Euler equation become hand-to-mouth and are left with little or no wealth.

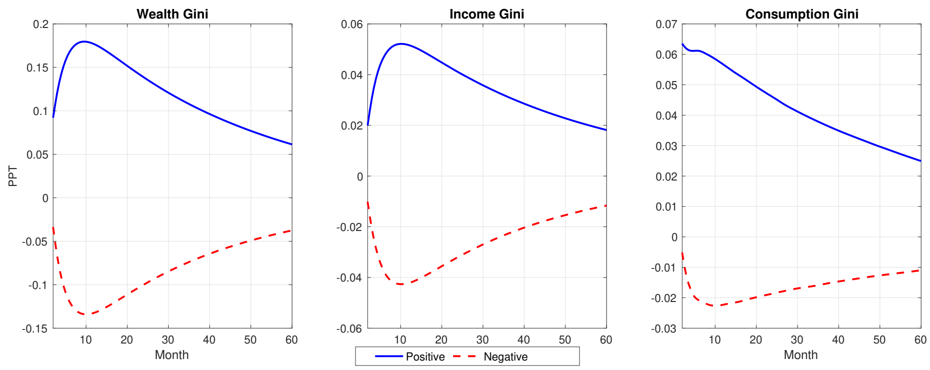

Figure 12: Impulse response functions to positive (solid lines) and negative (dashed lines) oil price shocks (Unit: Δ PPT from steady state)

8 Conclusion

This is the first paper that systematically examines the impact of oil price fluctuations on the dynamics of consumption, income and wealth inequality in an oil-importing economy. By analyzing data of macroeconomic aggregates, oil prices, and inequality, our study shows that a rise in oil prices triggers a sustained surge in inequality. To decompose the channels at which oil price shocks affect distributional variables, we delve into a continuous-time heterogeneous agent model where oil serves as both a consumption good and a production input. We then calibrate the model to the U.S. data in recent decades. Our findings reveal that a temporary positive oil price shocks yields substantial and lasting increases in consumption, income, and wealth inequality.

The framework presented in our study lays the groundwork for several interesting extensions and future explorations. For instance, incorporating oil production and enabling endogenous fluctuations of oil prices could offer insights into how the distributional effects of oil price shocks hinge upon the market power of oil production. Additionally, it could shed light on the consequence of oil price shocks on oil-exporting economies, particularly as domestic oil production gains higher market share in the international oil market. Another intriguing avenue for investigation would involve introducing stochastic shocks in oil prices, which can potentially yield more nuanced implications for inequality as agents adapt their behavior in response to varying levels of uncertainty of future oil price shocks. Lastly, future research could explore how different energy policies affect the distribution of income and wealth. For instance, a carbon tax may encourage households and firms to gradually adopt cleaner energy alternatives. It would therefore be valuable to examine how such fiscal policies influence inequality, particularly when alternative energy options become available.

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Appendices

A Data Description

A.1 Macro Variables

The macro-financial indicators and oil price instruments used in the IV-SVAR model, displayed in Figure 13, are defined as follows:

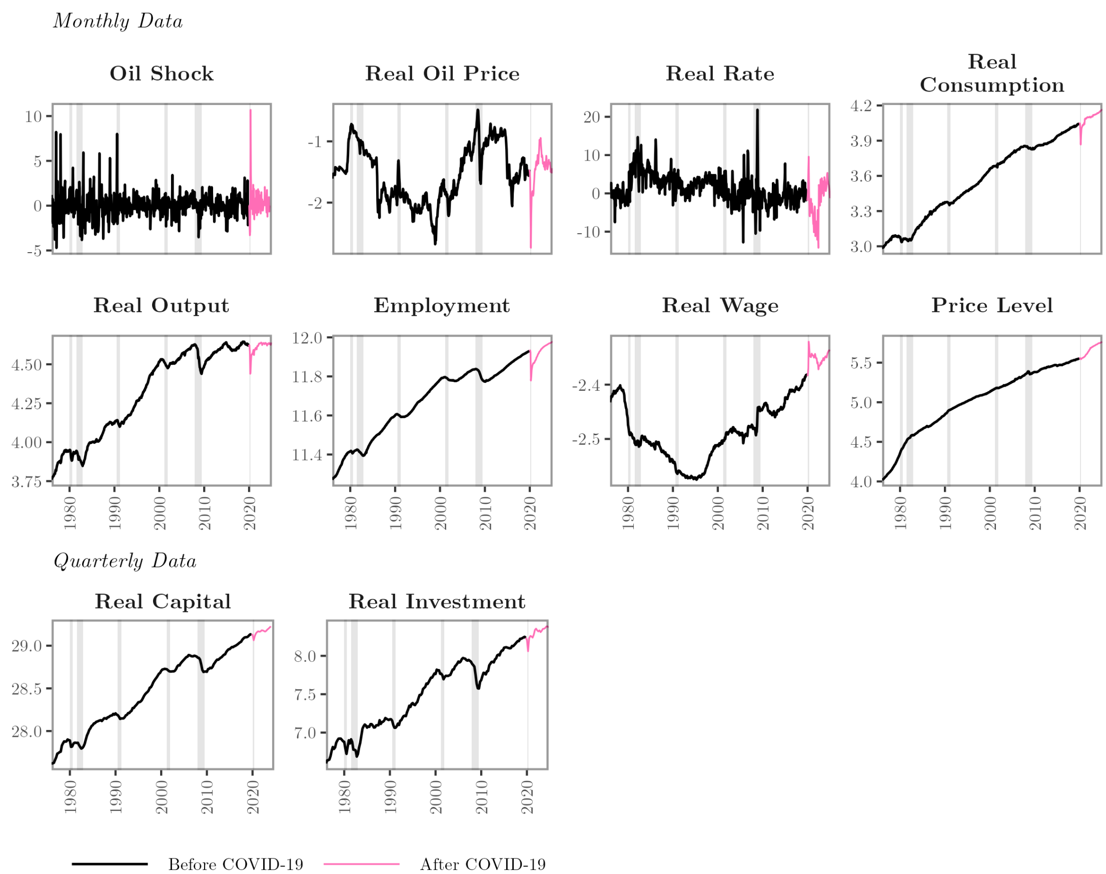

Figure 13: Macro Data.

NOTES – This figure presents the macroeconomic indicators used for the IRF estimation presented in Figure 1. The gray shades represent recession periods as identified by the National Bureau of Economic Research (NBER).

A.2 Inequality Data

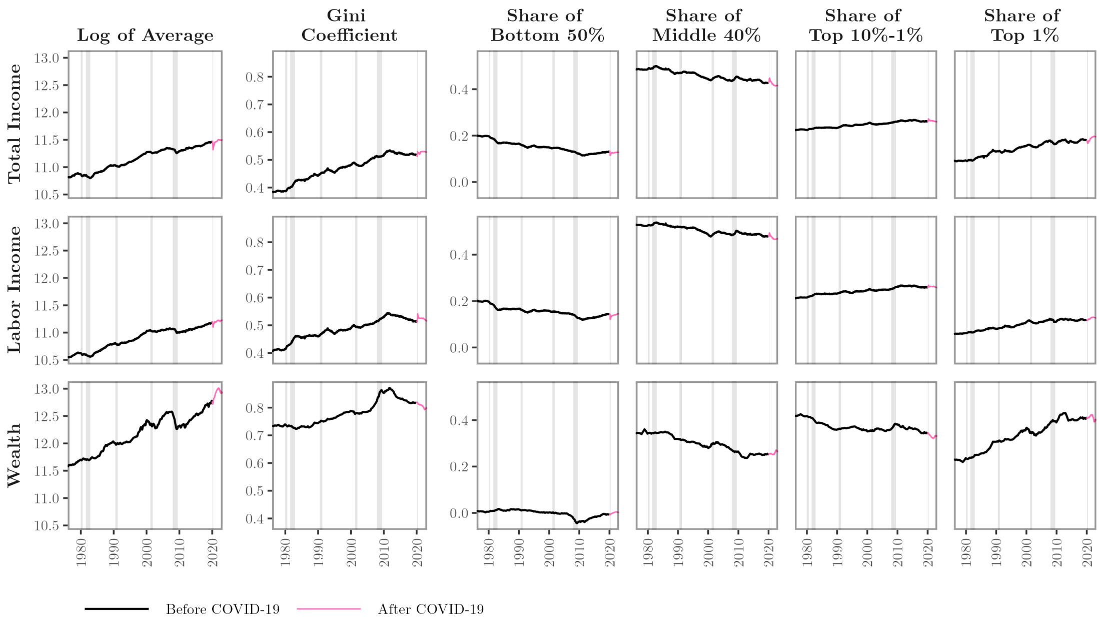

Figure 14: Inequality Data.

NOTES – This figure displays the subset of variables from the *Real-Time Inequality* dataset by Blanchet, Saez, and Zucman (2022), available at https://realtimeinequality.org, that are used in the IRF estimation presented in Figure 2. The gray shades represent recession periods as identified by the National Bureau of Economic Research (NBER).

A.3 Robustness Check of Alternative Oil Shocks

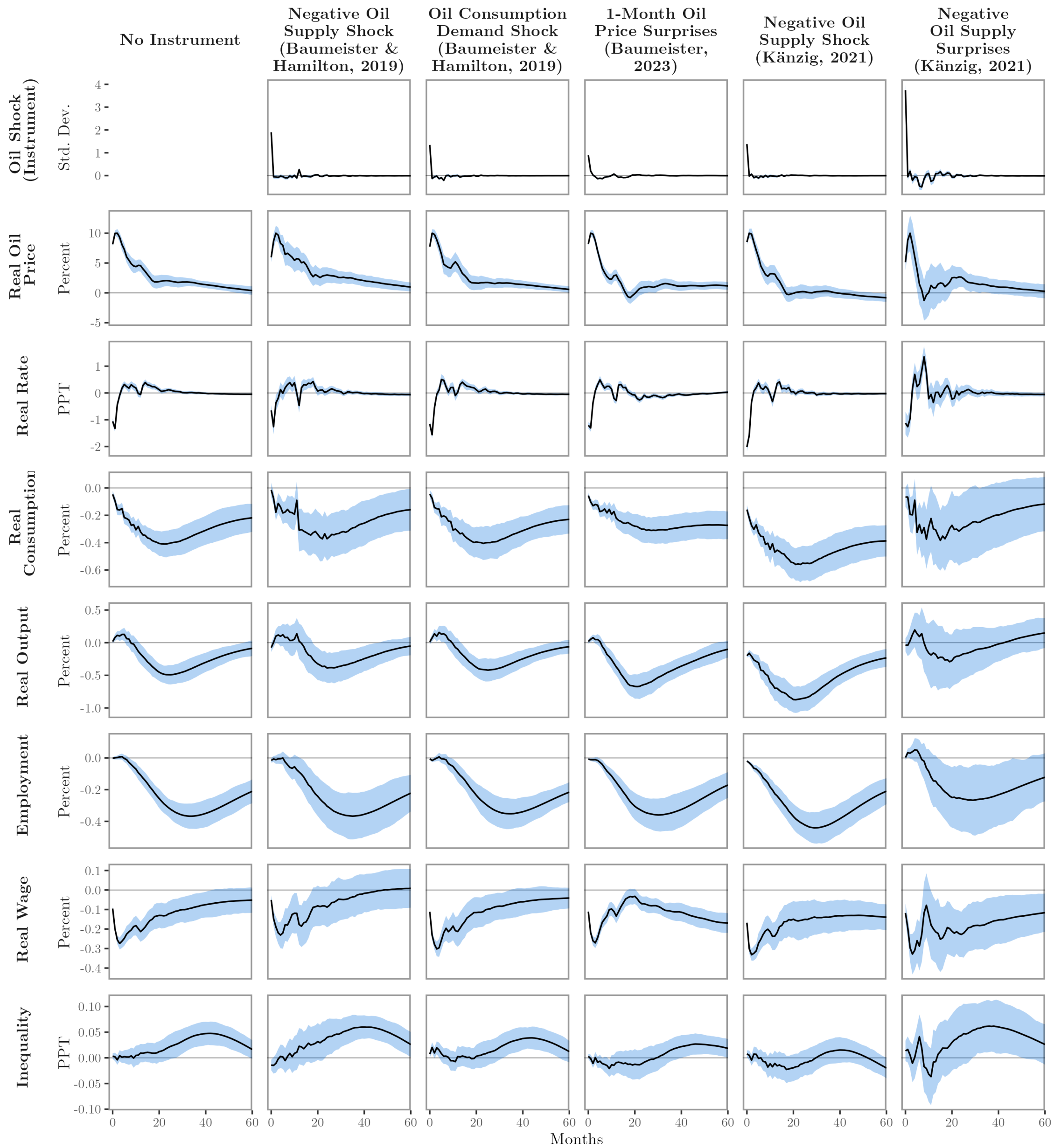

Figure 15: Robustness to Alternative Oil Shock Measures.

Notes – Impulse responses to a 10% increase in oil prices across different oil shocks for robustness, obtained from Baumeister and Hamilton (2019), Känzig (2021), and Baumeister (2023). The solid line is the point estimate and the shaded area is the 68 percent confidence band.

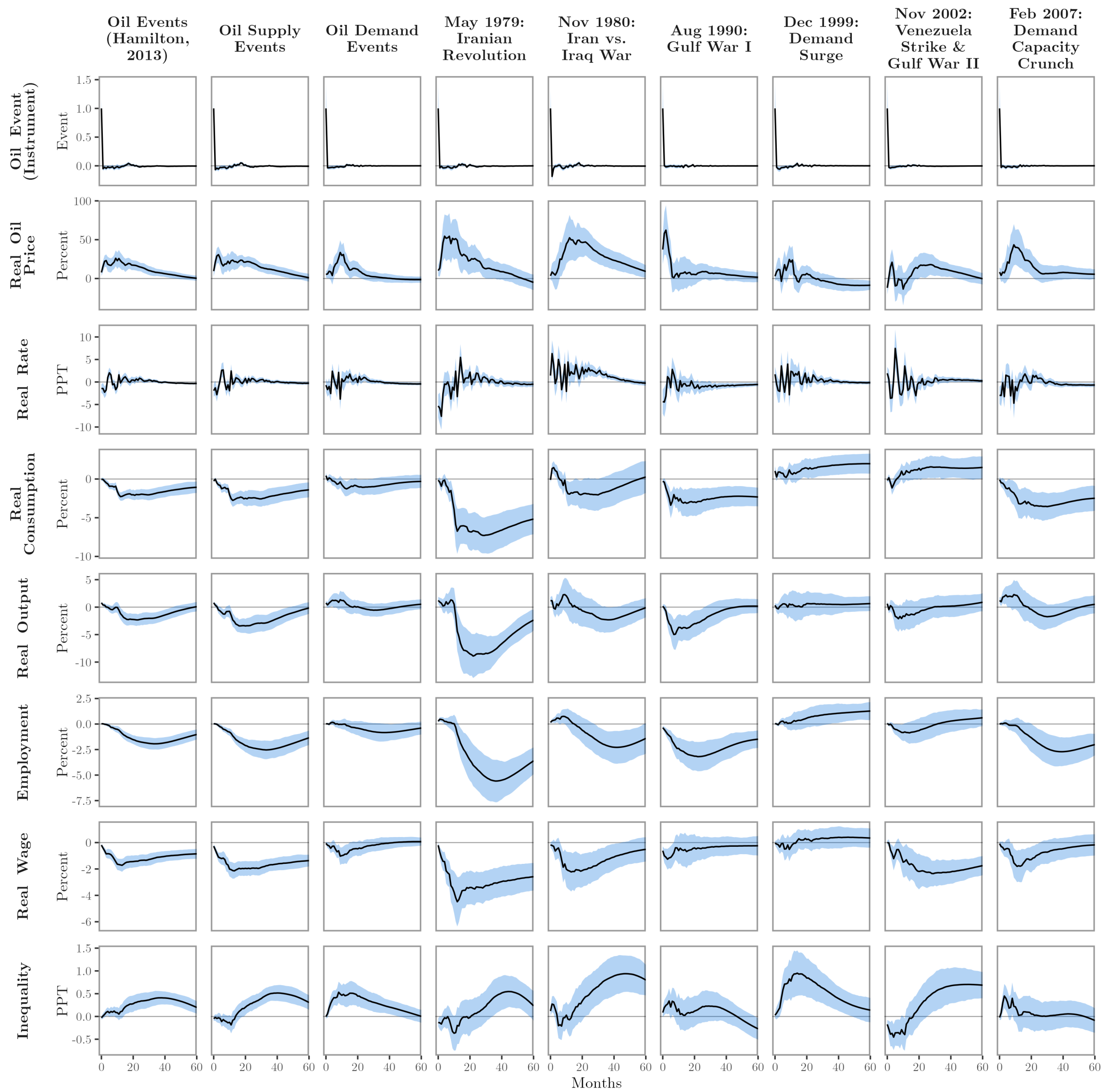

Figure 16: Robustness Using Dummy Oil Events as an Instrument.

NOTES – Impulse responses to a *one–unit increase* in the event indicator. The instrument equals one in the month an event begins and zero otherwise. The six events are taken from Hamilton (2013, Table 21.1) "Summary of Significant Postwar Events." Following Hamilton's classification, *Dec 1999* and *Feb 2007* are treated as *demand* events and the remaining episodes as *supply* events. Estimation follows the same VAR/IV setup as for the oil-shock IRFs; the only difference is that there is *no* scaling to a 10% oil-price increase. The solid line shows point estimates and the shaded area the 68% confidence band.

A.4 Robustness Check of Alternative Transformation

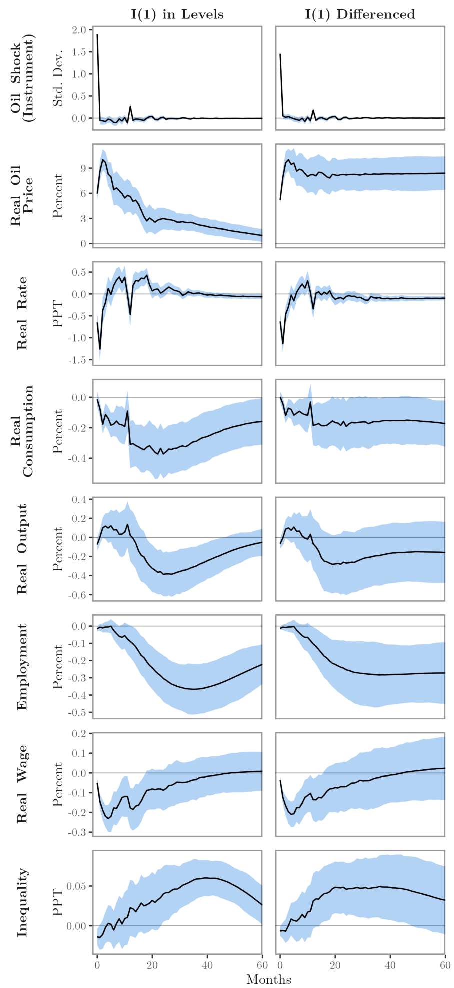

Figure 17: Robustness to Alternative Time Series Transformations.

Notes – Impulse responses of key macroeconomic indicators to a 10% increase in oil prices, identified using the oil supply shock from Baumeister and Hamilton (2019) as an instrument. The left panel shows results from a VAR estimated in levels (benchmark), while the right panel uses a VAR estimated in first differences for variables classified as I(1), with the corresponding responses then cumulated. We treat a variable as I(1) if the Augmented Dickey-Fuller test fails to reject the null of a unit root at the 10% significance level; this applies to all variables except the oil shock. Solid lines denote point estimates; shaded areas indicate 68% confidence bands.

B Numerical Methods

Following Achdou, Han, Lasry, Lions, and Moll (2022), we employ a finite difference method with an implicit upwind scheme to solve and simulate the model. To solve for the steady state, we begin by initializing the interest rate r^0 and the total labor supply L^0. The iterative process for each step $k = 0, 1, 2, \dots$ proceeds as follows:

1. Given r^k and L^k, we solve for the energy demand E^D, labor demand N^D and capital demand

K^D using the firm's first-order conditions (FOCs) and obtain implied w^k.

2. Using these prices, we solve the Hamilton-Jacobi-Bellman (HJB) equation using the finite difference method (implicit method), supplemented with an upwind scheme.

3. The Kolmogorov Forward (KFP) equation is then solved, and aggregate savings and labor supply L^{k+1} are computed.

4. We check for the presence of excess savings. If aggregate savings are positive, we set $r_{\max}$ for the next iteration to r^k and update the interest rate as the average of $r_{\min}$ and r^k. Conversely, if aggregate savings are negative, we set $r_{\min}$ to r^k and update the interest rate as the average of $r_{\max}$ and r^k.

5. Steps 1-5 are repeated until convergence is achieved.

To solve the transition dynamics, we adopt a similar iterative approach. First, we assume a path for aggregate savings $K^k(t)$ and aggregate labor supply $L^k(t)$, both are presumed to be equal to the steady-state value for all t as starting guesses. The following steps are then iterated:

1. Given the assumed path $K^k(t)$ and $L^k(t)$, we compute the implied interest rate $r^k(t)$ and wage rate $w^k(t)$ and solve the savings decision path in the HJB equation backward, utilizing the fact that the value function at the terminal point corresponds to its steady-state value.

2. Using the optimal savings path, we solve the KFP equation forward, with the initial condition that the joint distribution of income and wealth at the initial time is also equal to its steady-state value.

3. The solutions from steps 1 and 2 are combined to compute the path of aggregate savings.

4. If the resulting path of aggregate savings is not sufficiently close to that obtained in the previous iteration, we update $K^k(t)$ to $K^{k+1}(t)$ using a relaxation method.

5. Steps 1-4 are repeated until convergence is achieved.

C Robustness Checks

The baseline simulation results suggest that a temporary increase in oil prices raises income, consumption, and wealth inequality. To assess the robustness of these results, we conduct counterfactual analyses along three dimensions: (i) varying the elasticity of substitution between oil and other consumption goods, and (ii) varying the elasticity of substitution between oil and other production inputs, and (iii) relaxing the household borrowing constraint.

C.1 Varying oil Elasticity (Households)

We first consider the effect of increasing the elasticity of substitution between oil and non-oil goods from $\sigma = -3.88$ to $\sigma = -1.94$. The comparison outcomes are depicted in Figures 18 and 19. At the aggregate level, higher substitutability ($\sigma = -1.94$) softens the impact of an oil price shock: total consumption and output contract less, while energy demand adjusts more quickly as households reallocate spending toward non-oil goods. Income and wealth wealth inequality also increase less. The consumption inequality dynamics, however, become more pronounced. Poor households are already consuming close to the minimum oil requirement $\underline{c}$, leaving them with little effective substitution margin. When oil prices rise, they cannot reduce energy consumption further and must instead cut disproportionately from non-oil consumption. Richer households, by contrast, consume well above the minimum and can take full advantage of the higher elasticity by substituting away from oil, thereby stabilizing their total consumption bundle. This asymmetry widens the consumption gap between rich and poor, which then explains the sharper rise in the consumption Gini.

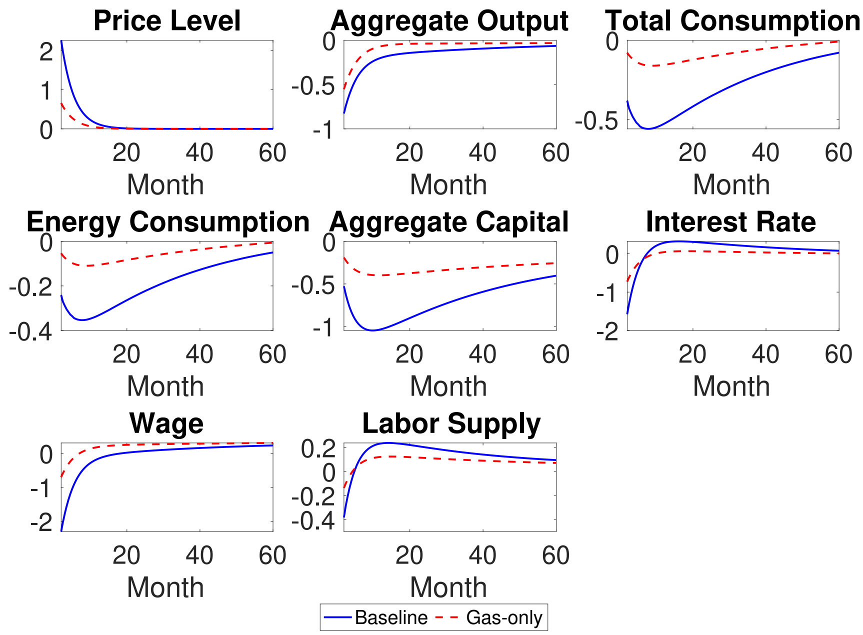

Figure 18: IRFs when $\sigma = -1.94$. Solid (dashed) lines represent the impulse responses estimated from the baseline (counterfactual) scenario. (Unit: Δ% from steady state), except interest rate is expressed as Δ PPT)

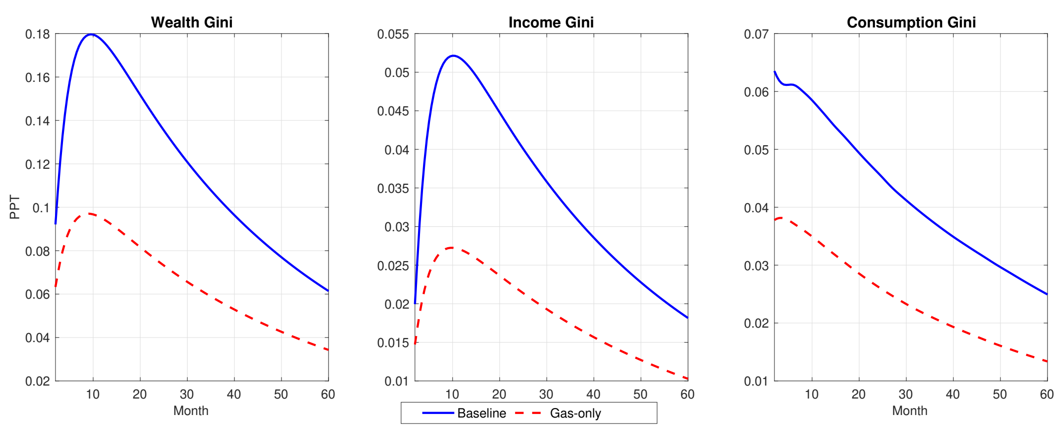

Figure 19: Impulse response functions when $\sigma = -1.94$. Solid (dashed) lines represent the impulse responses estimated from the baseline (counterfactual) scenario. (Unit: Δ PPT from steady state)

C.2 Varying oil Elasticity (Firms)

We next assess the sensitivity of the results to changes in oil substitutability on the production side. Specifically, we increase the elasticity from $\epsilon = 0.9$ toward $\epsilon = 1$, which corresponds to moving from the CES specification in the baseline to a Cobb–Douglas form. This adjustment raises the substitutability of oil relative to other inputs. The corresponding aggregate and distributional responses are shown in Figure 20 and Figure 21.

At the aggregate level, the responses to an oil price shock become noticeably milder. When oil is more easily substituted in production, firms can adjust their input mix more flexibly, reducing their reliance on energy without sacrificing as much output. As a result, the contraction in aggregate output, total consumption, and capital is smaller, while the price level and energy demand respond less sharply. Wages and labor supply also decline less, since firms maintain higher demand for labor when oil is more substitutable. On the distributional side, the inequality effects are correspondingly dampened: wealth, income, and consumption Ginis all rise by less and converge back more quickly. Overall, increasing ϵ attenuates both the macroeconomic downturn and the inequality surge following an oil shock.

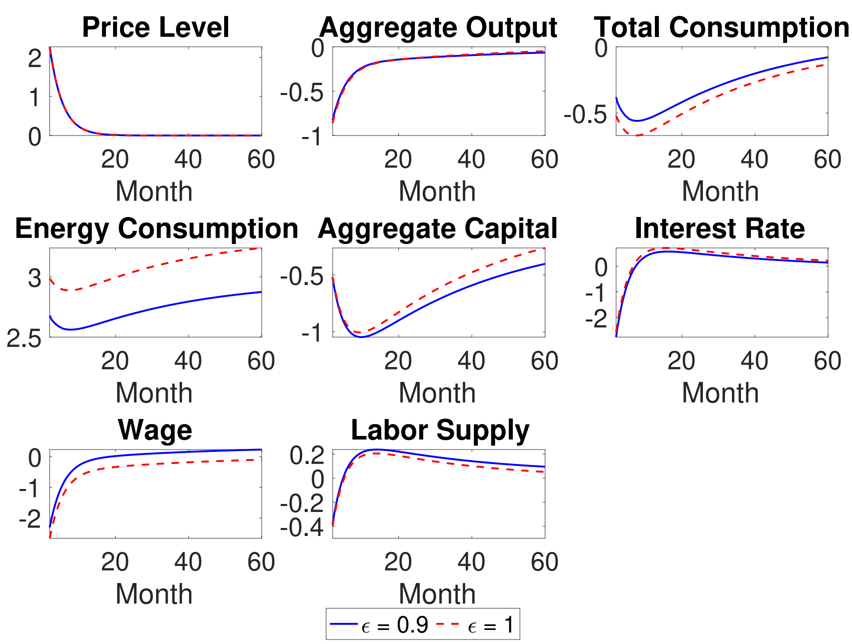

Figure 20: IRFs when $\epsilon \to 1$. Solid (dashed) lines represent the impulse responses estimated from the baseline (counterfactual) scenario. (Unit: $\Delta\%$ from steady state), except interest rate is expressed as Δ PPT)

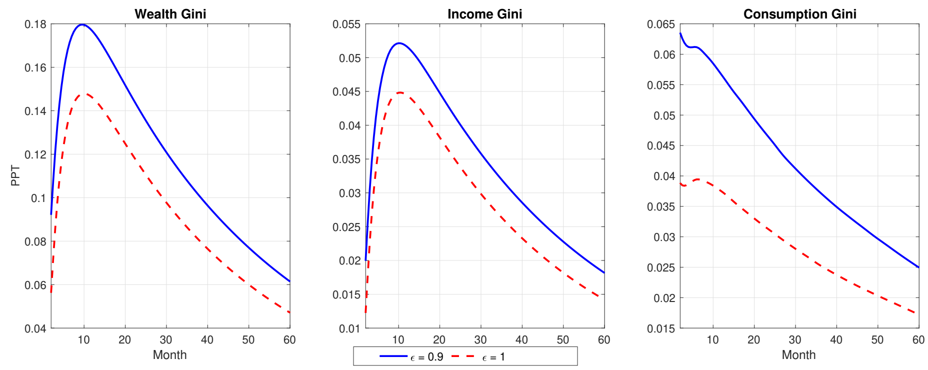

Figure 21: Impulse response functions when $\epsilon \to 1$. Solid (dashed) lines represent the impulse responses estimated from the baseline (counterfactual) scenario. (Unit: Δ PPT from steady state)

C.3 Varying Borrowing Limit a_{min}

We also explore the effect of loosening the borrowing limit from $a_{\min} = 0$ to $a_{\min} = -0.05$. Figures 22 and 23 plot the results. The main difference appears in the capital markets: when households are allowed to borrow, the decline in aggregate capital is slightly deeper and its recovery more gradual, leading the interest rate to fall further and rebound more slowly. This reflects the fact that borrowing temporarily postpones the rebuilding of household savings. On the labor market side, households that can smooth consumption with borrowing cut back labor supply less aggressively, which explains why the fall in labor input is smaller under the looser borrowing constraint. Allowing for negative asset positions also dampens the rise in inequality, especially in wealth and income. When borrowing is disallowed, poorer households must deplete their limited wealth to sustain basic consumption, which sharply deteriorates their net asset position and amplifies wealth inequality. With some borrowing margin, these households can instead smooth through debt, preventing as steep a divergence in wealth accumulation. Similarly, the income Gini rises less under $a_{\min} = -0.05$, since poor households can maintain more stable labor supply and avoid the sharp income drop associated with wealth depletion. By contrast, consumption inequality is almost unchanged: while borrowing provides some short-term relief for the poor, the gap in consumption smoothing ability between rich and poor households remains large, and wealthier households continue to rely on their buffers rather than credit.

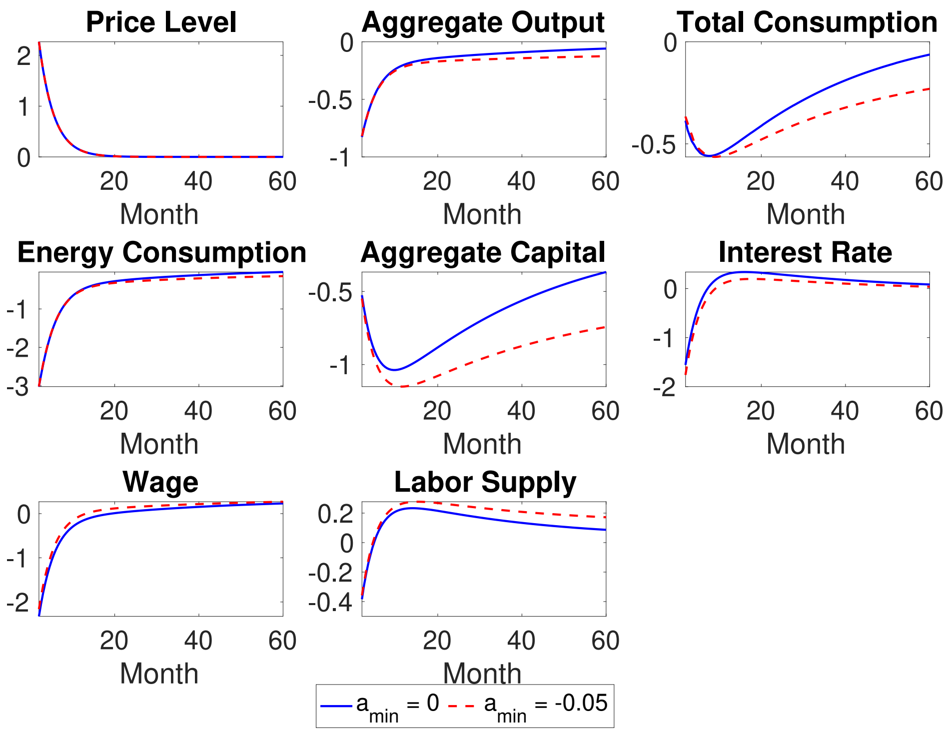

Figure 22: IRFs when $a = -0.05$. Solid (dashed) lines represent the impulse responses estimated from the baseline (counterfactual) scenario. (Unit: $\Delta\%$ from steady state), except interest rate is expressed as Δ PPT)

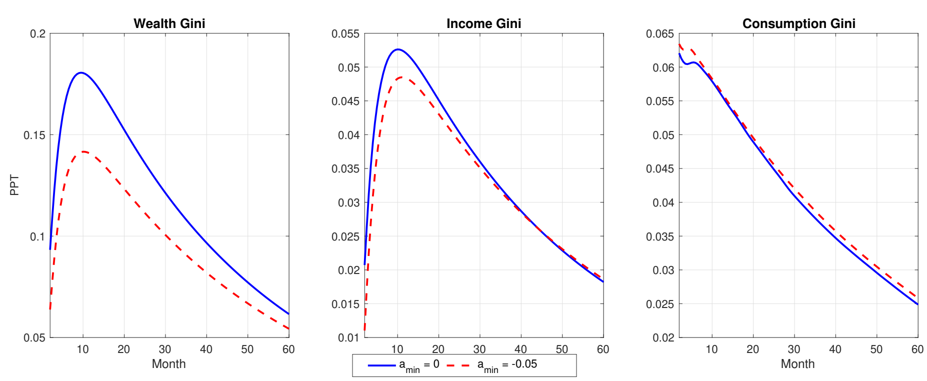

Figure 23: Impulse response functions when $a = -0.05$. Solid (dashed) lines represent the impulse responses estimated from the baseline (counterfactual) scenario. (Unit: Δ PPT from steady state)