From Policy to Practice: Applying Empirical Analysis and Historic Contexts to Understand Fiscal and Monetary Policy, and their Interaction

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To my grandparents Gertraud und Johann Hammer

Da ging ich, in mich gekehrt,
durch das gewölbte Tor,
sinnend zurück in die Stadt.
Warum, dachte ich,
sinkt wohl das Gewölbe nicht ein,
da es doch keine Stütze hat?
Es steht, weil alle Steine
auf einmal einstürzen wollen. (...)

(...) Und ich zog aus diesem Gedanken
einen unbeschreiblichen Trost,
der mir bis zum entscheidenden Augenblick
immer mit der Hoffnung zur Seite stand,
dass auch ich mich halten würde,
wenn alles mich sinken lässt.

Das gewölbte Tor, Lied von Christiane Rösinger nach einem Text von Heinrich von Kleist

Declaration of Co-Authorship and Publications

This dissertation consists of four research papers. One paper is single-authored, two papers are written in collaboration with one co-author, and one paper is written with three co-authors. My contribution in conception, implementation and drafting can be summarized as follows:

1. **No Taxation Without Reallocation: The Distributional Effects of Tax Changes**

   by Stephanie Ettmeier

   Contribution: 100 percent

2. **Fatal Austerity: The Economic Consequences of Heinrich Brüning**

   by Stephanie Ettmeier, Alexander Kriwoluzky, Moritz Schularick, and Lucas ter Steege

   Contribution: 30 percent

   Selected results of this study were published as:

   Ettmeier, S. and Kriwoluzky, A. (2022). Brüning's austerity policies of the early 1930s intensified the economic slump and increased unemployment, *DIW Weekly Report*, 24/25:163-168, Deutsches Institut für Wirtschaftsforschung (DIW), Berlin.

3. **Same, but Different? Testing Monetary Policy Shock Measures**

   by Stephanie Ettmeier and Alexander Kriwoluzky

   Contribution: 50 percent

   It is published as:

Ettmeier, S. and Kriwoluzky, A. (2019). Same, but different? Testing monetary policy shock measures, *Economics Letters*, 184, 108640.

4. **Active or Passive? Revisiting the Role of Fiscal Policy in the Great Inflation**

   by Stephanie Ettmeier and Alexander Kriwoluzky

   Contribution: 50 percent

   Earlier versions of this chapter were published as:

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   Ettmeier, S. and Kriwoluzky, A. (2020). Active, or Passive? Revisiting the Role of Fiscal Policy in the Great Inflation, *DIW Berlin Discussion Paper* No. 1872, German Institute for Economic Research, Berlin.

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I thank Moritz Schularick, my second supervisor, for his guidance at important moments. To me, with my diverse research interests and educational background, his experience and feedback was immensely valuable for sharping my profile. I have already learned a lot and hope to continue to learn even more in the years to come. I look forward starting to work in his group of inspiring and vibrant colleagues.

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My parents and my zii Beate und Gerhard Arold have provided me lifelong unconditional love and support and granted me from very early on the personal responsibility I was seeking. My sister Pit and I are common in spirit and do not need many words to communicate sincerely. Her care and help over the last three years was immense. Almost half my life I share with Michele. Without losing ourselves, we are there for each other. I could not wish for better support.

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List of Abbreviations

1Y	One-year nominal government bond rate (1Y)
2Y	Two-year nominal government bond rate (2Y)
AMAF	Active monetary policy authority, active fiscal policy authority (explosive regime)
AMPF	Active monetary policy authority, passive fiscal policy authority (regime M)
AR	Autoregressive
B	Beta distribution
BC	Monetary policy shock measure of Barakchian and Crowe (2013)
BEA	Bureau of Economic Analysis
CEX	Consumer Expenditure Survey
CI	Corporate income tax shock
CPI	Consumer price index
CU	Consumer unit
DSGE	Dynamic stochastic general equilibrium
e.g.	exempli gratia
EO	Extraordinary budget
ESS	Effective sample size
EBP	Excess bond premium of Gilchrist and Zakrajšek (2012)
FF^*	Federal funds shadow rate of Wu and Xia (2016)
FOMC	Federal Open Market Committee
FTPL	Fiscal Theory of the Price Level
fVAR	Functional vector autoregressive
G	Gamma distribution
GDP	Gross Domestic Product
GK	Monetary policy shock measure of Gertler and Karadi (2015)
GNP	Gross National Product
IRF	Impulse response function
i.e.	id est
i.i.d.	independent and identically distributed
IP	Industrial production
IV	Instrument variable / Proxy
IW	Inverse Wishart

LP-IV	Local projection estimation with proxy variables
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary least squares
MAR	Monetary policy shock measure of Miranda-Agrippino and Ricco (2021)
MCMC	Markov Chain Monte Carlo
MDD	Marginal data density
MLE	Maximum likelihood
M	Month / Million
N	Normal distribution
NIPA	National Income and Product Accounts
PI	Personal income tax shock
PMAF	Passive monetary policy authority, active fiscal policy authority (regime F)
PMPF	Passive monetary policy authority, passive fiscal policy authority (indeterminacy)
Q	Quarter
RM	Reichsmark
RR	Monetary policy shock measure of Romer and Romer (2004)
RWMH	Random walk Metropolis-Hastings
SD	Standard deviation
SMC	Sequential Monte Carlo
SVAR	Structural vector autoregressive
SW	Monetary policy shock implied by the DSGE model of Smets and Wouters (2007)
US	United States of America
VAR	Vector autoregressive
WPI	Wholesale price index

Introduction

It is too early to speculate on whether the Covid-19 pandemic and Russia's invasion of Ukraine will yield a turning point for global macroeconomic stability. Fast-growing prices, in particular energy prices, unprecedented sovereign debt levels, and the need to provide relief to financially vulnerable members of our societies from the increased cost of living have pushed fiscal and monetary policy to the center of both the public and academic discourses. This dissertation contributes insights and guidance for these questions in its four chapters. It draws on empirical evidence to deepen our understanding on the distributional and macroeconomic effects of fiscal policy, the causal analysis of monetary policy transmission, and the interaction of fiscal and monetary policies. In particular, this dissertation combines studies on the effect of US tax changes on the cross-sectional distribution of disposable income, the macroeconomic consequences of Chancellor Heinrich Brüning's austerity intervention at the height of the Great Depression in Germany, the performance of four widely-used and directly measured monetary policy shock instruments in terms of identifying the causal effects of monetary policy, and the role of US fiscal policy in the pre-Volcker inflation build-up.

Chapter 1, titled "No Taxation Without Reallocation: The Distributional Effects of Tax Changes," investigates the dynamic causal effects of tax cuts on the cross-sectional distribution of disposable income for the US for the 1980 to 2006 period. While the macroeconomic effects of tax shocks are well-understood (Blanchard and Perotti, 2002; Mountford and Uhlig, 2009; Romer and Romer, 2010; Caldara and Kamps, 2017; Mertens and Ravn, 2013), the empirical literature is still largely silent on tax shocks' distributional consequences - surprisingly so, as tax policy is meant to be redistributive. The first chapter aims to close this gap, quantifying the distributional effects of tax cuts. In particular, I employ the functional vector autoregressive model (fVAR) of Chang et al. (2021) that allows me to study, for the first time, the causal effects of aggregate tax shocks on the distribution of disposable income and macroeconomic aggregates jointly in a dynamic setup at business cycle frequency.

I combine aggregate data from the National Income and Product Accounts and micro-level data on disposable income from the Consumer Expenditure Survey, and base the identification on the tax shock measure of Mertens and Ravn (2014) that identifies exogeneous variation in tax policy changes based on the narrative strategy introduced by Romer and Romer (2010). Including all major unanticipated exogenous federal tax liability changes that happened between 1980 and 2006, this measure can be interpreted as approximate changes in the average tax rate. To pin down the distributional effects of heterogenous tax policy instruments, in a second step, I use the personal income and corporate income tax shock measure of Mertens and Ravn (2013). I document that tax cuts during the 1980 to 2006 period hurt the bottom and center of the distribution, but benefitted the rich - independent of the tax shock measure. For instance, after a one standard deviation cut in the average tax rate, the 10th percentile experiences a decrease in after-tax income of 0.5 %, while the 90th percentile benefits with an income increase of 0.1 %. Decomposing the cross-sectional disposable income distribution according to personal characteristics allows me to verify prevalent narratives surrounding US tax policy legislation. While my findings do not support political statements that US tax policy benefitted low-income households, they lend empirical substance to narratives describing US tax legislation as pro-family and pro-business.

Chapter 2, titled "Fatal Austerity: The Economic Consequences of Heinrich Brüning,“ is joint work with Alexander Kriwoluzky, Moritz Schularick, and Lucas ter Steege. It shifts the focus toward Germany's economic turbulent Interwar period. At the height of the Great Depression, Heinrich Brüning, Germany's Chancellor from March 30, 1930, to May 30, 1932, opted for deflation and undemocratically implemented one of modern history's most extreme series of tax increases and cuts in government spending and transfers. Economic and social hardship fueled mass frustration and political radicalization that benefitted the German Nazi party, which had intensively campaigned against Brüning's austerity course and became Germany's strongest party as a result (Kaltefleiter, 1968; King et al., 2008; Galofré-Vilà et al., 2021). From July 1932, when Brüning was forced to resign as chancellor, it was only half a year before Adolf Hitler took over the same office.

There is a long-running debate about potential alternatives to Brüning's deflationary policy (Borchardt, 1979; Holtfrerich, 1982; Borchardt, 2015, e.g.). However, until today, the macroeconomic consequences of Brüning's austerity measures remain obscure and subject to speculation. Our study provides this evidence and quantifies, for the first time, the effects of Brüning's belt-tightening on economic activity and unemployment. The backbone of our empirical approach is the narrative identification of the austerity shock instrument variable and a newly constructed monthly dataset on historical government finances and macroeconomic time series. Our findings lend support to the concern that Brüning's fiscal consolidations aggravated the Great Depression. His actions caused an extra 3.31 million people to become unemployed while lowering Germany's GDP per capita by 4.5 percent.

Chapter 3, titled "Same, but Different? Testing Monetary Policy Shock Measures," is joint work with Alexander Kriwoluzky and was published in 2019 in *Economics Letters*. Our motivation was to provide to applied researchers a comparison of widely-used and directly measured monetary policy shock proxy variables, thus structuring, at that time, a fast growing literature. In particular, we analyze the narrative series of Romer and Romer (2004), the high-frequency series of Barakchian and Crowe (2013), the high-frequency series of Gertler and Karadi (2015), and the series of Miranda-Agrippino and Ricco (2021) combining the insights from the narrative approach and high-frequency identification. We use a Proxy-SVAR model framework (Stock and Watson, 2012; Mertens and Ravn, 2013) and, in a first step, examine the monetary policy shock measures' relevance and lead-lag exogeneity, certainly the two most important decision criteria for applied researchers interested in sharp inference and correctly identified dynamic causal effects. Second, we investigate the dynamic effects of monetary policy shocks identified with the proxy variables on interest rates, industrial production, prices, and credit conditions. Our results show that only the shock proxy of Miranda-Agrippino and Ricco (2021) satisfies the relevance and the lead-lag exogeneity conditions. In addition, it is the only series that produces significant impact effects that are in line with the theoretical predictions.

Chapter 4, titled "Active or Passive? Revisiting the Role of Fiscal Policy in the Great Inflation," is dedicated to another seminal historic economic episode - the years of high inflation between 1960 and 1979 preceding Paul Volcker's Federal Reserve chairmanship. The chapter is joint work with Alexander Kriwoluzky. It is well established that the effects of monetary and fiscal policy depend on the prevailing monetary-fiscal policy regime (Sargent and Wallace, 1981; Leeper, 1991; Sims, 1994; Woodford, 1996; Cochrane, 2001). However, for the pre-Volcker period, the debate about the monetary-fiscal policy mix is still unsettled. The literature largely agrees that monetary policy in the pre-Volcker period was unable to stabilize prices and, hence, played a passive role (Clarida et al., 2000; Lubik and Schorfheide, 2004; Coibion and Gorodnichenko, 2011, e.g.). However, concerning the stance of fiscal policy, the evidence is ambiguous. Bhattarai et al. (2016), who apply random walk Metropolis-Hastings sampling (RWMH) to estimate a fixed-regime DSGE model with monetary and fiscal policy interactions, find that the fiscal authority was passive and strongly increased taxes to debt. On the contrary, studies relying on regime-switching DSGE models like Davig and Leeper (2006), Bianchi (2012), Bianchi and Ilut (2017), and Chen et al. (2019) mainly attribute the leading role in the pre-Volcker period to the fiscal authority.

In our study, we revisit the role of fiscal policy during the Great Inflation with a novel empirical toolkit. Specifically, the Sequential Monte Carlo algorithm (SMC), a posterior sampler established in the DSGE literature by Herbst and Schorfheide (2014, 2015), allows us to create new perspectives on a long-standing question. As demonstrated by Herbst and Schorfheide (2014, 2015) and Cai et al. (2020), the SMC sampler outperforms the RWMH in the presence of multimodal posteriors, an outcome that is highly likely in a DSGE model with monetary-fiscal policy interactions. We contrast the RWMH's and SMC's performance in such a model and show that the choice of the posterior sampler determines the estimation outcome. While the SMC sampler can deal with the irregular posterior surface and can navigate through the entire parameter space, the RWMH produces posterior regime probabilities that highly depend on the sampler's starting value. By re-estimating the fixed-regime model of Bhattarai et al. (2016) with the more suitable SMC posterior sampler, we can finally reconcile the opposing evidence on the stance of fiscal policy in the pre-Volcker period. In line with Bhattarai et al. (2016), we find that a passive monetary/passive fiscal policy mix receives highest posterior probability throughout the pre-Volcker period. However, echoing the conclusion of regime-switching DSGE models, we also find strong evidence that a fiscal dominant regime, at 37 % posterior probability, was an important driver behind the pre-Volcker inflation build-up.

CHAPTER 1

No Taxation Without Reallocation: The Distributional Effects of Tax Changes

Stephanie Ettmeier

"My friends, history is clear: Lower tax rates mean greater freedom, and whenever we lower the tax rates, our entire nation is better off."

Ronald Reagan, October 3, 1985

1.1 Introduction

What are the distributional effects of changes in tax policy? Over the last decades, the macroeconomic implications of tax changes have been the focus of empirical research and distributional evidence remains scarce. This is despite the explicit redistributory function of tax policy and prevalent political narratives on who should benefit from changes in tax policy. My paper presents this empirical evidence, quantifying the effect of tax changes on the cross-sectional distribution of disposable income for the US for the 1980 to 2006 period.

The fresh ingredient for my analysis is the functional vector autoregressive (fVAR) model of Chang et al. (2021); it allows me to study the causal effects of tax changes on the cross-sectional distribution of disposable income and macroeconomic variables jointly in a dynamic setup at business cycle frequency. I use micro-level data on after-tax income constructed from the Consumer Expenditure Survey (CEX) to approximate a log density of cross-sectional disposable income for each quarterly observation period. Together with aggregate macroeconomic data on tax revenues, government spending, GDP, non-durable consumption, and disposable income, these approximated log densities enter the fVAR model, which is estimated with Bayesian techniques.

I base the identification on the tax shock measure of Mertens and Ravn (2014), which isolates exogeneous variation in tax policy changes from narrative sources accompanying the tax legislation process - a strategy introduced by Romer and Romer (2010). Including all major unanticipated exogenous Federal tax liability changes that happened between 1980 and 2006, this measure can be interpreted as approximate changes in the average tax rate in the US. To document, in a similar manner, the heterogeneous effects of different tax types available to governments along the distribution, in a second step, I employ the personal income and corporate income tax shock measure of Mertens and Ravn (2013) for identification.

The micro-level information of the CEX data allows me to scrutinize prevalent narratives on US tax policy. A systematic study of government documents covering the 1980 to 2006 period reveals that, over the entire sample and independent of the government's political background, three narratives repeatedly emerge: tax changes are directed toward low-income people, are pro-business, and are pro-family. To empirically validate these political statements, I decompose the cross-sectional disposable income distribution according to personal characteristics, discriminating between (i) entrepreneurs and non-entrepreneurs, and (ii) families and non-families.

I document that tax cuts throughout the 1980 to 2006 period have regressive effects on cross-sectional disposable income: they hurt the bottom and center of the distribution and benefit the rich - independent of the tax shock measure. For instance, after a one standard deviation cut in the average tax rate that increases aggregate disposable income on impact by 0.16 % at the median, the 10th percentile experiences a decrease in after-tax income of 0.5 %, while the 90th percentile benefits with an income increase of 0.1 %. Hence, my findings do not lend empirical substance to political rhetoric selling tax changes as targeted toward low-income households. However, they support political claims according to which tax changes foster business and families. I find that entrepreneurs and families benefit more from tax cuts than non-entrepreneurs and non-families.

The fVAR model framework, modeling the interaction between macroeconomic aggregates and cross-sectional level, lends itself particularly well for addressing the crucial question on the distributional impacts of aggregate tax shocks. It quantifies the distributional effects dynamically by taking into account the behavioral changes initiated by the tax intervention. The strength of the method is that it does so, without having to model the underlying micro-level heterogeneity in labor supply or saving decisions (Guvenen, 2011; Guner et al., 2011), explicitly, as the fVAR model focuses on the response of the distribution as opposed to the individual. In this respect, the empirical evidence of my study complements distributional analysis based on micro-simulation models, as carried out by the Urban-Brookings Tax Policy Center, the Congressional Budget Office, the Joint Committee on Taxation, and the Treasury Department's Office of Tax Analysis, as these simulations usually do not consider the behavioral responses induced by the tax change (Elmendorf et al., 2008; Auerbach et al., 2017).
Modeling the dynamics of the entire distribution compared to modeling the dynamics of pre-selected distributional statistics like the Gini-coefficient, provides a more comprehensive and unambiguous perspective on the distributional effects of tax changes.

As Chang et al. (2021) point out, unlike a VAR model that includes quantiles of the cross-sectional distribution that may cross in a forward simulation, the fVAR model is theoretically coherent, ensuring non-negative cross-sectional densities of disposable income that integrate to one.

Related literature While the macroeconomic effects of tax shocks are extensively studied (Blanchard and Perotti, 2002; Mountford and Uhlig, 2009; Romer and Romer, 2010; Barro and Redlick, 2011; Auerbach and Gorodnichenko, 2012; Cloyne, 2013; Mertens and Ravn, 2013; Caldara and Kamps, 2017; Cloyne et al., 2022) and over the years a consensus on what is driving the size of the tax multiplier has emerged (Mertens and Ravn, 2014; Ramey, 2019), empirical evidence on the distributional impacts of tax shocks remains sparse. Zidar (2019) quantifies the importance of the distribution of tax changes for their overall impact on economic activity to discriminate between trickle-down vs. bottom-up economics. In a similar vein, Ferrière and Navarro (2022) show how the effects of government spending are shaped by the distribution of taxes. Cloyne and Surico (2017) study the role of household debt in the transmission of tax shocks estimating group-specific VAR models discriminating between households with different debt positions. Misra and Surico (2014), using CEX data, study the heterogeneous consumption response to the 2001 and 2008 US tax rebates in a heterogeneous response model. Mertens and Montiel Olea (2018) derive annual narrative measures of exogenous variation in marginal tax rates for the US and study how counterfactual tax changes for the top 1 % or the bottom 99 % of the income distribution affect economic activity and incomes before taxes. In contrast, my study contributes the first comprehensive dynamic analysis on the quantitative effects of exogenous tax changes on the entire distribution of disposable income.

My study also connects to the literature that computes the dynamic responses in micro-level behavior, in particular consumption expenditure, following an aggregate tax shock. Johnson et al. (2006) and Parker et al. (2013) are corresponding examples. Unlike these panel studies, which focus on the partial equilibrium effects of tax changes and, without further imputation, cannot provide estimates on general equilibrium dynamics (Wolf, 2021), the fVAR model approach directly takes into account general equilibrium effects, modeling the interaction between macroeconomic aggregates and micro-level data explicitly.

The remainder of this paper is structured as follows. Section 1.2 summarizes the fVAR model framework and outlines the data, the identification, and the estimation approach. In Section 1.3, I present the effects of an unanticipated cut in the average tax rate on the cross-sectional distribution of disposable income, while in Section 1.4, I decompose these effects. I analyze the distributional effects of different tax types, distinguishing between changes in the personal income and the corporate income tax rate and using micro-level information to quantify the distributional consequences of tax cuts on families and business-owners separately. Section 1.5 concludes.

1.2 The functional VAR model

The fVAR approach developed by Chang et al. (2021) allows me to study the distributional effects of aggregate tax shocks in a dynamic setup. Unlike traditional VAR models, the fVAR model interacts macroeconomic aggregates with cross-sectional distributions.

The $n_Y \times 1$ vector Y_t collects the macroeconomic variables and $p_t(x)$ denotes the cross-sectional density.[1] In my application, I use a log density defined as $\ell_t(x) = \ln p_t(x)$ and the cross-sectional variable x is disposable income. Y_t and ℓ_t are decomposed into a deterministic component $(Y_*, \ell_*(x))$ and fluctuations around the deterministic component:

$$Y_t = Y_* + \tilde{Y}_t, \quad \ell_t = \ell + \tilde{\ell}_t. \tag{1.1}$$

It is assumed that the deviations from the deterministic component evolve jointly according to the following linear fVAR law of motion, which can be interpreted as reduced-form fVAR model:

$$\begin{aligned} \tilde{Y}_t &= B_{YY}\tilde{Y}_{t-1} + \boldsymbol{B_{Y\ell}}[\tilde{\ell}_{t-1}] + u_{Y,t} \\ \tilde{\ell}_t(x) &= B_{\ell Y}(x)\tilde{Y}_{t-1} + \boldsymbol{B_{\ell\ell}}[\tilde{\ell}_{t-1}](x) + u_{\ell,t}(x). \end{aligned} \tag{1.2}$$

$\boldsymbol{B_{Y\ell}}[\tilde{\ell}_{t-1}]$ and $\boldsymbol{B_{\ell\ell}}[\tilde{\ell}_{t-1}](x)$ are integral operators and defined as $\boldsymbol{B_{Y\ell}}[\tilde{\ell}_{t-1}] = \int B_{Y\ell}(\bar{x})\tilde{\ell}_{t-1}(\bar{x})d\bar{x}$ and $\boldsymbol{B_{\ell\ell}}[\tilde{\ell}_{t-1}](x) = \int B_{\ell\ell}(x,\bar{x})\tilde{\ell}_{t-1}(\bar{x})d\bar{x}$. The matrix B_{YY} and the function $B_{\ell Y}(x)$ collect the coefficients. $u_{Y,t}$ is a mean-zero reduced-form error with covariance Ω_{YY} and $u_{\ell,t}(x)$ is a reduced-form error in a Hilbert space with covariance function $\Omega_{\ell\ell}(x,\bar{x})$.

I follow Chang et al. (2021) and estimate a functional state-space model in which the log density $\ell_t(x)$ is the state variable. In this framework, the linear fVAR in Equation (1.2) constitutes the state-transition equation. For every period $t = 1, ..., T$, I observe the macroeconomic aggregates Y_t as well as a sample of N_t draws x_{it}, $i = 1, ..., N_t$ from the cross-sectional density $p_t(x)$. The draws for each period t are collected in a vector $X_t = [x_{it}, ..., x_{Nt}]'$. The draws are assumed to be independently and identically distributed (i.i.d) over the cross-section and independent over time. The measurement equation for the cross-sectional data is specified as

$$x_{it} \sim \text{i.i.d. } p_t(x) = \frac{\exp\{\ell_t(x)\}}{\int \exp\{\ell_t(x)\}dx}, \quad i = 1, ..., N, \quad t = 1, ..., T \tag{1.3}$$

and captures the error in estimating log densities from repeated cross-sectional samples. The data as well as the estimation of the log densities and the functional state-space model is outlined in the following.

[1] For better comparability, I follow closely the original study's notation for recapitulating the method. Readers interested in further details on the implementation of the fVAR method are referred to Chang et al. (2021).

1.2.1 Data and identification

I estimate the model for the US for the period 1980Q1 – 2006Q4 using three types of quarterly data: (i) exogenous tax policy changes, (ii) macroeconomic time series, and (iii) cross-sectional data on disposable income. While data on exogenous tax policy changes and macroeconomic outcomes is available for the entire postwar period, quarterly cross-sectional data on disposable income is only available since 1980, thus determining the start of the sample.

Exogenous tax policy changes I use a narrative tax policy shock series to identify the causal effects of tax policy changes, in particular the tax policy instruments of Mertens and Ravn (2014). These instruments build on the work of Romer and Romer (2009, 2010), who classified all major Federal tax liability changes between 1950 to 2006 according to their motivations given by the executive and legislative decisionmakers. Mertens and Ravn (2014) retain those tax changes that were not implemented for reasons related to changes in current or prospective future economic conditions and those that were implemented less than 90 days after becoming law (Mertens and Ravn, 2011). For each of these identified exogenous and unanticipated tax policy changes, a quantitative measure of projected tax revenue change is constructed from narrative sources and scaled by nominal GDP. Hence, the resulting shock series can be interpreted as approximate changes in the average tax rate.

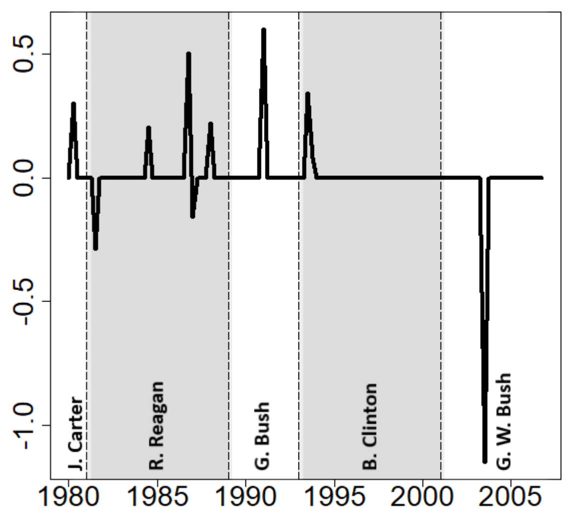


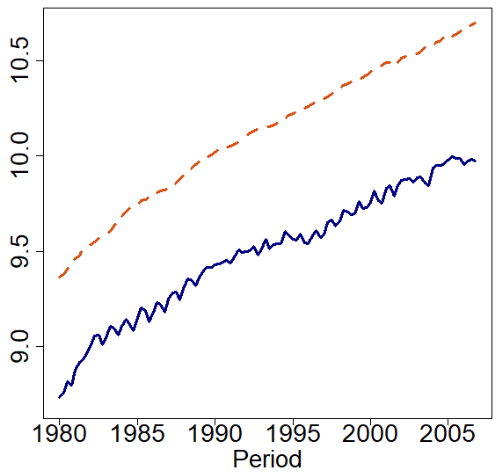
Figure 1.1: Narrative measure of unanticipated tax shocks of Mertens and Ravn (2014)

Figure 1.1 shows the shock instrument. For the 1980Q1 – 2006Q4 period, the series contains ten observations of tax liability changes. One of the changes falls in the presidency of Jimmy Carter, five in Ronald Reagan's presidency, one in the George H.W. Bush presidency, two were legislated under Bill Clinton, and one under George W. Bush. Seven out of the ten changes increased the average tax rate. Tempalski (2006) or Romer and Romer (2009) include a detailed list on the tax bills major provisions.

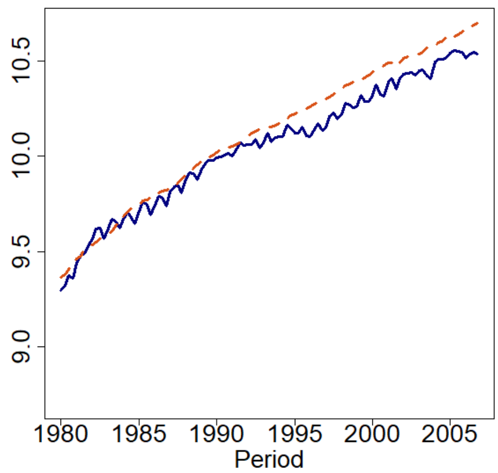
To identify the structural effects of tax policy changes on macroeconomic and cross-sectional variables, I order the instrument first in the functional VAR model, a strategy pioneered by Kilian (2006) and Ramey (2011), and theoretically discussed in Plagborg-Møller and Wolf (2021).

Macroeconomic data Besides the tax policy shock instrument, I use five macroeconomic time series to estimate the model: (i) tax revenues, (ii) non-durable consumption expenditure, (iii) government spending, (iv) GDP, and (v) disposable income. I construct the variables from the National Income and Product Accounts (NIPA). All series are converted to per-capita terms and are used in log-levels. Appendix 1.A includes a detailed data description.

Cross-sectional data Cross-sectional data on disposable income is constructed from the Consumer Expenditure Survey (CEX) conducted by the Bureau of Labor Statistics. I clean the data in the same way and apply the same definitions as in Heathcote et al. (2010). Appendix 1.A summarizes the details. In panel (a) of Figure 1.2, I plot average log per-capita disposable income obtained from the CEX against log per-capita disposable income obtained from the NIPA tables. CEX disposable income is lower over the whole period, but follows a similar trend. The measurement error between CEX and NIPA income is well-documented in the literature and arises from underreporting in the CEX (Slesnick, 1992; Heathcote et al., 2010; Coeurdacier et al., 2015).



(a) Unscaled CEX series



(b) Scaled CEX series

Figure 1.2: CEX average log per-capita disposable income (blue, solid) and NIPA log per-capita disposable income (red, dashed)

I follow Chang and Schorfheide (2022) and correct for this underreporting bias by scaling cross-sectional disposable income to the level of the aggregate. Let Y_t^D be NIPA aggregate per-capita disposable income and y_{it}^D cross-sectional per-capita disposable income from CEX. I calculate the scaling factor as $\frac{1}{T}\sum_{t=1}^{T}\text{median}(y_{it}^D, ..., y_{Nt}^D)/Y_t^D \approx 0.57$ and define $y_{it}^{D*} = y_{it}^D/(0.57 \cdot Y_t^D)$. Hence, if $y_{it}^{D*} = 1$ the individual's disposable income corresponds to the level of aggregate disposable income per capita. The scaled micro-level series is plotted in panel (b) of Figure 1.2. To retain zero, or close-to-zero, observations of cross-sectional disposable income, I apply an inverse hyperbolic sine transformation to obtain x_{it}.

1.2.2 Estimation and implementation

The estimation of the fVAR succeeds in two steps. First, for every quarter t, a log density of cross-sectional disposable income is approximated. Second, the estimated coefficients of the density approximation are stacked with the macroeconomic aggregates into a linear functional state-space model which is estimated using Bayesian techniques. I select the approximation order of the densities and the hyperparameters for the prior distribution based on marginal data densities (MDD).

Density approximation I follow Chang et al. (2021) and approximate the log cross-sectional densities $\ell_t(x)$ by finite-dimensional sieves with K fixed spline basis functions and time-varying coefficients that capture the dynamics:

$$\ell_t(x) \approx \ell_t^{(K)}(x) = \sum_{k=1}^{K} \alpha_{k,t}\zeta_k(x) = [\zeta_1(x), ...\zeta_K(x)] \cdot \begin{bmatrix} \alpha_{1,t} \\ \vdots \\ \alpha_{K,t} \end{bmatrix} = \zeta'(x)\alpha_t. \tag{1.4}$$

The vector α_t includes the coefficients, while the vector $\zeta(x)$ collects a sequence of basis functions with knots x_k, $k = 1, ..., K-1$. I consider different approximation orders K and place the knots at predetermined percentiles of the empirical distribution of cross-sectional disposable income. Table 1.1 summarizes the specifications. The sieve coefficients are estimated by maximum likelihood (MLE), compressed to remove potential collinearities and seasonally-adjusted.

Table 1.1: Knot placement at percentiles

K	1st	2.5th	5th	10th	15th	25th	35th	50th	65th	75th	85th	90th	95th
4						✓		✓		✓			
6				✓		✓		✓		✓		✓	
8			✓	✓		✓		✓		✓		✓	✓
10	✓	✓	✓	✓		✓		✓		✓		✓	✓
14	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: The cross-sectional observations are pooled across i and t. $T = 108$, $N_{min} = 1353$ (1996Q1), and $N_{max} = 3289$ (2004Q1).

This approximation turns the reduced-form VAR model in Equation (1.2) to the following representation:

$$\begin{aligned} \tilde{Y}_t &= B_{YY}\tilde{Y}_{t-1} + \boldsymbol{B}^{(K)}_{\boldsymbol{Y\ell}}[\tilde{\ell}^{(K)}_{t-1}] + u_{Y,t} \\ \tilde{\ell}_t^{(K)}(x) &= B^{(K)}_{\ell Y}(x)\tilde{Y}_{t-1} + \boldsymbol{B}^{(K)}_{\boldsymbol{\ell\ell}}[\tilde{\ell}^{(K)}_{t-1}](x) + u^{(K)}_{\ell,t}(x). \end{aligned} \tag{1.5}$$

The coefficient matrix B_{YY} is of dimension $n_Y \times n_Y$, the function $B_{\ell Y}(x)$ is of dimension $K \times n_Y$ and approximated as $B_{\ell Y}(x) \approx B^{(K)}_{\ell Y}(x) = \xi'(x)B_{\ell Y}$. $\xi(x)$ is a second vector of $K \times 1$ basis functions. $\boldsymbol{B}^{(K)}_{\boldsymbol{Y\ell}}[\cdot]$ and $\boldsymbol{B}^{(K)}_{\boldsymbol{\ell\ell}}[\cdot](x)$ are the operators associated with the transition kernels, which are approximated as $B_{Y\ell}(\bar{x}) \approx B^{(K)}_{Y\ell}(\bar{x}) = B_{Y\ell}\xi(\bar{x})$ and $B_{\ell\ell}(x,\bar{x}) \approx B^{(K)}_{\ell\ell}(x,\bar{x}) = \zeta'(x)B_{\ell\ell}\xi(\bar{x})$, and of dimension $n_Y \times K$ and $K \times K$, respectively. The functional innovation $u_{\ell,t}$ is of dimension $K \times 1$ and approximated as $u_{\ell,t} \approx u^{(K)}_{\ell,t} = \zeta'(x)u_{a,t}$.

Functional state-space model estimation Equations (1.1), (1.4), and (1.5) can be combined to the following vector autoregressive system for the macroeconomic aggregates and the estimated sieves coefficients $\hat{\alpha}_t$:

$$\begin{bmatrix} Y_t - Y_* \\ \hat{\alpha}_t \end{bmatrix} = \begin{bmatrix} \Phi_{YY} & \Phi_{Y\alpha} \\ \Phi_{\alpha Y} & \Phi_{\alpha\alpha} \end{bmatrix} \begin{bmatrix} Y_{t-1} - Y_* \\ \hat{\alpha}_{t-1} \end{bmatrix} + \begin{bmatrix} u_{Y,t} \\ u_{a,t} \end{bmatrix} \tag{1.6}$$

As explained in detail in Chang et al. (2021), the measurement equation in (1.3) can be linearized to

$$\hat{\alpha}_t(X_t) = \alpha_t + N^{-1/2}\eta_t, \quad \eta_t \sim \mathcal{N}(0, \hat{V}_t). \tag{1.7}$$

As the measurement error variance $\hat{V}_t$ vanishes for large N, like in my application, the MLE estimates $\hat{\alpha}_t$ enter the system directly. The $\Phi_{..}$'s denote the coefficient matrices. Under the assumption that the innovations are normally distributed, the state transition can be expressed as a multivariate linear regression model:

$$W_t = \Phi_1 W_{t-1} + u_t, \qquad u_t \sim \mathcal{N}(0, \Sigma), \tag{1.8}$$

where $W_t = [(Y_t - Y_*)', \hat{\alpha}']'$ and $u_t = [u'_{Y,t}, u'_{\alpha_t}]'$. In matrix form the state-transition takes the form

$$W = Z\Phi + U. \tag{1.9}$$

I estimate the model using Bayesian techniques following Chang et al. (2021). I demean the macroeconomic variables, fit them like Mertens and Ravn (2014) on a linear and quadratic trend[2], and include one lag such that $\Phi = \Phi'_1$. The likelihood of the linear state-space model is evaluated with the Kalman filter. The prior distribution is defined as

$$\Sigma \sim IW(\underline{\nu}, \underline{S}), \qquad \phi|\lambda \sim \mathcal{N}(0, \underline{P}_\phi^{-1}(\lambda)), \tag{1.10}$$

[2]The results I report are not sensitive to this deterministic trend assumption.

where $IW(\cdot)$ stands for the Inverse-Wishart distribution with degrees of freedom $\underline{\nu} = n_Y + K + 5$ and scale matrix $\underline{S}$. For the prior of the coefficients, $\phi = \text{vec}(\Phi)$ and $\underline{P}_\phi(\lambda)$ is the prior precision matrix. It is a function of a vector of hyperparameters $\lambda = [\lambda_1, \lambda_2, \lambda_3]'$ and corresponds to the partitions $W_t' = [(Y_t - Y_*)', \hat{\alpha}_t{}']$. It is given as

$$\underline{P}_\phi(\lambda) = \lambda_1 \begin{bmatrix} (\underline{\Sigma}^{-1})_{YY} \otimes \begin{bmatrix} \hat{D}_Y & 0 \\ 0 & \lambda_2 \hat{D}_\alpha \end{bmatrix} & (\underline{\Sigma}^{-1})_{Y\alpha} \otimes \begin{bmatrix} \sqrt{\lambda_3}\hat{D}_Y & 0 \\ 0 & \sqrt{\lambda_2}\hat{D}_\alpha \end{bmatrix} \\ (\underline{\Sigma}^{-1})_{\alpha Y} \otimes \begin{bmatrix} \sqrt{\lambda_3}\hat{D}_Y & 0 \\ 0 & \sqrt{\lambda_2}\hat{D}_\alpha \end{bmatrix} & (\underline{\Sigma}^{-1})_{\alpha\alpha} \otimes \begin{bmatrix} \lambda_3 \hat{D}_Y & 0 \\ 0 & \hat{D}_\alpha \end{bmatrix} \end{bmatrix}. \tag{1.11}$$

$\hat{D}_Y$ and $\hat{D}_\alpha$ are diagonal matrices of dimension $n_Y \times n_Y$ and $K \times K$, respectively, which are used to rescale the prior variances. I set $\hat{D}_Y$ and $\hat{D}_\alpha$ equal to the corresponding sample variance of W_t'. For $\underline{\Sigma}$, I use the OLS estimate of Σ in Equation (1.8).

The hyperparameter λ_1 scales the overall precision of the prior distribution, λ_2 controls the relative precision of the prior distribution for the coefficients that capture the effect of $\hat{\alpha}_{t-1}$ on $\tilde{Y}_t$, and λ_3 the relative precision of the prior distribution for the coefficients that control the effect of $\tilde{Y}_{t-1}$ on $\hat{a}_t$. Hence, the prior in Equation (1.11) allows me to regulate the degree of interaction between distributional and aggregate dynamics. As $\lambda_2, \lambda_3 \to \infty$, the posterior distributions of $\Phi_{\alpha Y}$ and $\Phi_{Y\alpha}$ concentrate around the mean of zero, which shuts down spillover effects. Conditional on λ, I use a Gibbs sampler to take draws from the posterior distribution of (ϕ, Σ) following the approach in Carter and Kohn (1994). In total, I generate 11,000 posterior draws, discard the first 1,000 as burn-in, and use every 10th draw for the empirical analysis.

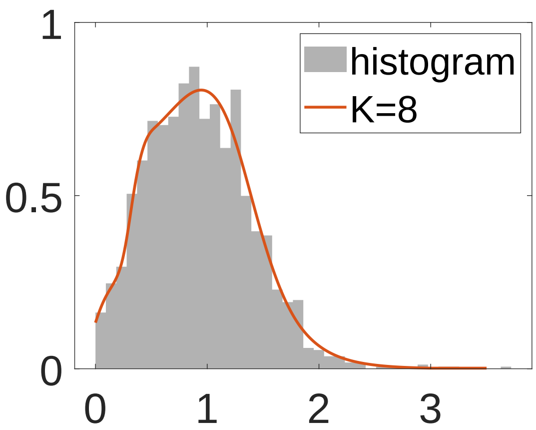
Model selection I compute log MDD's to choose the hyperparameters in λ and the number of knots K used to approximate the cross-sectional densities. I evaluate five different approximation orders ($K \in 4, 6, 8, 10, 14$) and consider for each element in vector λ ten equally-spaced values of $\ln\lambda_j$ on the interval $[-5, 6]$.

Table 1.2 summarizes the results. For each K, columns two to four show the estimated optimal λ_j, while column five gives the log MDD differentials with respect to $K = 4$. In all specifications, the optimal values for λ_2 and λ_3 are found to be large which means that the off-diagonal blocks of the prior precision matrix are shrunk to zero and Granger-causal relationships between the macroeconomic variables and cross-sectional disposable income are missing. The log MDD is maximized for $K = 8$.

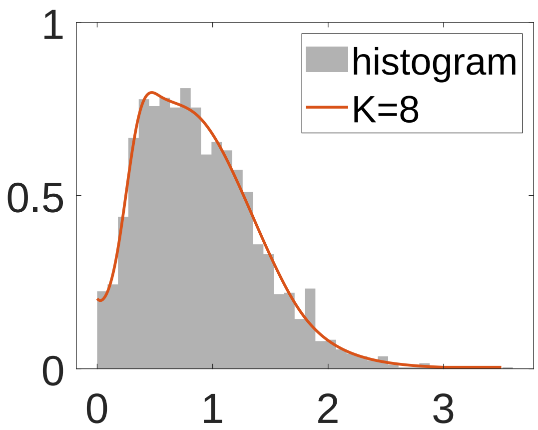
Table 1.2: Log MDD's and hyperparameter estimates

K	$\hat{\lambda}_1$	$\hat{\lambda}_2$	$\hat{\lambda}_3$	MDD differential
4	1.25	95	95	0
6	1.25	95	95	2993
8	**1.25**	**403**	**95**	**3170**
10	1.25	95	95	3067
14	5.3	22	95	2973

Figure 1.3 shows the fitted densities for $K = 8$ for the start and the end of the sample and compares them against histograms. The distribution of disposable income is right-skewed. The approximated densities capture the form of the histograms and have a smooth surface.



(a) 1980Q1



(b) 2006Q4

Figure 1.3: Fitted densities of disposable income distribution

Figure 1.4 presents percentiles of the estimated densities over time and compares them against their sample counterparts. The estimated percentiles move in tandem with the sample percentiles, indicating that the fitted densities capture well the evolution of cross-sectional disposable income over time. The 80th and 90th percentiles exhibit a pronounced increase in disposable income at the beginning of the 1980s. While this increase is permanent at the 90th percentile, disposable income at the 80th percentile falls below its initial value at the end of the sample. The 10th, 20th, 30th, 40th, and 50th percentile evolve almost in parallel over time. Similar to the 80th percentile, the median and the percentiles below experience a decrease in level over the sample period.

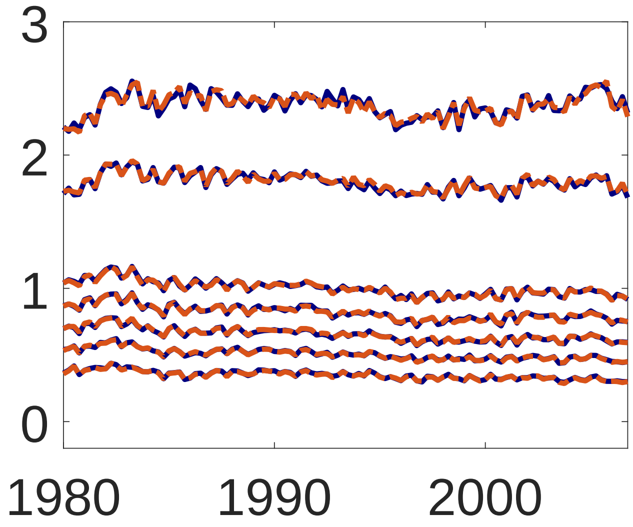


Figure 1.4: Percentiles (10th, 20th, 30th, 40th, 50th, 80th, and 90th) of disposable income distribution; sample percentiles (red), estimated percentiles (blue)

1.3 New insights on the effects of tax shocks

While the aggregate effects of tax shocks are well-studied, their distributional consequences are still undetermined. The fVAR allows me to quantify both in a unified framework.

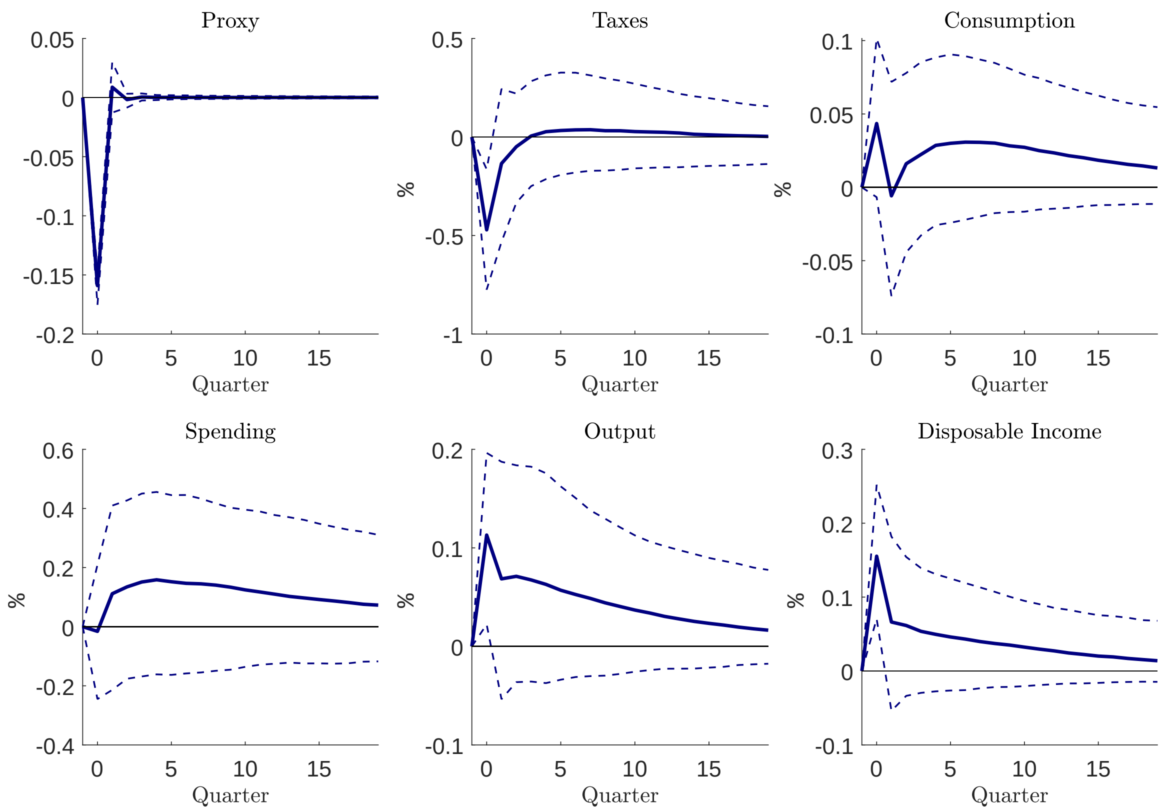


Figure 1.5: Aggregate responses to a one standard deviation tax cut; median (blue, solid), 80-percent credible interval (blue, dashed). Shock occurs at $h = 0$.

Aggregate responses I first outline the aggregate dynamics. Figure 1.5 displays the impulse responses of the aggregate variables in the fVAR to a one standard deviation tax cut. The solid lines show the posterior median responses, while the dashed lines represent the corresponding 80-percent credible bands. The system is in steady-state at horizon $h = -1$ and the shock occurs at $h = 0$. The responses of the aggregate variables are qualitatively in line with previous findings in the literature. Tax revenues decrease on impact by 0.5 percent on the median and revert to zero within one year. The tax cut leads to an immediate increase in median consumption expenditure by five basis points and does not have an instantaneous effect on government spending. Output and disposable income show a similar pattern: the two variables rise on impact on the median by 11 and 16 basis points, respectively and stay above zero for four years.

Distributional responses How does the increase in aggregate disposable income change the cross-sectional distribution? Figure 1.6 shows the response of the disposable-income distribution to a one standard deviation tax cut. These results are new to the literature.

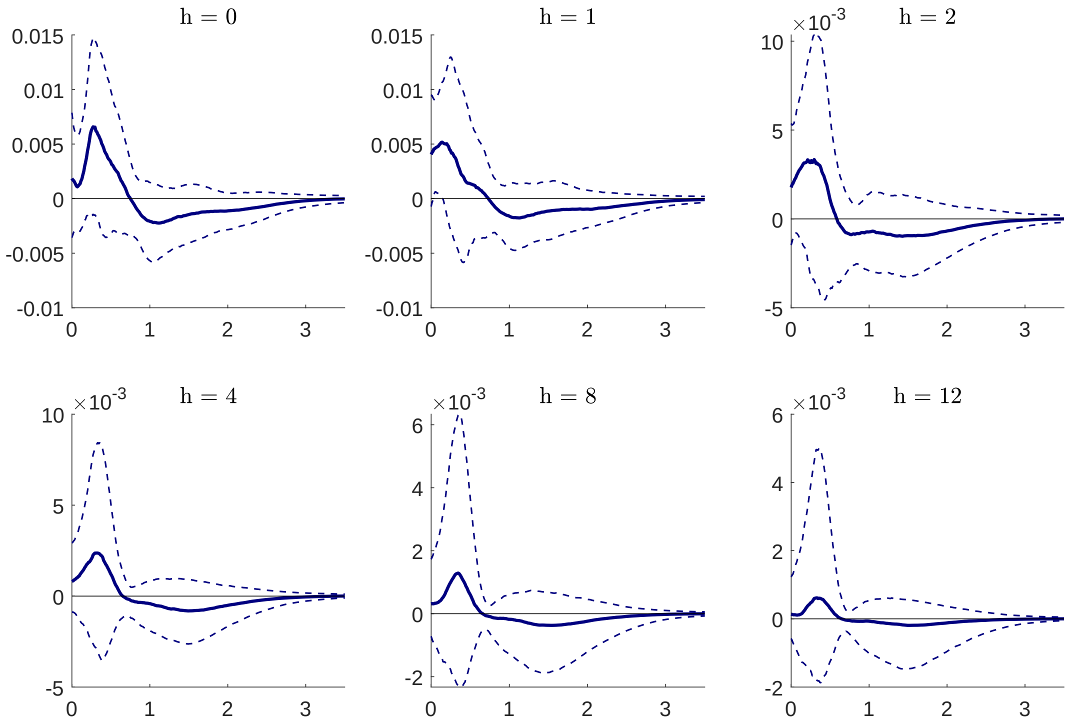


Figure 1.6: Density responses to a one standard deviation tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

The panels display the difference between the steady-state disposable income density and the shocked density for different horizons h. The x-axis shows the level of disposable income and a value of one corresponds to an individual who has aggregate disposable income per capita available. The top-row panel on the left ($h = 0$) depicts the impact response. Because aggregate disposable income increases in response to the tax cut, the probability mass of the shocked density increases relative to the steady state density.

The mass of individuals with less than aggregate disposable income per capita increases over all horizons according to the median response. Most of the probability mass is added between 0 and 0.5. The mass of individuals with disposable income between 0.6 and 2.8 drops, whereas the mass of individuals with disposable income over three is not affected by the tax shock. For all horizons the 80-percent bands are wide, including both positive and negative values. After 12 quarters the negative density differential for disposable income between 0.6 and 2.8 reverts back to zero, while the positive differential for after-tax income between 0 and 0.6 is more persistent.

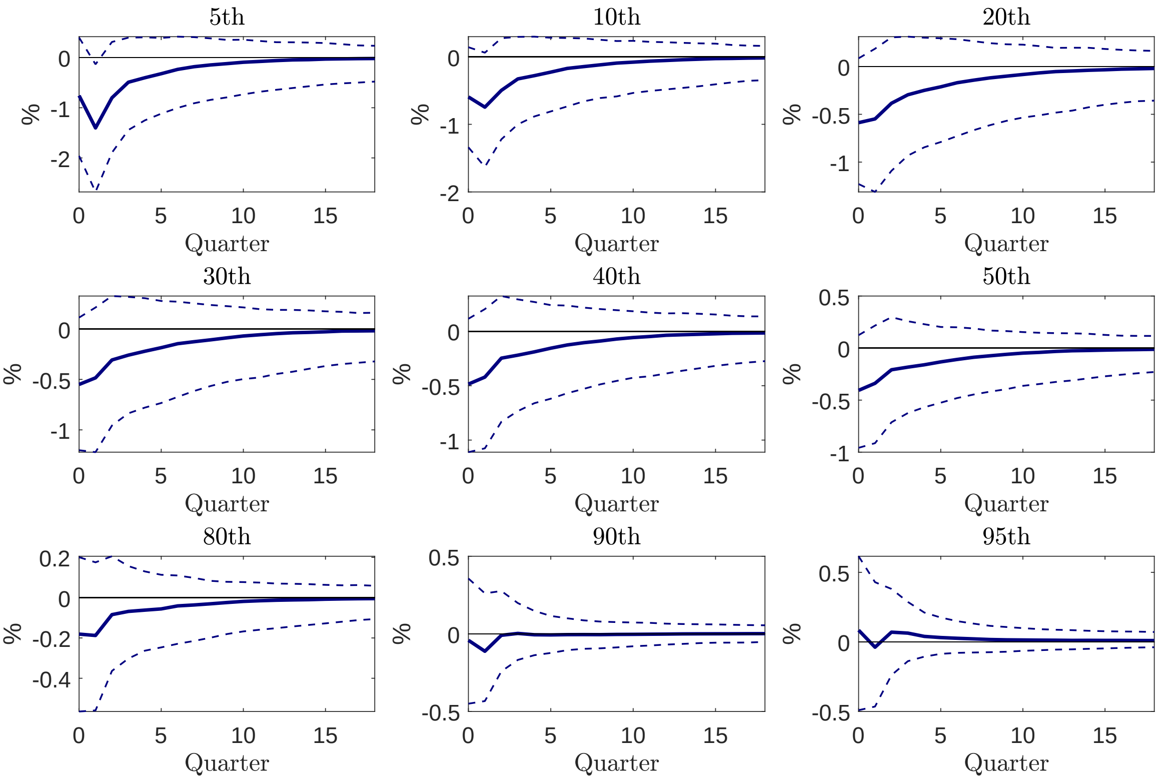


Figure 1.7: Percentile responses to a one standard deviation tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

A major advantage of the fVAR model is that the response of the cross-sectional density can be converted into any distributional statistic. Figure 1.7 illustrates percentile responses to a one standard deviation tax cut. The percentile responses are computed as percentage changes relative to their steady-state level. All percentiles, except the 95th, shift down relative to their steady-state position. The tax cut has the largest impact on the 5th percentile, which declines significantly by more than one percent. From the 10th to the 90th percentile the decline becomes smaller and less persistent. Only the 95th percentile experiences a slight and short-lived increase. The finding is consistent with the density response in Figure 1.6, thus providing evidence that after a tax cut the mass in the left tail of the disposable income distribution is increasing.

The previous results show that tax cuts have heterogeneous distributional effects. In the following, I quantify the effects along the disposable income distribution. I compute the absolute effect of the tax change to shed light on (i) which percentile benefitted and (ii) by how much from the tax cut. The absolute effect of the tax intervention per percentile is defined as

$$\underbrace{\left(\frac{\partial \ell^{**}_{t+h}}{\partial IV_t}/\ell^{ss} - 1\right)\cdot 100}_{\text{Percentage change in level of income at percentile **}} \quad + \quad \underbrace{\frac{\partial Y^D_{t+h}}{\partial IV_t}}_{\text{Change in aggregate income}} \quad , \qquad h = 0, 1, ..., H, \tag{1.12}$$

where $\frac{\partial Y^D_{t+h}}{\partial IV_t}$ is the response of aggregate disposable income to the tax shock IV_t, ℓ^{ss} denotes the steady-state density of cross-sectional disposable income and $\frac{\partial \ell^{**}_{t+h}}{\partial IV_t}$ is the disposable income density response at a certain percentile. For instance, $\frac{\partial \ell^{90}_{t+h}}{\partial IV_t}$ is the density response to a tax cut at the 90th percentile. A positive absolute effect for a percentile means that the percentile has benefitted from the increase in aggregate disposable income, while a negative absolute effect states that the respective percentile is worse off after the tax change.

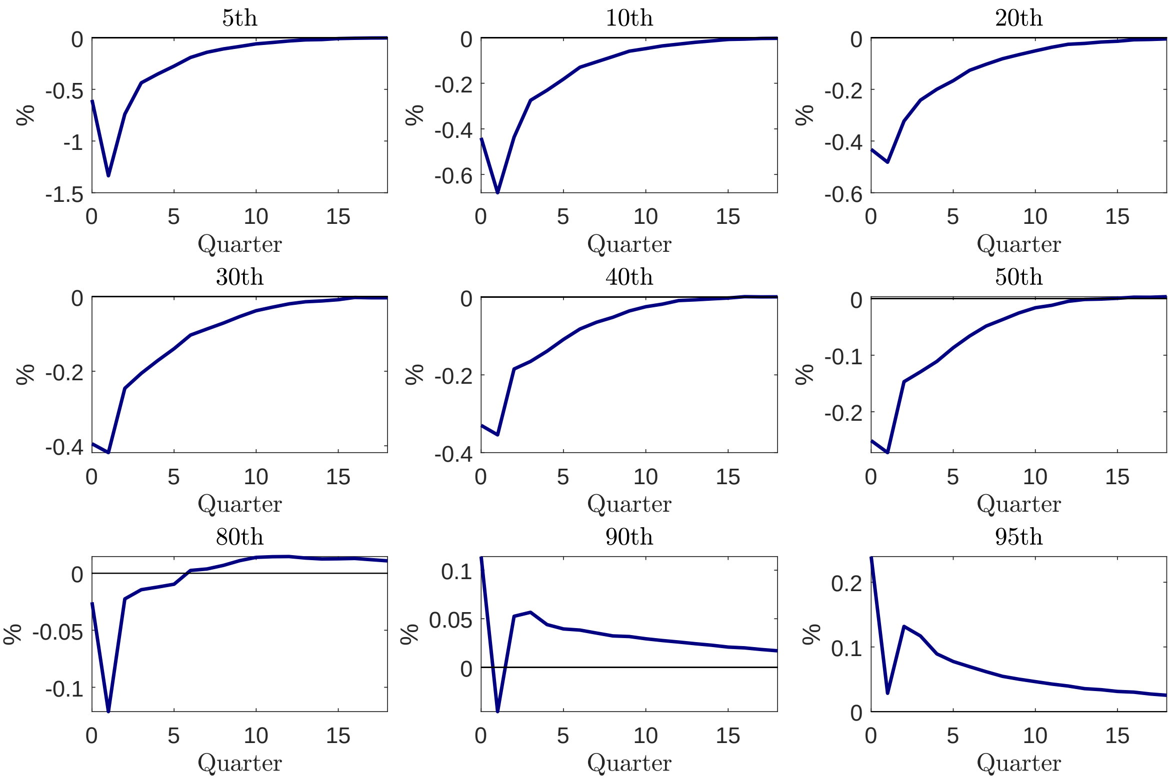


Figure 1.8: Absolute benefit from a one standard deviation tax cut computed at the median

Figure 1.8 displays the absolute effect of a one standard deviation tax cut on disposable income per percentile computed at the posterior median.[3] The first finding is that the sign of the impact response differs across percentiles. While the percentiles at the bottom and center of the distribution are negatively affected by the tax cut, the

[3]Appendix 1.B contains the corresponding plot with credible bands.

immediate benefit becomes positive between the 80th and 90th percentile, growing toward the right tail of the distribution. Second, the differences in the size of the effect across percentiles are pronounced: whereas disposable income at the 10th percentile declines on impact by 0.44 percent and stays below its initial level for three years, disposable income at the 90th percentile increases upon impact by 0.11 percent and remains positive from the third quarter.

In summary, the average exogenous tax cuts in the US during the 1980 to 2006 period show a regressive pattern: only the upper percentiles see their disposable income increased after a tax cut and can benefit from the increase in aggregate disposable income. Individuals in the center and the bottom of the disposable income distribution not only cannot profit from the increase in aggregate disposable income, but are even made worse off. This finding also provides a rationale for the distributional dynamics observed in Figure 1.6 and 1.7. The increase in probability mass in the left tail of the distribution following a tax cut is driven by those individuals who cannot benefit from the tax cut.

1.4 Decomposing the effects

While the baseline results in Section 1.3 focus on the distributional effects of the average exogenous tax rate changes implemented between 1980 and 2006, in this section I provide evidence on the distributional effects of different tax types. I follow Mertens and Ravn (2013) and decompose the average tax rate changes into personal and corporate income tax changes separately. Moreover, I use additional microlevel information to split the disposable income distribution according to different personal characteristics. In particular, I differentiate between disposable income from (i) entrepreneurs and non-entrepreneurs, and (ii) families and non-families.

1.4.1 Nature of the change in tax code

To determine the distributional effects of different tax types, I employ the narrative personal income and corporate income tax shock series derived in Mertens and Ravn (2013). Personal income tax liability changes mainly include marginal rate adjustments and tax deductions and credits. Corporate income tax liability changes incorporate mostly adjustments in depreciation allowances and investment tax credits. Across the 1980 to 2006 sample, Mertens and Ravn (2013) identify seven personal income and six corporate income tax changes.

To estimate the structural effects of personal and corporate income tax shock series, I include the two proxy variables in the vector of aggregate macroeconomic variables Y_t and use sign and covariance restrictions to identify the two shocks separately. Instead of tax revenues, like in the baseline specification outlined in Section 1.2.1, I include as Mertens and Ravn (2013) the average personal and corporate income tax rates, respectively.[4]

[4] Appendix 1.A outlines their construction.

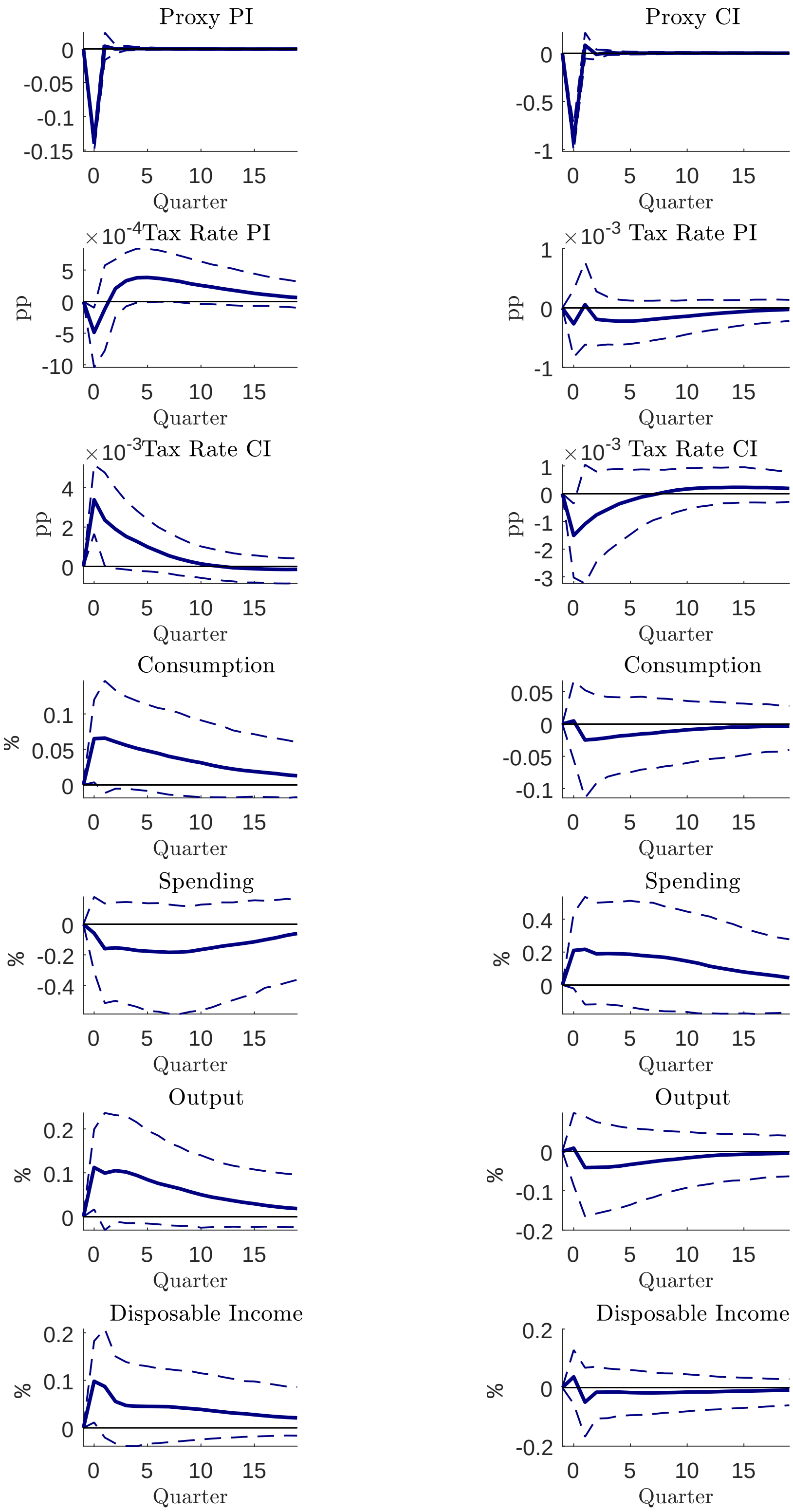
Table 1.3: Identifying restrictions

Variable	Personal income tax shock	Corporate income tax shock
	Covariance restrictions	
	$\mathrm{E}(IV_t^{PI}, \epsilon_t^{PI}) \geq 0$	$\mathrm{E}(IV_t^{CI}, \epsilon_t^{CI}) \geq 0$
	$\mathrm{E}(IV_t^{PI}, \epsilon_t^{PI}) \geq \mathrm{E}(IV_t^{PI}, \epsilon_t^{CI})$	$\mathrm{E}(IV_t^{CI}, \epsilon_t^{CI}) \geq \mathrm{E}(IV_t^{CI}, \epsilon_t^{PI})$
	Sign restrictions	
Personal income tax rate	≤ 0	$\bullet$
Corporate income tax rate	$\bullet$	≤ 0

Notes: Covariance restrictions and restrictions on the contemporaneous responses of variables to shocks. ≤ 0 and $\bullet$ denote the respective sign restrictions and unrestricted responses.

Table 1.3 summarizes the identifying restrictions I use to separate the tax changes. Additional identifying restrictions become necessary because the personal and corporate income proxy series exhibit positive correlation (Mertens and Ravn, 2013). I follow Giacomini et al. (2022), by employing the same sign and covariance restrictions to decompose average tax changes into personal and corporate income tax changes. IV_t^{PI} and IV_t^{CI} denote the personal income and corporate income proxy variable and ϵ_t^{PI} and ϵ_t^{CI} represent the corresponding structural shock. It is assumed that each proxy variable is positively correlated with its associated structural shock and that each proxy variable is stronger correlated with its own structural shock than with the structural shock associated with the other proxy variable. Moreover, it is assumed that the response of each tax rate to its own structural shock following a tax cut is nonpositive.

Figure 1.9 shows the identified impulse responses to the aggregate variables. The left panel displays the responses to a one standard deviation personal income tax cut and the right panel illustrates the corporate income tax cut responses. Except for the only on impact positive output response following a corporate income tax cut, the findings are qualitatively in line with what was found in earlier and longer-spanning samples in the literature. By construction, the impact response of the tax rates associated with the structural shock of interest satisfy the sign restrictions. The personal income tax rate (left panel) and the corporate income tax rate (right panel) both decline. While a personal income tax cut decreases government spending by at most 20 basis points, a corporate income tax cut elicits a positive response of circa 20 basis points on impact at the median. Following a personal income tax cut, consumption and output increase over a period of five years, whereas a corporate income tax cut only produces on impact a slight positive response in consumption and output that is not precisely estimated. Both the personal and the corporate income tax cuts increase disposable income on impact: in the left panel disposable income rises on impact by 10 basis points and stays above its initial level for 20 quarters. Corporate income tax cuts lead to a less strong



(a) Personal income tax shock

(b) Corporate income tax shock

Figure 1.9: Aggregate responses to a one standard deviation personal (left panel) and corporate income (right panel) tax cut; median (blue, solid), 80-percent credible interval (blue, dashed). Shock occurs at $h = 0$. PI and CI stands for personal income and corporate income, respectively.

increase in aggregate disposable income. After an initial increase of 4 basis points, the response becomes negative, reverting back to zero after five years.

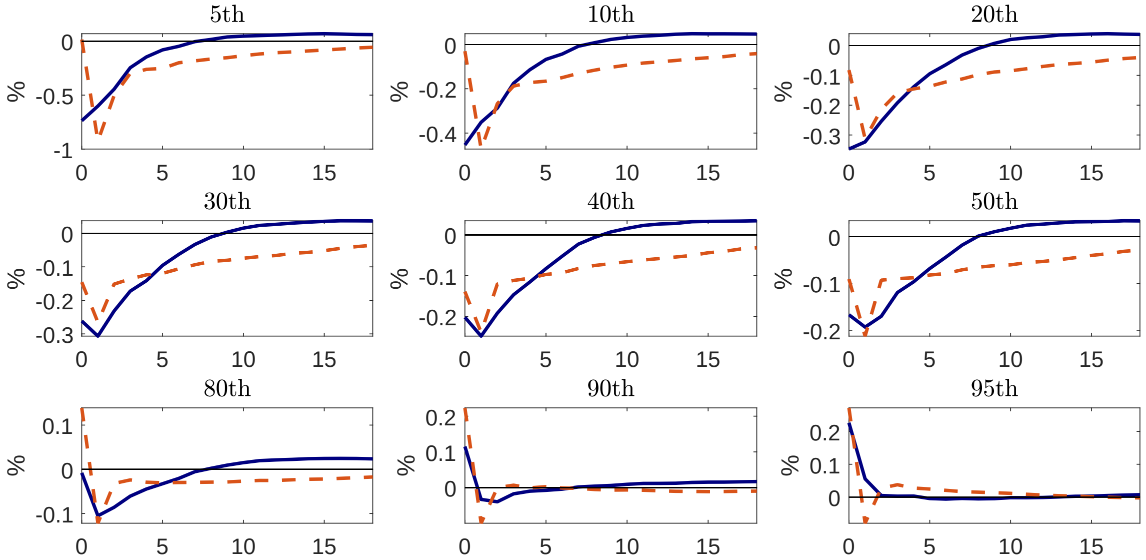


Figure 1.10: Absolute benefit from a one standard deviation tax cut computed at the median; personal income tax cut (blue, solid), corporate income tax cut (red, dashed).

The distributional effects of a personal and corporate income tax cut are contrasted in Figure 1.10, which shows the absolute effect of each tax intervention on percentiles of cross-sectional disposable income.[5] The plot makes obvious that the nature of the tax change is critical for the cross-sectional effect. Personal and corporate income tax changes impact disposable income along the distribution differently. First, the regressive pattern documented in the analysis of average tax shock effects in Section 1.3 persists. Only the upper percentiles of the disposable income distribution benefit from the tax intervention. Corporate income tax cuts exert stronger impact effects than personal income tax cuts. The spread is mostly pronounced at the 80th percentile, where the benefit on impact is 10 basis points for the corporate income tax cut and slightly negative for the personal income tax cut. Second, individuals are hurt by tax cuts up to the median percentile. Only after two years they benefit from personal income tax cuts. The effect of corporate income tax cuts remains negative over the whole period of five years. In summary, corporate income tax cuts clearly benefit the upper percentiles and hurt the bottom and the center of the disposable income distribution. For personal income tax cuts, the pattern is more ambiguous. While all individuals up to the 80th percentile benefit modestly two years after the policy change from the increase in aggregate disposable income, the top of the distribution registers an immediate and more pronounced increase in after-tax income.

1.4.2 Personal characteristics

To investigate the heterogenous distributional effects of personal and corporate income tax cuts further, I partition the disposable income distribution according to personal

[5]Appendix 1.B shows the corresponding density differential and percentile plots.

characteristics. To learn which groups politicians target when implementing their tax policy changes, I revert to the anecdotal evidence accompanying the legislative tax policy process in the US. In particular, I study presidential speeches, the US Budget Reports, and the Economic Reports of the President.[6] Over the entire sample, and, independent of the government's political background, three narratives repeatedly emerge: tax changes (i) are directed toward low-income people, (ii) are pro-business, and (iii) pro-family. For instance, George W. Bush stated, on May 28, 2003, on the occasion of signing the Jobs and Growth Tax Relief Reconciliation Act:[7]

> "We are helping workers who need more take-home pay. We're helping small-business owners looking to grow and to create more new jobs. We're helping families with children who will receive immediate relief."

To assess these narratives empirically, I distinguish between disposable income (i) of entrepreneurs versus non-entrepreneurs, and (ii) families versus non-families. Entrepreneurs are defined as households with business income $\neq 0$. Families are defined as having at least one person below the age of 18 in their household. Appendix 1.A provides all details.

Entrepreneurs Figure 1.11 compares the steady-state densities for entrepreneurs and non-entrepreneurs. The x-axis indicates the level of after-tax income. Both distributions are right-skewed and exhibit a similar shape. The mode of the disposable income distribution of entrepreneurs is shifted to the right.

The absolute benefits from a personal income tax cut on disposable income of entrepreneurs and non-entrepreneurs are depicted in Figure 1.12. The differences between entrepreneurs and non-entrepreneurs are pronounced. Across all percentiles, entrepreneurs benefit more from the personal income tax cut than non-entrepreneurs. This discrepancy is strongest at the top of the distribution. While at the 90th percentile disposable income of an entrepreneur increases on impact by 1 percent, the non-entrepreneur sees no change in disposable income. Non-entrepreneurs are mostly negatively affected by the personal income tax cut. Only the percentiles in the middle of the distribution experience modest increases in disposable income. Even here, the regressive pattern is present. The upper percentiles benefit more from the tax change than the lower percentiles - independent of being an entrepreneur.

Figure 1.13 displays the absolute effects of a corporate income tax cut for entrepreneurs and non-entrepreneurs. Not surprisingly, entrepreneurs benefit more strongly than non-entrepreneurs from corporate income tax cuts. Again, a robust finding in this exercise is the regressive nature of the tax cut. While the lower percentiles hardly benefit from the

[6] Presidential speeches are retrieved from "The American Presidency Project", accessible via https://www.presidency.ucsb.edu/. The Budget of the United States Government contains the Budget Message of the President, information on the President's priorities, budget overviews organized by agency, and summary tables for every fiscal year. It can be accessed via https://fraser.stlouisfed.org/title/budget-united-states-government-54?browse=1920s. The Economic Report of the President is an annual report written by the Chairman of the Council of Economic Advisers. It can be accessed via https://fraser.stlouisfed.org/title/economic-report-president-45?browse=1940s.

[7] Appendix 1.C provides a collection of further relevant examples from the narrative sources.

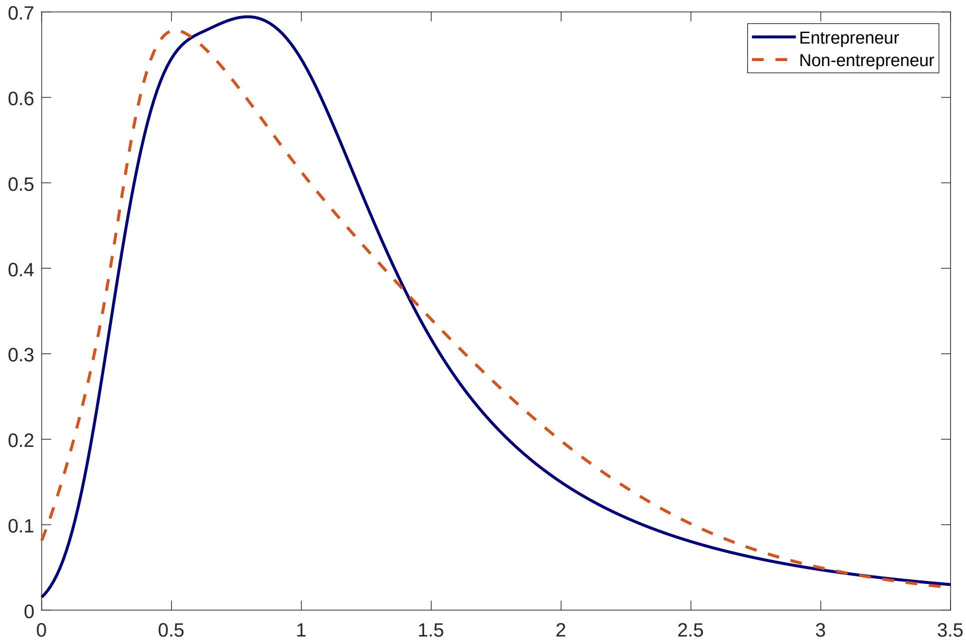


Figure 1.11: Steady-state density of disposable income of entrepreneurs (blue, solid) and non-entrepreneurs (red, dashed) income.

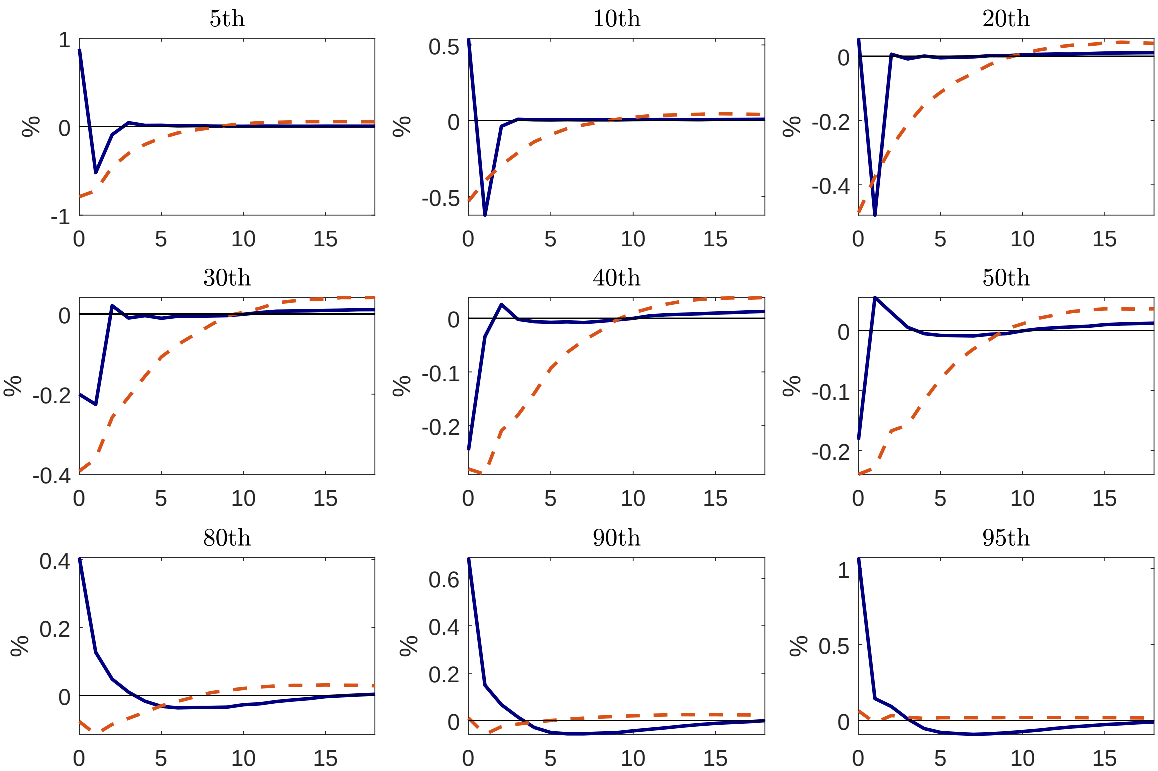


Figure 1.12: Absolute benefit from a one standard deviation personal income tax cut computed at the median; entrepreneurs (blue, solid), non-entrepreneurs (red, dashed).

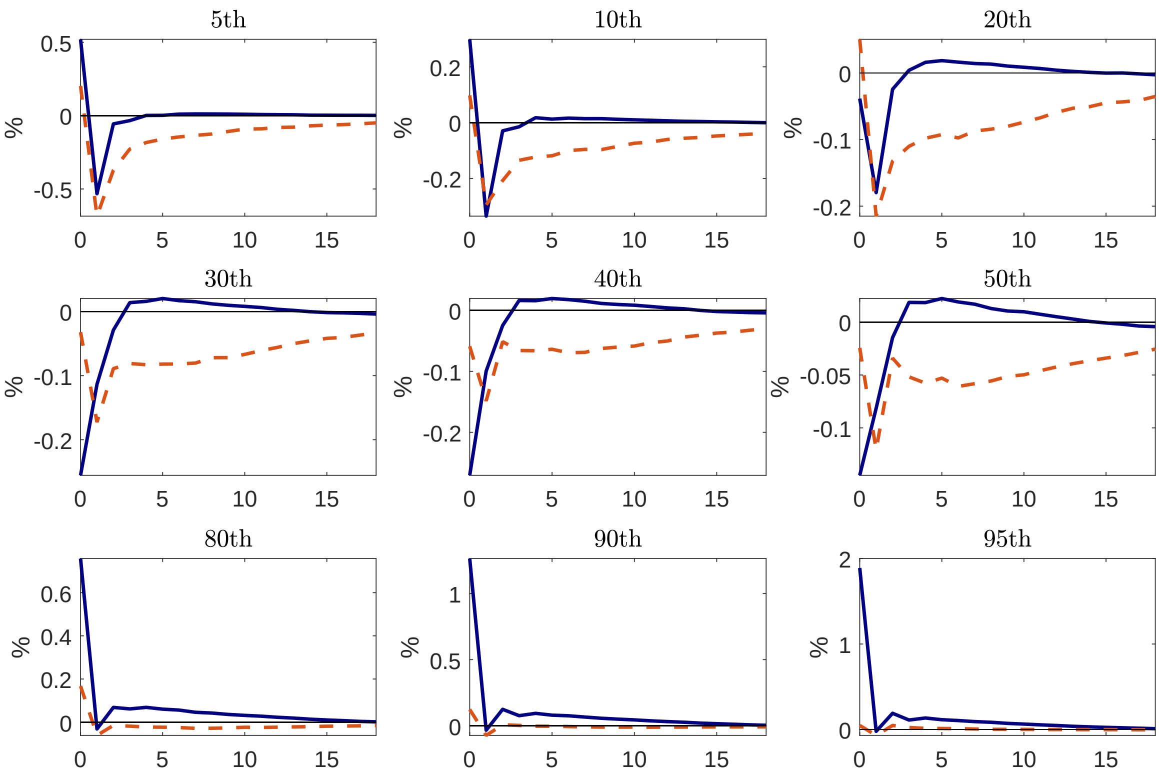


Figure 1.13: Absolute benefit from a one standard deviation corporate income tax cut computed at the median; entrepreneurs (blue, solid), non-entrepreneurs income (red, dashed).

increase in aggregate disposable income, disposable income for entrepreneurs at the top of the distribution increases considerably - on impact more than 1 percent at the 90th percentile. Further, households without business income register changes in disposable income. Non-entrepreneurs at the bottom and center of the distribution are made worse off by the tax cut, while the 80th percentile benefits the most. As non-entrepreneurs are not directly affected by the cut in corporate income taxes, their change in income has to be related indirectly to the entrepreneurs' change in income.

In summary, decomposing the distributional effects of tax cuts for entrepreneurs and non-entrepreneurs separately confirms the political narrative: US tax policy between 1980 and 2006 was indeed directed toward entrepreneurs and pro-business oriented.

Families Figure 1.14 shows the steady-state densities for families and non-families. Both distributions are right-skewed. The mode of the disposable-income-distribution of families lies at 0.7, while the disposable-income-distribution of non-families peaks at an income level of 0.5.

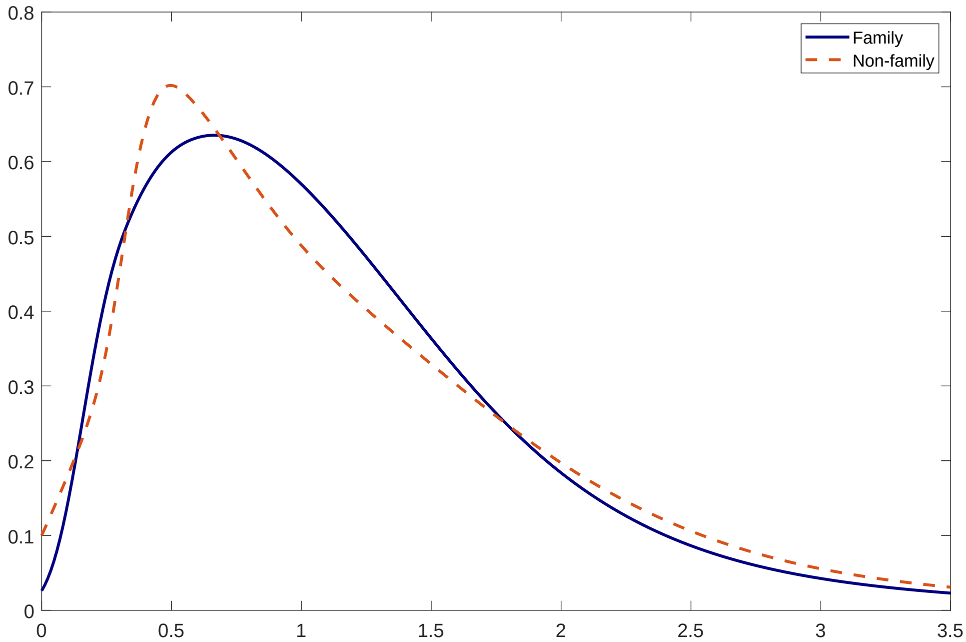


Figure 1.14: Steady-state density of disposable income partitioned into disposable income from families (blue, solid) and non-families (red, dashed).

The absolute benefits of a personal income tax cut on families and non-families are presented in Figure 1.15.[8] Two findings stand out. First, families benefit more from personal income tax cuts than non-families. This results holds throughout the entire distribution. While, for families, the tax cut already results in increases in disposable income at the bottom of the distribution, non-families do not register income gains and, except for the very top of the distribution, are even made worse off. Second,

[8]The absolute benefits of a corporate income tax cut on families and non-families is presented in Appendix 1.B.

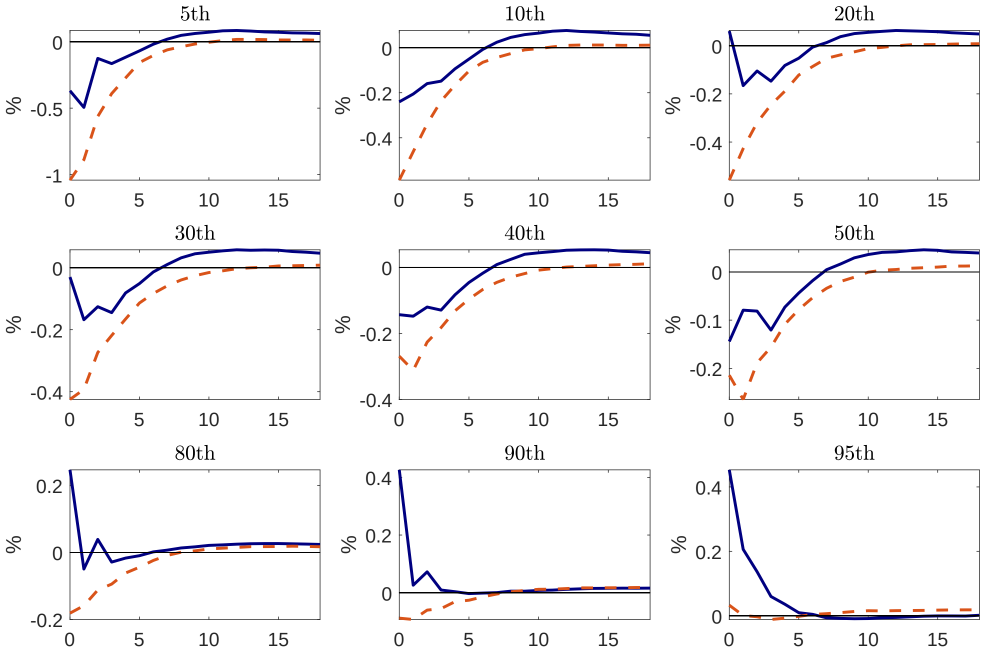


Figure 1.15: Absolute benefit from a one standard deviation personal income tax cut computed at the median; income of families (blue, solid), income of non-families (red, dashed).

controlling for family status does not remove the regressive effects associated with the tax cut. For both families and non-families, the lower percentiles benefit less from the change in aggregate disposable income than the upper percentiles. In summary, this decomposition confirms that US tax policy indeed fostered families.

1.5 Conclusion

How tax changes affect the distribution of income is a long-standing question in macroeconomics. In this paper, I provide the first comprehensive empirical analysis and estimate a fVAR model that interacts macroeconomic aggregates and the cross-sectional distribution of disposable income on US data for the 1980 to 2006 period. This setup allows me to quantify the distributional effects of aggregate tax shocks.

My findings provide evidence that the average tax cut in this period had heterogeneous effects along the income distribution: it hurt the bottom and center of the distribution and benefitted the rich. This regressive pattern is also confirmed in a more granular analysis in which I distinguish between personal and corporate income tax cuts. Decomposing the cross-sectional disposable income according to personal characteristics allows me to verify prevalent narratives surrounding US tax policy legislation. While my findings do not support political statements that US tax policy benefitted low-income households, they lend empirical substance to narratives describing US tax legislation as pro-family and pro-business.

Although my analysis is silent on the long-term relationship between rising US income inequality and the contribution of tax policy, the results show that the analyzed tax changes have not shrunk the gap. I leave for future work the linking of the response of the distribution of disposable income to micro-level consumption expenditure and identifying the individuals in the distributions according to their micro-level characteristics.

Appendices

1.A Data description

In this appendix, I outline how I construct the aggregate and cross-sectional variables.

Aggregate variables

Unless otherwise noted, the data is retrieved from the NIPA Tables published by the Bureau of Economic Analysis (BEA). All time series in nominal values are converted to real values by dividing them by the GDP deflator. To obtain per capita values, I divide the variables by the civilian non-institutional population of 16 years and older provided by Francis and Ramey (2009) ('civnipop16'). All variables are seasonally adjusted.

Average corporate income tax rate: The average corporate income tax rate is the variable 'ACITR' from the replication files of Mertens and Ravn (2013) and defined as federal taxes on corporate income excluding Federal Reserve banks divided by corporate profits.

Average personal income tax rate: The average personal income tax rate is the variable 'APITR' from Mertens and Ravn (2013) and defined as the sum of federal personal current taxes and federal contributions for government social insurance divided by the personal income tax base. The personal income tax base is defined as personal income less government transfers plus contributions for government social insurance.

Corporate income tax changes proxy variable: The narrative corporate income tax shock series from Section 1.4 is the variable 'm_CI' from the replication files of Mertens and Ravn (2013).

Disposable Income: Aggregate disposable income per capita is given by the logarithm of disposable personal income divided by population. The data on disposable personal income is retrieved from the FRED database of the Federal Reserve Bank of St. Louis (variable code: DSPI) and originates from the BEA (BEA account code: A067RC).

GDP deflator: The GDP deflator is the implicit price deflator for GDP (table 1.1.9, line 1) (index, 2012 = 100) divided by 100.

Government spending: Government spending per capita is the logarithm of the sum of federal consumption expenditures (table 3.9.5, line 10) and federal gross investment (table 3.9.5, line 11) divided by population.

Non-durable consumption expenditure: Non-durable consumption expenditure per capita is defined as the logarithm of the sum of non-durable goods (table 1.1.5, line 5) and services (table 1.1.5, line 6) divided by population.

Output: Output per capita is defined as the logarithm of GDP (table 1.1.5, line 1) divided by population.

Personal income tax changes proxy variable: The narrative personal income tax shock series from Section 1.4 is the variable 'm_PI' from the replication files of Mertens and Ravn (2013).

Tax revenue: Tax revenue per capita is the logarithm of the sum of federal current tax receipts (table 3.2, line 2), and contributions for government social insurance (table 3.2, line 10) minus corporate income taxes (table 3.2, line 8) divided by population.

Total tax changes proxy variable: The proxy variable used in Section 1.3 is the variable 'Tax Narrative' in the replication files of Mertens and Ravn (2014).

Cross-sectional disposable income I use income data from the Family Characteristics and Income (FAMILY) files of the CEX. The CEX is a rotating panel of households selected to be representative of the US population and is conducted by the Census Bureau for the Bureau of Labor Statistics. The CEX provides detailed information on consumption expenditures and income of each consumer unit (CU), which corresponds to households or families who are living at the same address. The survey additionally includes detailed demographic information about all CU members. Each CU stays in the sample for a maximum of four consecutive periods before it is dropped. Although the CEX started in 1960, continuous data is only available since the first quarter of 1980, which is the beginning of my sample.

I take disposable income from the dataset provided by Heathcote et al. (2010), in particular the variable 'tian' from the file 'cex_a.dta'. Disposable income is defined as the sum of wages, salaries, business income (farm and non-farm) earned by each member, financial income (interest, dividends and rent), private transfers (including private pensions, alimony and child support), public transfers (including social security, unemployment compensation, welfare and food stamps) minus total taxes paid (including federal, state, local and social security contribution).

In Section 1.4.2, I partition total disposable income into disposable income from (i) entrepreneurs and non-entrepreneurs and (ii) families and non-families. I use an indicator variable to partition total disposable income into disposable income of CUs with different characteristics. I define a CU as "entrepreneur"-CU if its business income $\neq 0$. Over the sample 1980 – 2006, the share of CU with business income is 9 % relative to 91 % without business income. A CU is counted toward the "family"-category if at least one individual below the age of 18 lives in the CU. This definition applies to 64 % of the CUs, as opposed to 36 % who are counted as "non-family".

1.B Additional results

Additional results Section 1.3

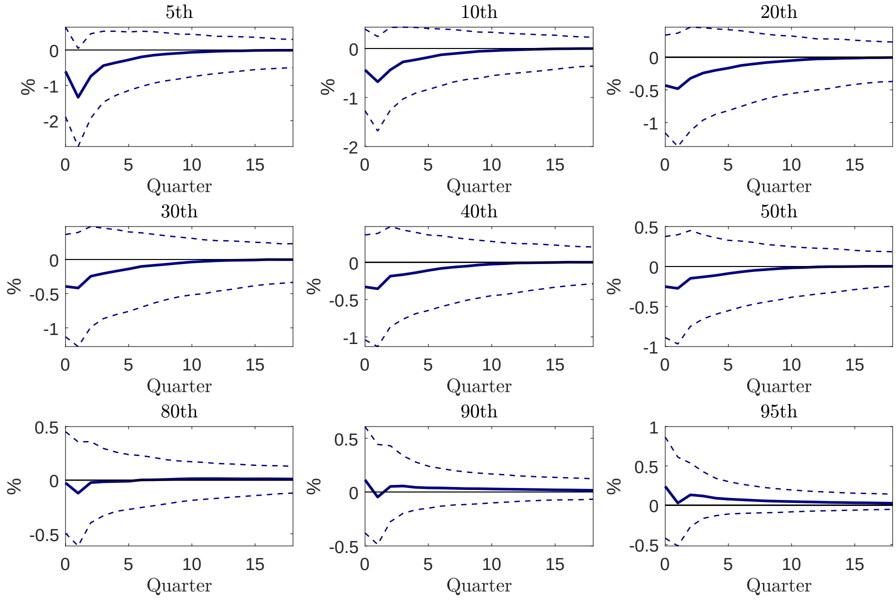


Figure 1.16: Absolute benefit from a one standard deviation total tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

Additional results Section 1.4.1

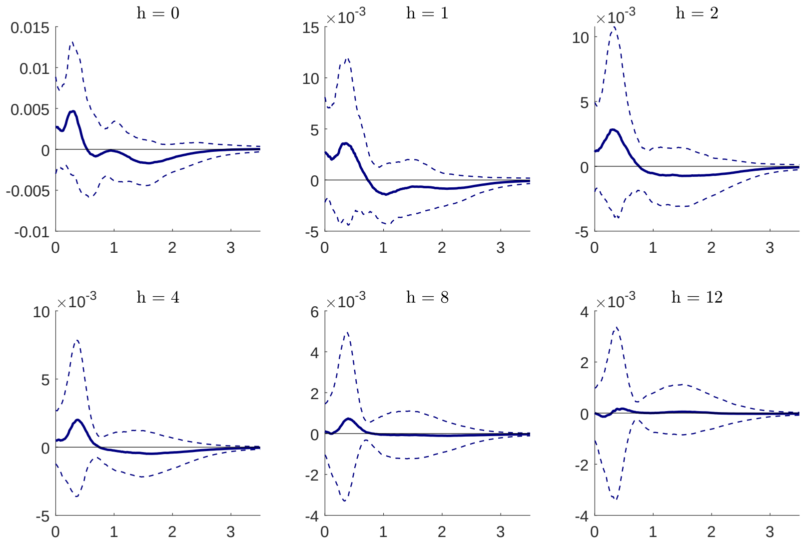


Figure 1.17: Density responses to a one standard deviation personal income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

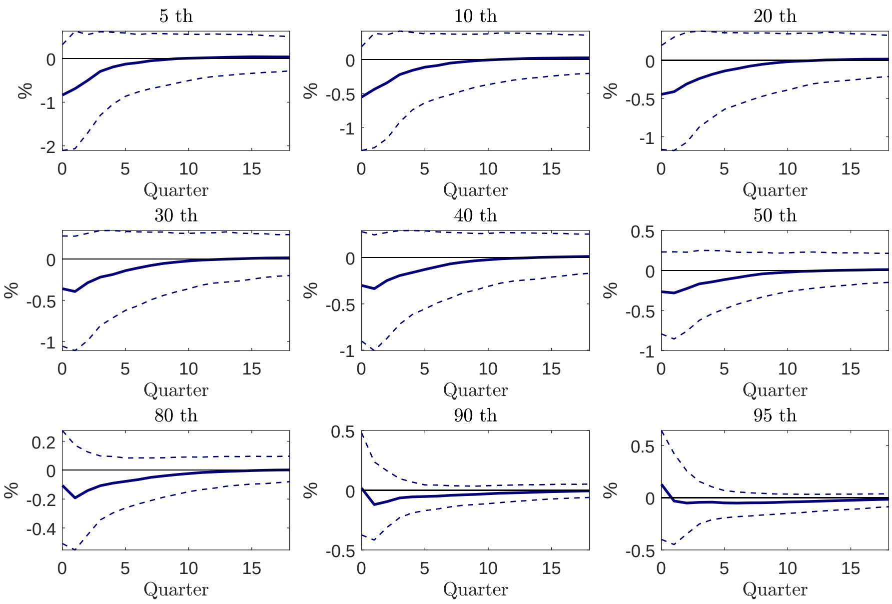


Figure 1.18: Percentile responses to a one standard deviation personal income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

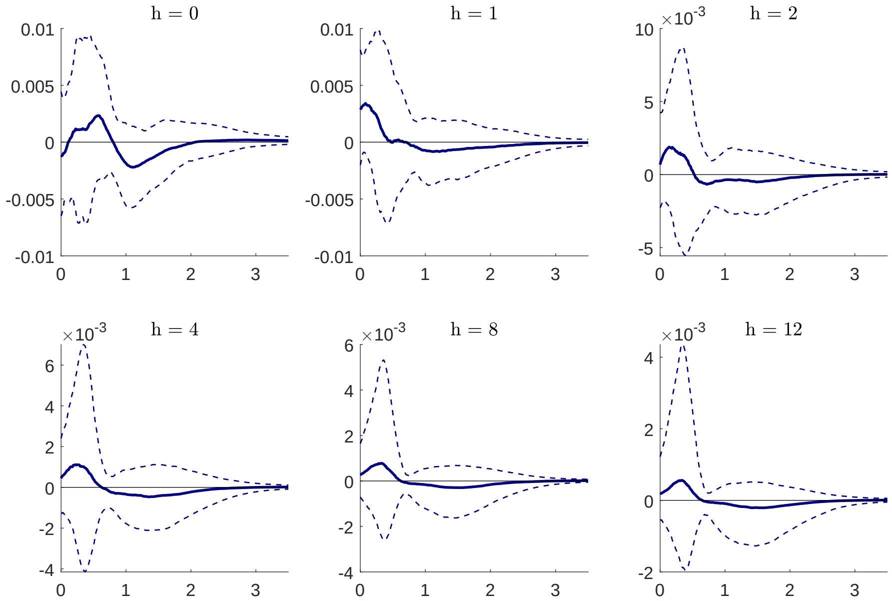


Figure 1.19: Density responses to a one standard deviation corporate income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

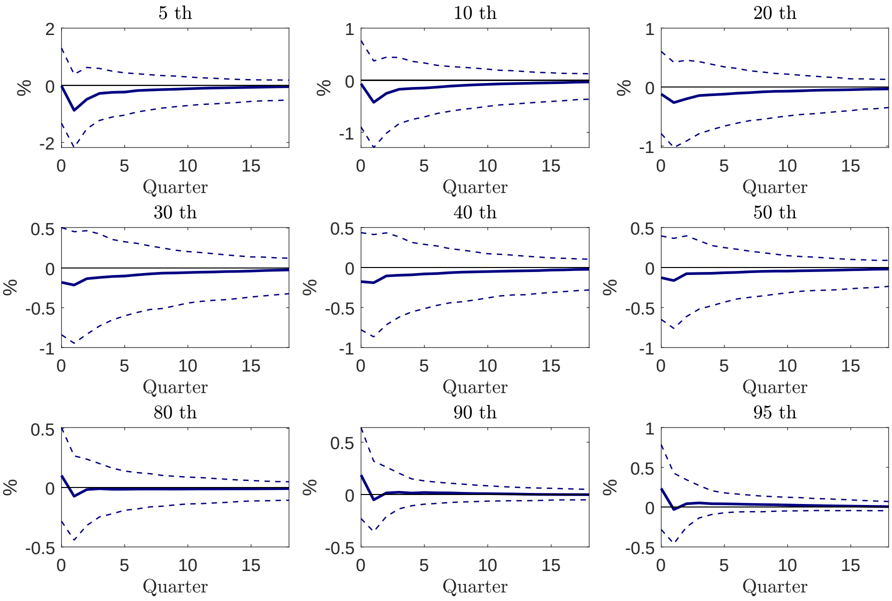


Figure 1.20: Percentile responses to a one standard deviation corporate income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

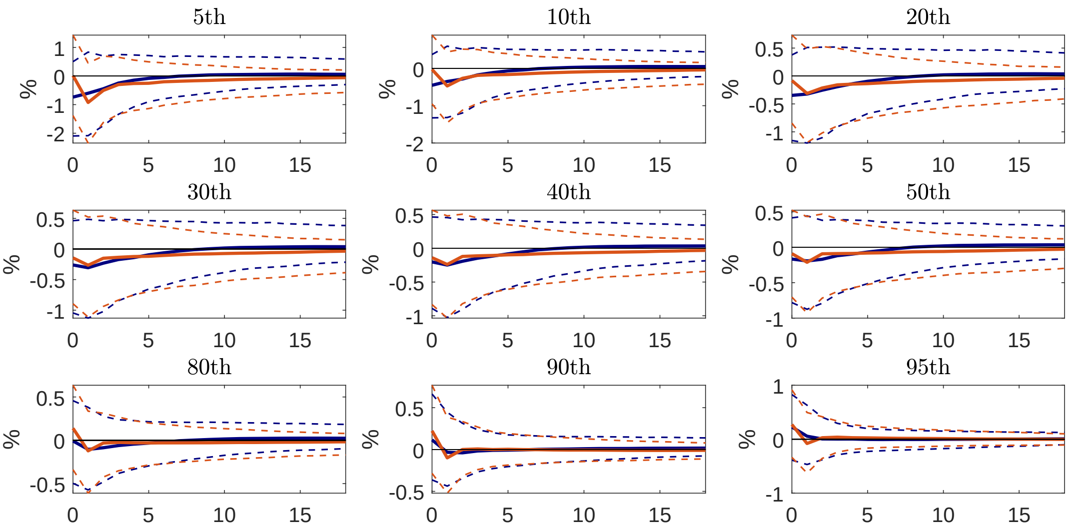


Figure 1.21: Absolute benefit from a one standard deviation tax cut; personal income tax cut (blue), corporate income tax cut (red), median (solid), 80-percent credible interval (dashed)

Additional results Section 1.4.2

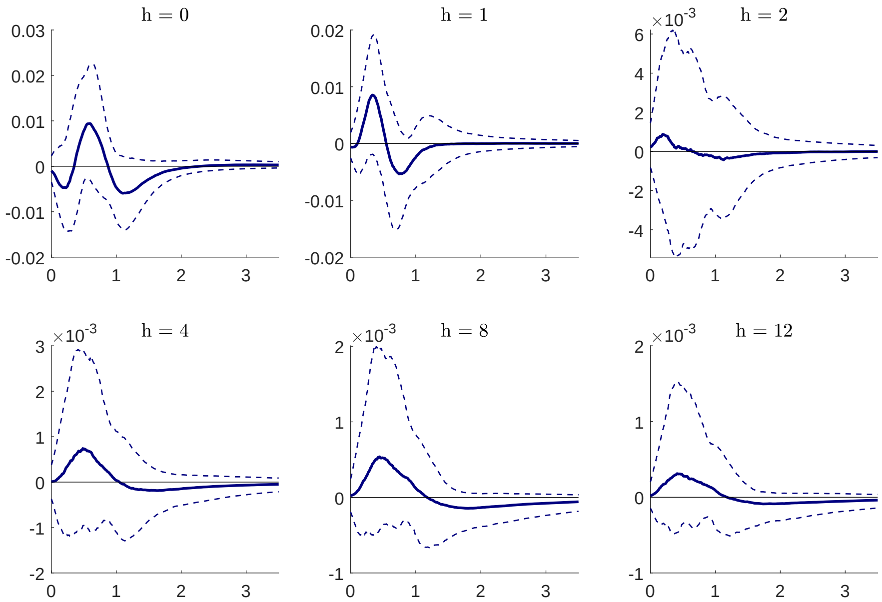


Figure 1.22: Density response to a one standard deviation personal income tax cut of entrepreneurs; median (blue, solid), 80-percent credible interval (blue, dashed)

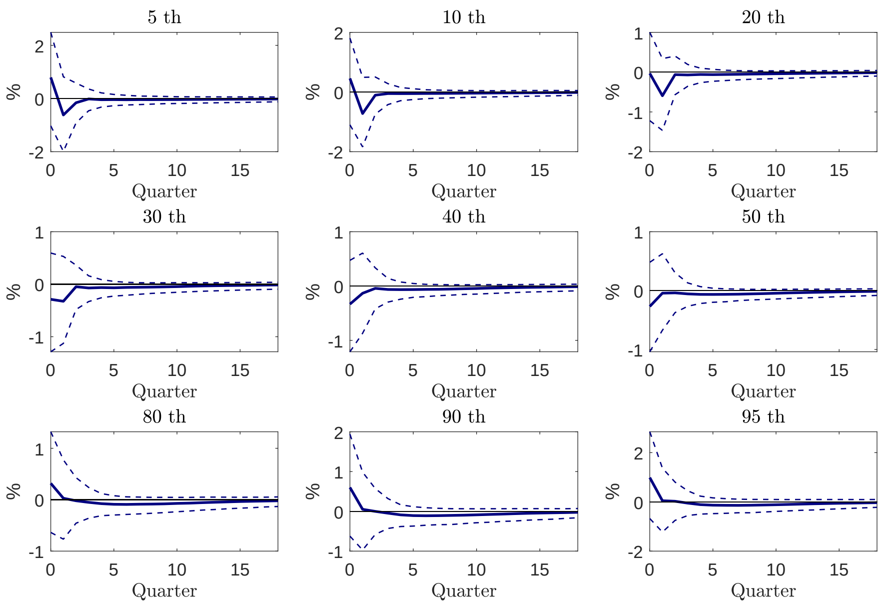


Figure 1.23: Percentile responses of entrepreneurs to a one standard deviation personal income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

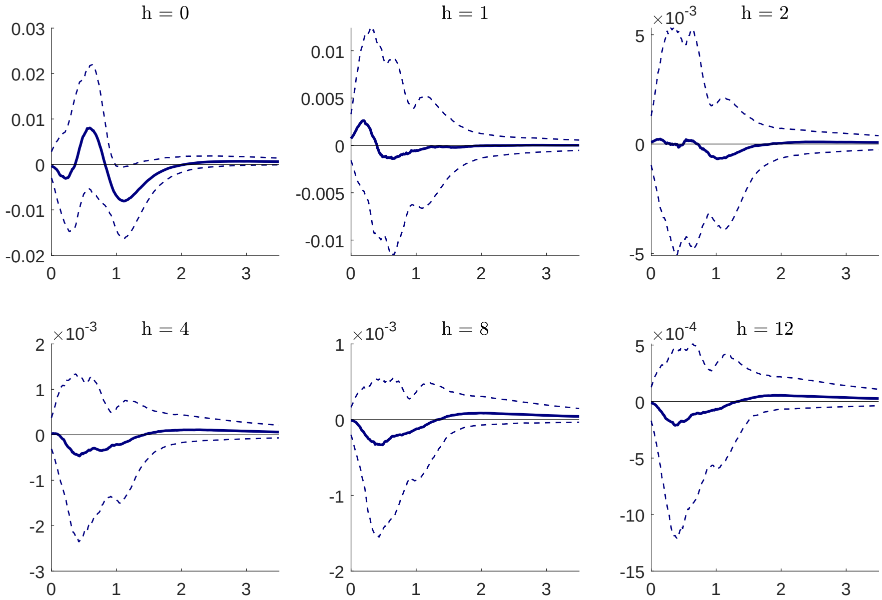


Figure 1.24: Density responses to a one standard deviation corporate income tax cut of entrepreneurs; median (blue, solid), 80-percent credible interval (blue, dashed)

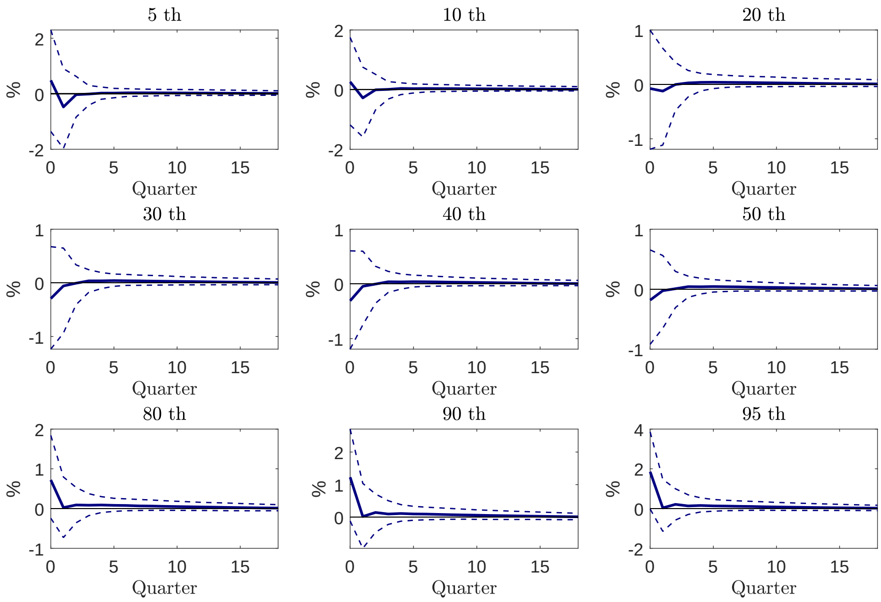


Figure 1.25: Percentile responses of entrepreneurs to a one standard deviation corporate income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

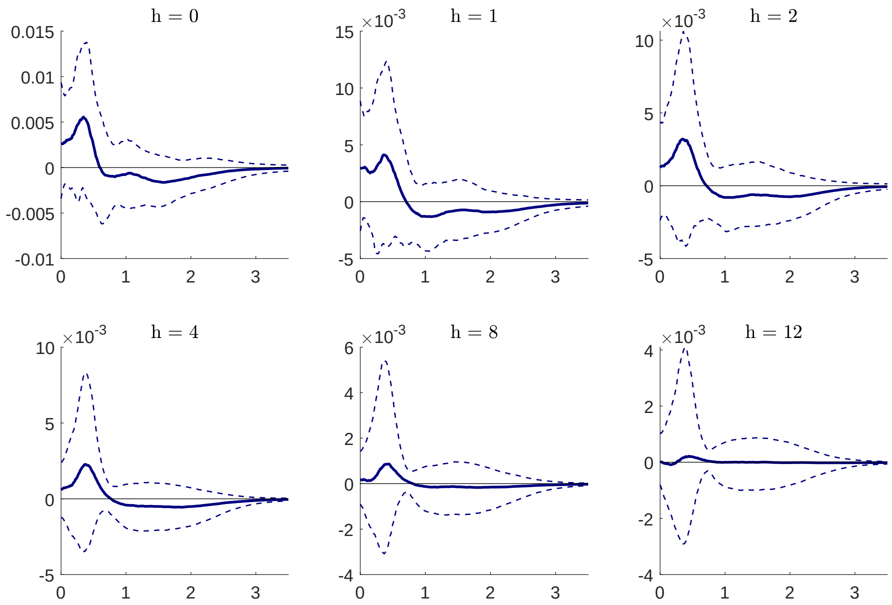


Figure 1.26: Density responses to a one standard deviation personal income tax cut of non-entrepreneurs; median (blue, solid), 80-percent credible interval (blue, dashed)

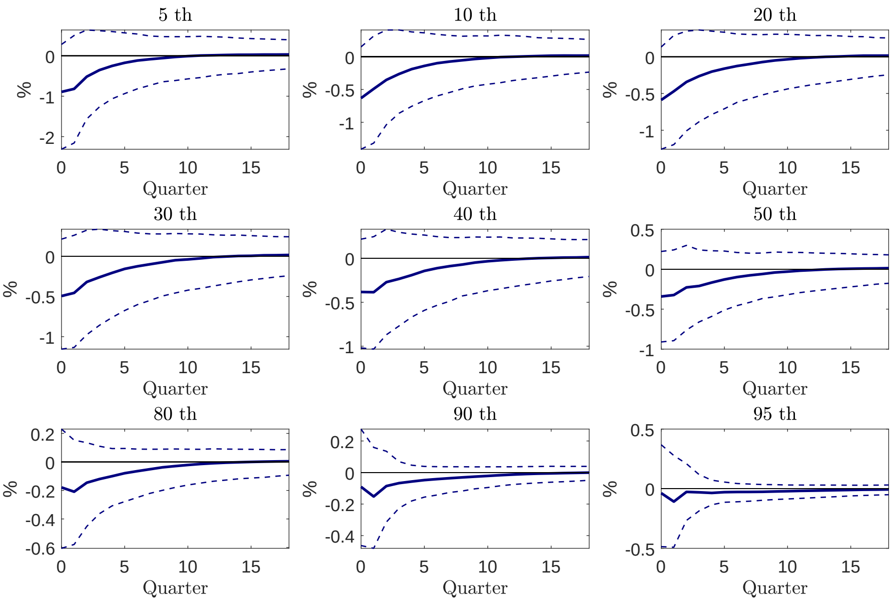


Figure 1.27: Percentile responses of non-entrepreneurs to a one standard deviation personal income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

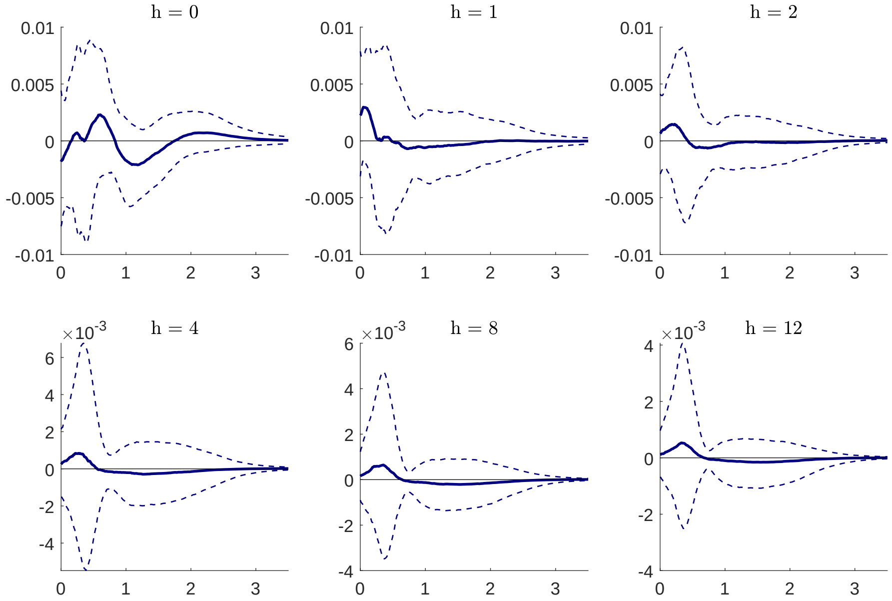


Figure 1.28: Density responses to a one standard deviation corporate income tax cut of non-entrepreneurs; median (blue, solid), 80-percent credible interval (blue, dashed)

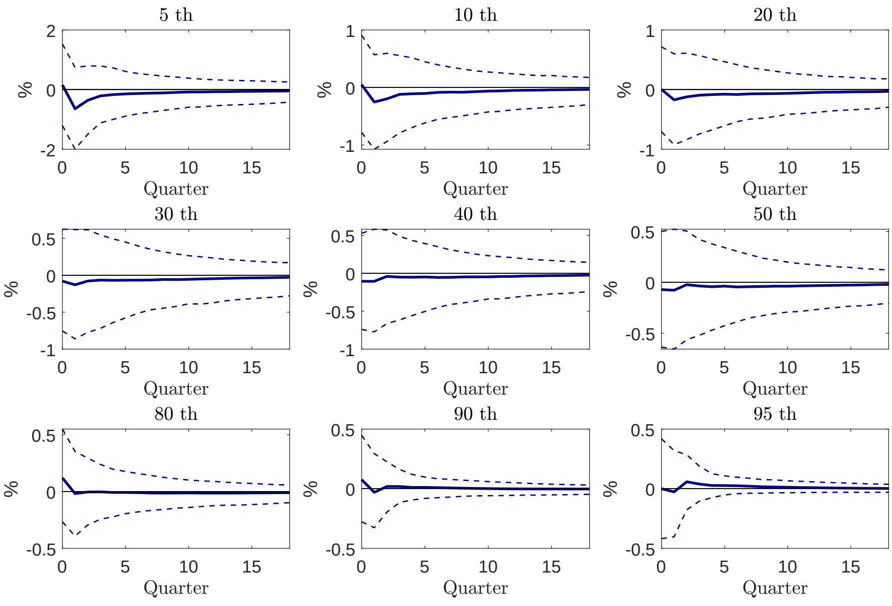


Figure 1.29: Percentile responses of non-entrepreneurs to a one standard deviation corporate income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

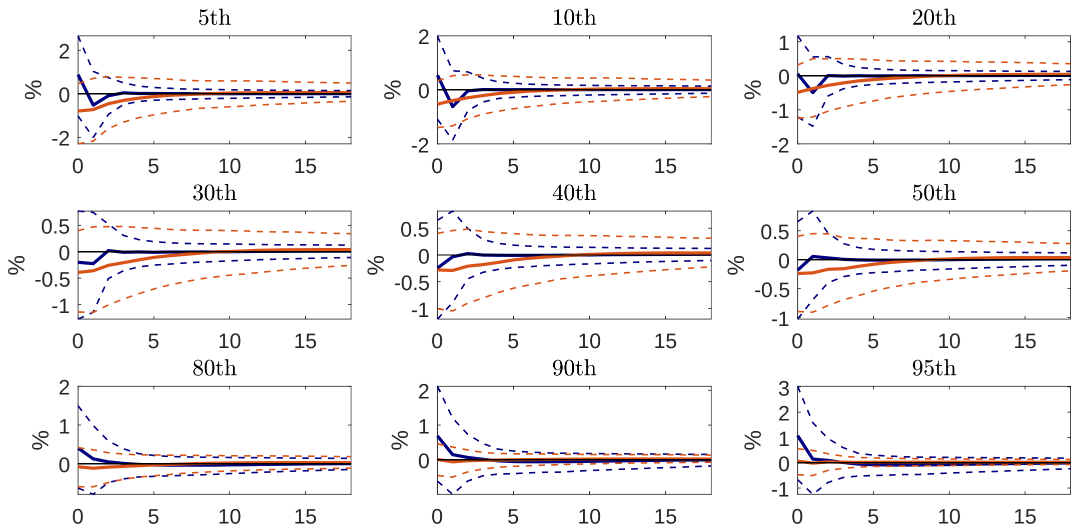


Figure 1.30: Absolute benefit from a one standard deviation personal income tax cut; entrepreneurs (blue), non-entrepreneurs (red), median (solid), 80-percent credible interval (dashed)

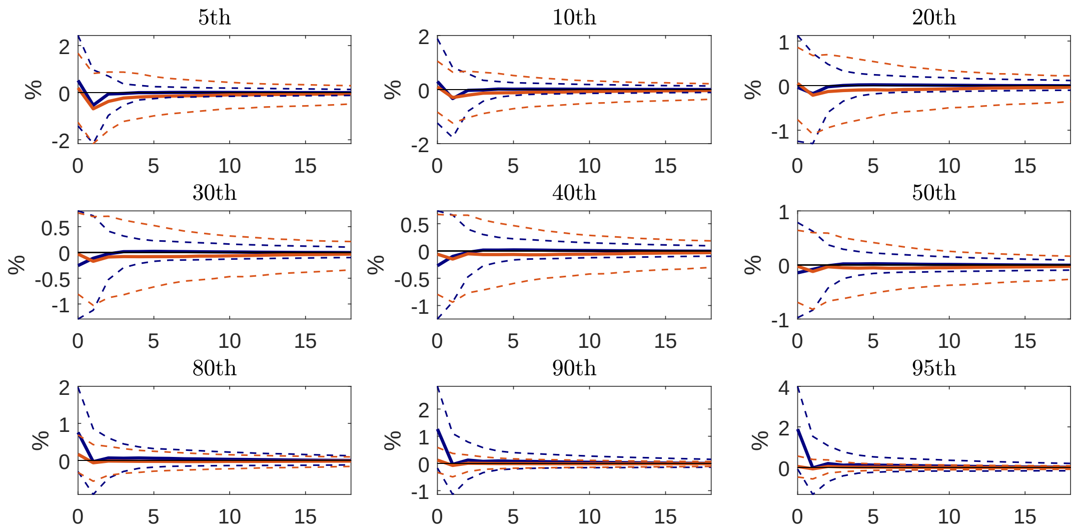


Figure 1.31: Absolute benefit from a one standard deviation corporate income tax cut; entrepreneurs (blue), non-entrepreneurs income (red), median (solid), 80-percent credible interval (dashed)

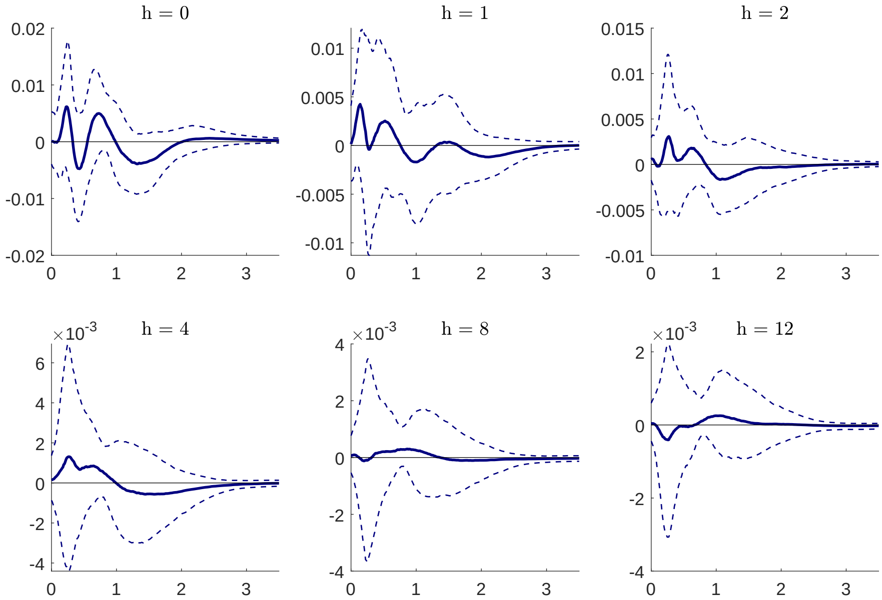


Figure 1.32: Density responses of income of families to a one standard deviation personal income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

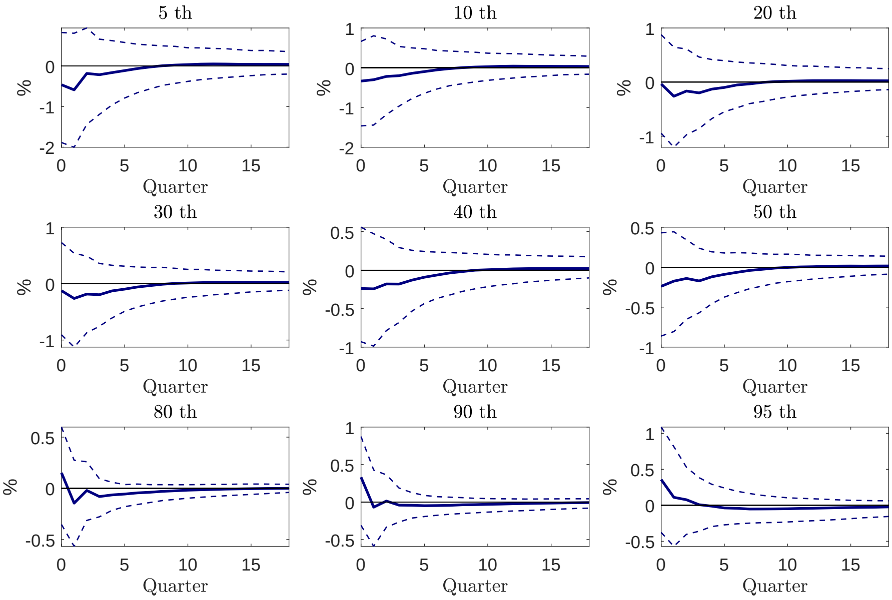


Figure 1.33: Percentile responses of income of families to a one standard deviation personal income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

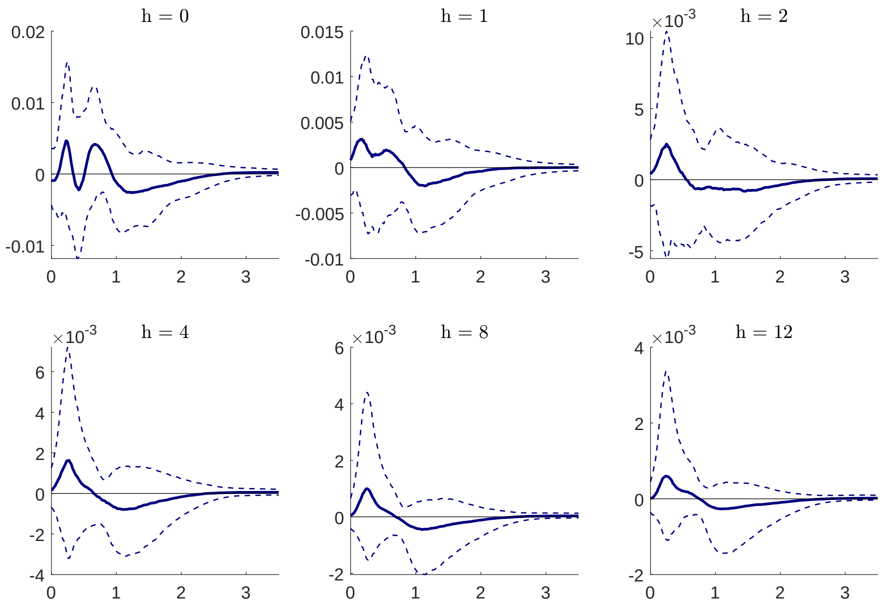


Figure 1.34: Density responses of income of families to a one standard deviation corporate income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

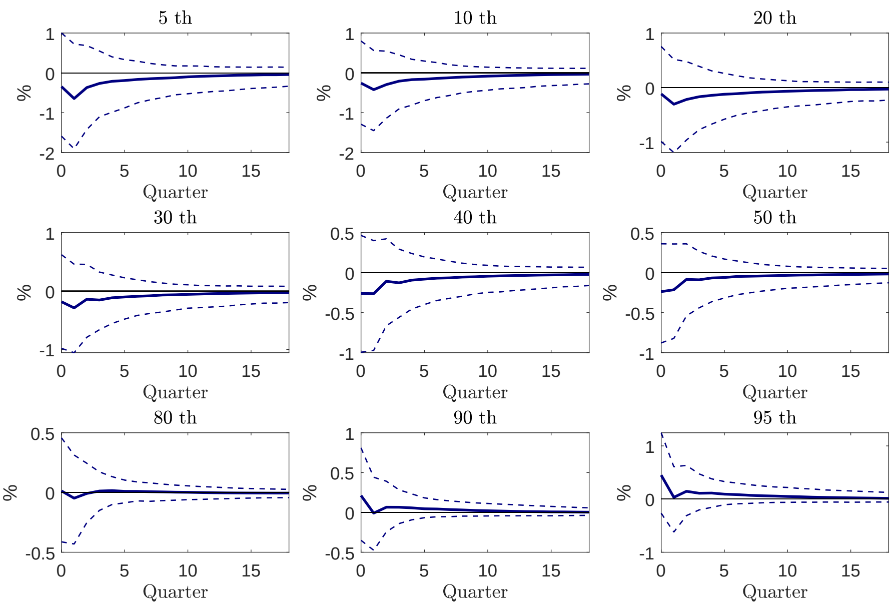


Figure 1.35: Percentile responses of income of families to a one standard deviation corporate income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

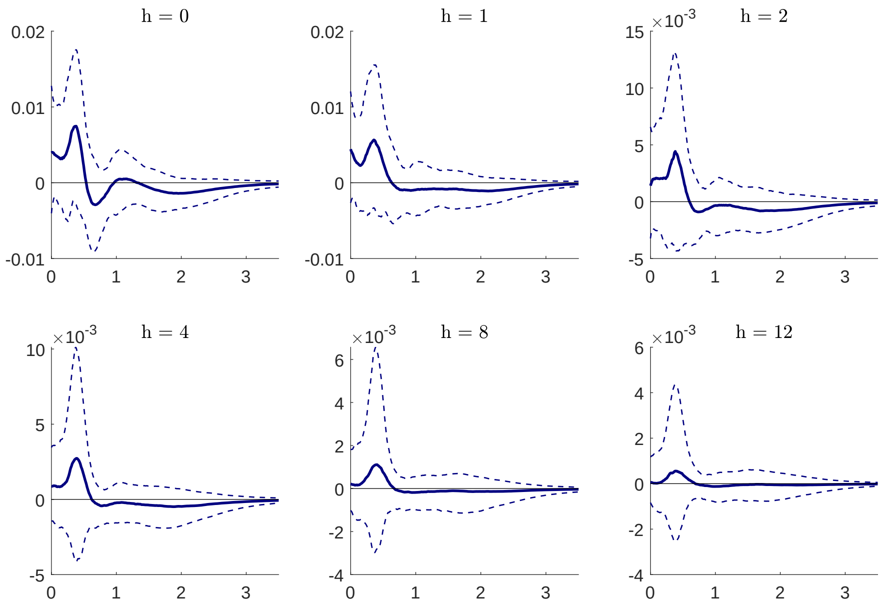


Figure 1.36: Density responses of income of non-families to a one standard deviation personal income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

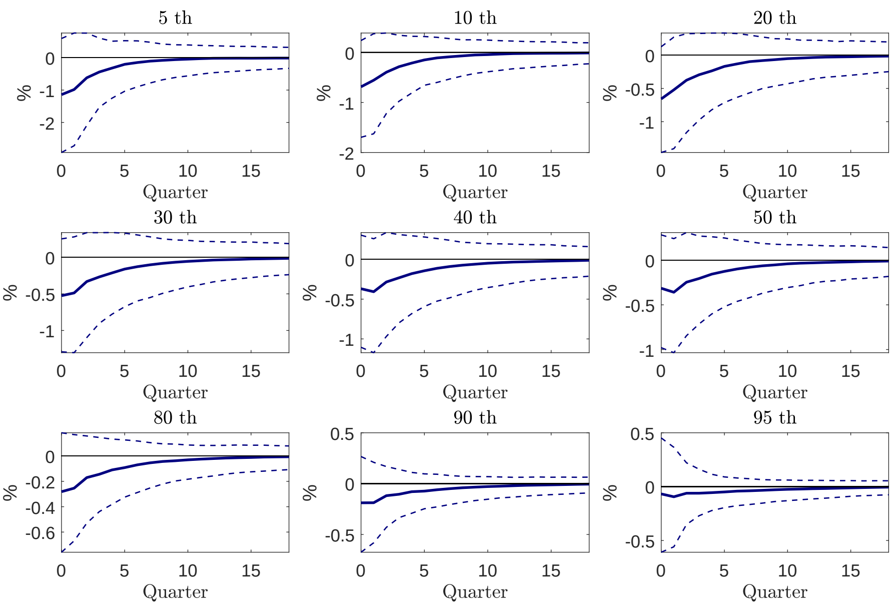


Figure 1.37: Percentile responses of income of non-families to a one standard deviation personal income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

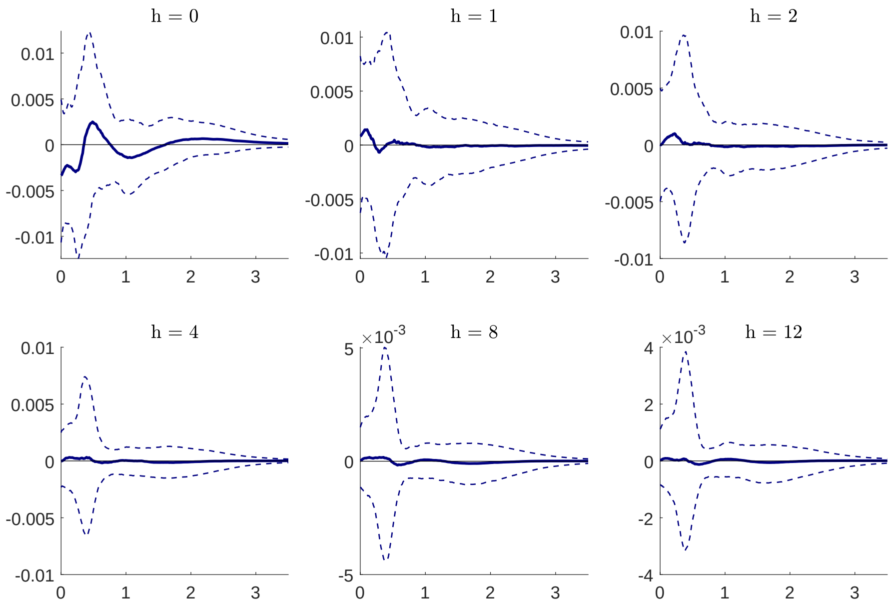


Figure 1.38: Density responses of income of non-families to a one standard deviation corporate income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

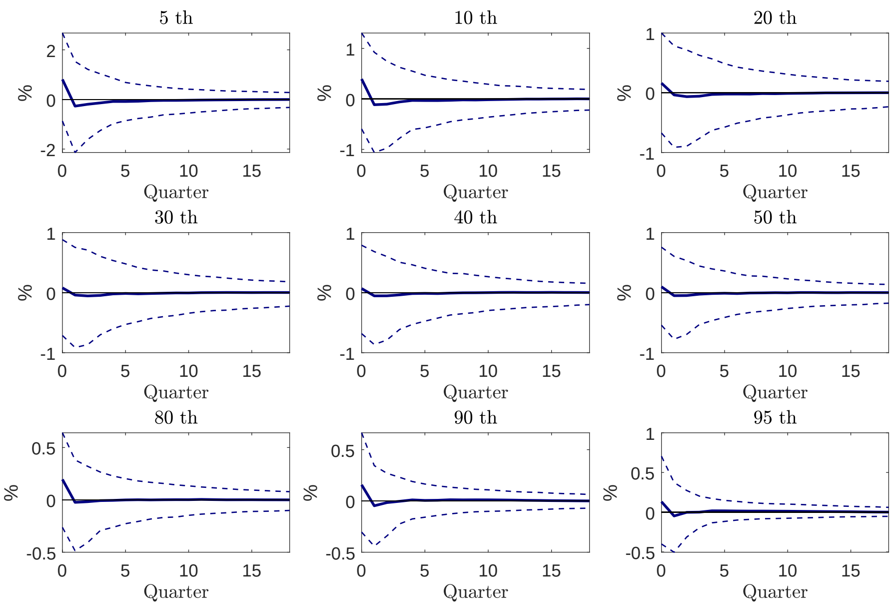


Figure 1.39: Percentile responses of income of non-families to a one standard deviation corporate income tax cut; median (blue, solid), 80-percent credible interval (blue, dashed)

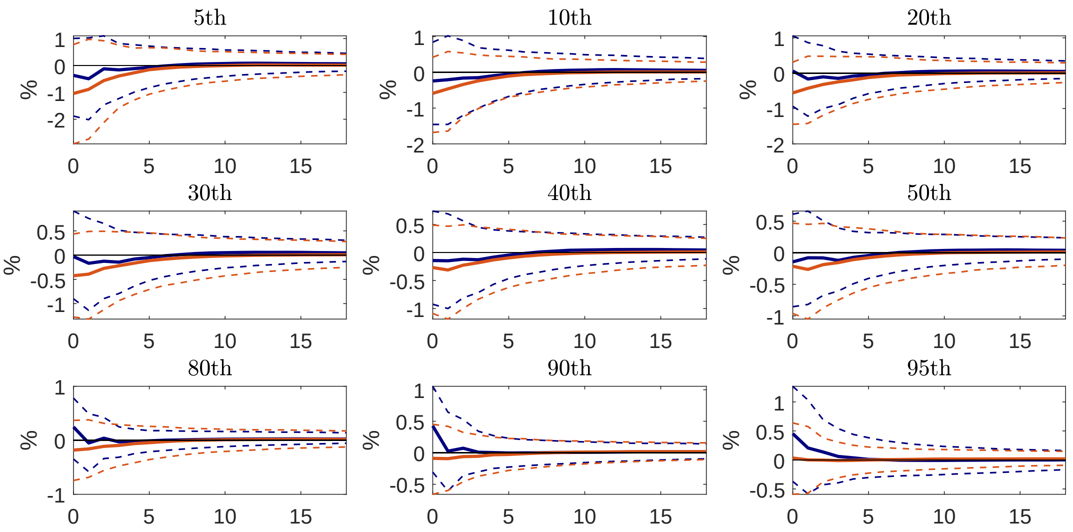


Figure 1.40: Absolute benefit from a one standard deviation personal income tax cut; income of families (blue), income of non-families (red), median (solid), 80-percent credible interval (dashed)

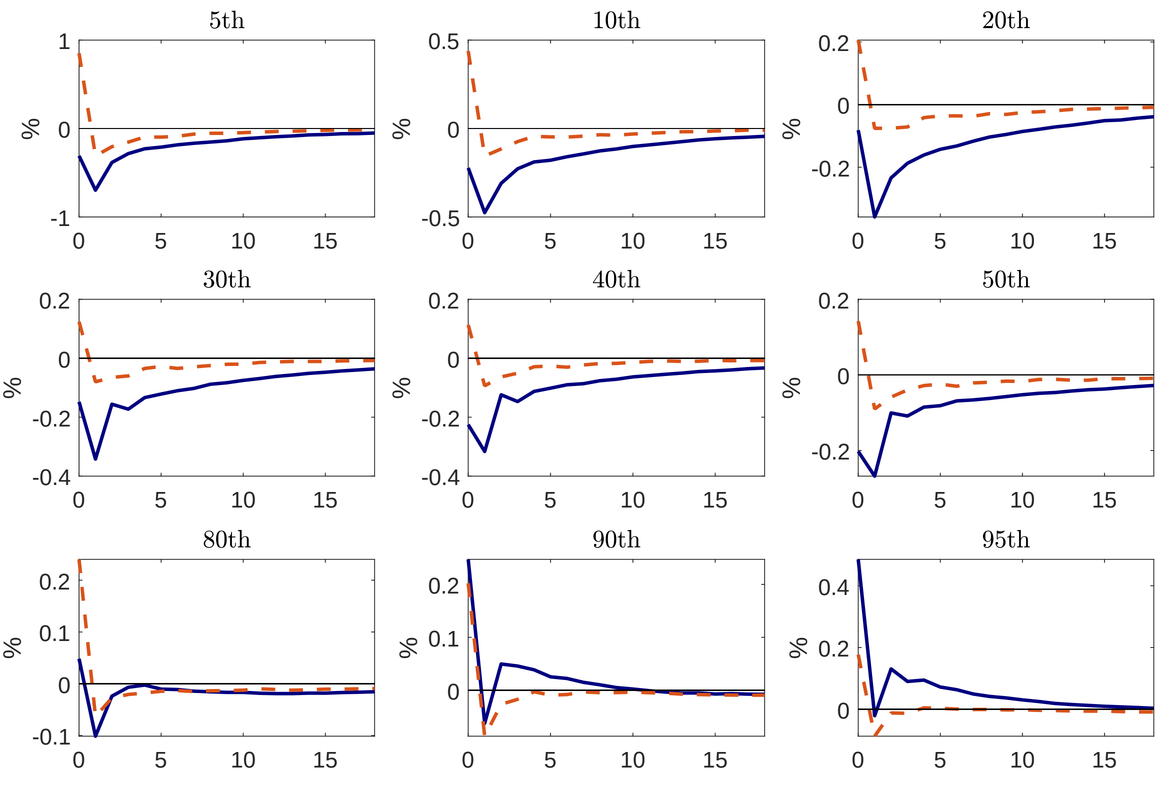


Figure 1.41: Absolute benefit from a one standard deviation corporate income tax cut computed at the median; income of families (blue, solid), income of non-families (red, dashed).

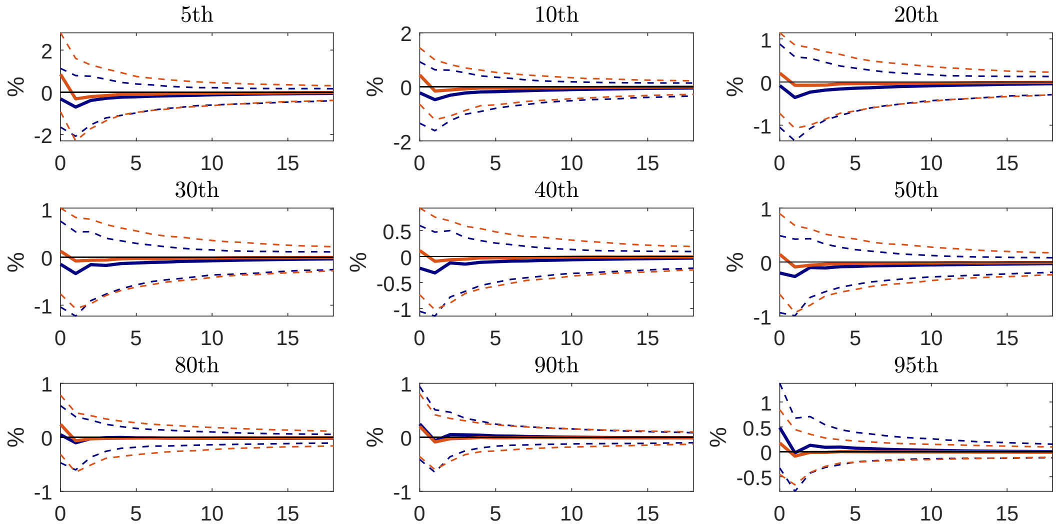


Figure 1.42: Absolute benefit from a one standard deviation corporate income tax cut; income of families (blue), income of non-families (red), median (solid), 80-percent credible interval (dashed)

1.C Tax policy narratives

This appendix collects anecdotal evidence on governmental statements accompanying the tax legislation process in the US. In particular, I study presidential speeches, the US Budget Reports, and the Economic Reports of the President. From these sources three narratives repeatedly emerge: tax changes (i) are directed toward low-income people, (ii) are pro-business, and (iii) pro-family. All sources were accessed last on September 28, 2022.

- **December 20, 1977, Jimmy Carter, Social Security Amendments of 1977 Remarks at the Bill Signing Ceremony:** This legislation is wise. It's been evolved after very careful and long preparation. It focuses the increased tax burdens, which were absolutely mandatory, in a way that is of least burden to the families of this Nation who are most in need of a sound income. The level of payments were raised for those who are wealthier in our country where they can most easily afford increased payments. In the past they've avoided the rate being applied to their much higher income than the average working family. `https://www.presidency.ucsb.edu/documents/social-security-amendments-1977-remarks-the-bill-signing-ceremony`

- **January 28, 1980, under Jimmy Carter, US Budget Fiscal Year 1981 (p. 61) on the Crude Oil Windfall Profit Tax Act of 1980:** Higher OPEC prices and the phased decontrol of domestic oil prices will result in high profits for domestic oil producers. Fairness requires that some of these windfall profits be returned to the Nation as a whole, to be used for public purposes including the reduction of oil imports, conservation of energy, and mitigation of the impact of higher energy prices on low-income Americans. The President, therefore, proposed a windfall profit tax to become effective January 1, 1980. `https://fraser.stlouisfed.org/title/budget-united-states-government-54/fiscal-year-1981-19035`

- **April 02, 1980, under Jimmy Carter on the Crude Oil Windfall Profit Tax Act of 1980:** When I proposed this tax I indicated that the revenues should be used for three basic purposes: one, to assist low-income households in bearing the burden of rapidly increasing energy costs; secondly, to improve the transit systems of our country, including not only rail but also buses and subways, and even the sharing of rides in other rubber-tired vehicles; and third, the development of alternative supplies of energy. `https://www.presidency.ucsb.edu/documents/crude-oil-windfall-profit-tax-act-1980-remarks-signing-hr-3919-into-law`

- **January 15, 1981, under Jimmy Carter, Annual Report of the Secretary of the Treasury on the State of the Finances 1980 (p. 43) on the Crude Oil Windfall Profit Tax Act of 1980:** As part of the act, increased personal and business tax subsidies are provided for conservation investments and the production of fuels from renewable and exotic sources. In addition the act contained three income tax provisions: A $200 exclusion for interest and dividends ($400 for married couples), repeal of carryover basis, and changes to last-in, first-out (LIFO) accounting rules. https://fraser.stlouisfed.org/title/annual-report-secretary-treasury-state-finances-194/annual-report-secretary-treasury-state-finances-fiscal-year-1980-5626

- **January 17 1981, under Jimmy Carter, Economic Report of the President 1981 (p. 166):** To shift additional national resources into investment, a larger than-usual share of the funds available for tax reduction will have to be devoted to investment incentives. But some other forms of tax relief are both feasible and desirable. The President's program[9] proposes three principal areas of such relief. First, individuals and employers would receive an income tax credit sufficient to offset the rise in social security taxes which took place at the start of the year. This type of tax cut was chosen because it not only would reduce tax burdens but also lower business costs and thus help modestly with our inflation problem. Second, for workers who face a growing social security tax burden but earn too little to pay income taxes, the program would expand the earned income tax credit. This would more than offset the increase in social security taxes for our lowest-paid workers. Third, the program proposes a phased reduction in the tax burden on two-earner families by reducing the so-called "marriage penalty" that taxes married couples with roughly equal incomes at rates higher than unmarried couples with the same incomes. https://fraser.stlouisfed.org/title/economic-report-president-45/1981-8152

- **February 8, 1982, under Ronald Reagan, US Budget Fiscal Year 1983 (M6/p. 11) on the Economic Recovery Tax Act of 1981:** The Economic Recovery Tax Act of 1981 is the largest, most comprehensive, and most constructive tax bill ever adopted. [...] • The penalty tax rate on investment income has been eliminated. By dropping the top rate from 70 to 50%, the attractiveness of tax shelters will be reduced and the incentives for productive investment in stocks, bonds, new business ventures, and other financial assets will be increased. Our Nation's capital will again flow to the growth of business and jobs rather than to the vendors of protection from punitive taxation. • Marginal tax rates have been significantly lowered for the first time in two decades. The 23% across-the-board rate reduction will mean $183 billion in lower taxes for individuals over the first 3 years. The financial reward for savings, work effort, and new production will stop diminishing and start rising once again. [...] • The confiscatory taxing of estates and inheritances has been halted as well. By raising the exemption to $600,000, by lowering the rate to 50%, and by removing the limits on the marital deduction, 99.7% of all estates will eventually be exempt from estate taxation. Hard-working American farmers, small businessmen, investors, and workers can once again be confident that the sweat, sacrifices, and accumulations of a lifetime will belong to their heirs rather than their Government. https://fraser.stlouisfed.org/title/budget-united-states-government-54/fiscal-year-1983-19037

[9]Refers to The Economic Revitalization Program

- **February 10, 1982, under Ronald Reagan, Economic Report of the President 1982 (p. 7) on the Economic Recovery Tax Act of 1981:** To spur further business investment and productivity growth, the new tax law provides faster write-offs for capital investment and a restructured investment tax credit. Research and development expenditures are encouraged with a new tax credit. Small business tax rates have been reduced. https://fraser.stlouisfed.org/title/economic-report-president-45/1982-8153

- **February 2, 1983, under Ronald Reagan, Economic Report of the President 1983 (p. 139) on the Economic Recovery Tax Act of 1981:** To the extent that the accelerated cost recovery system in the Economic Recovery Tax Act of 1981 reduced the tax on earnings of depreciable property, it raised the real interest rate that business borrowers are willing to pay. In addition, large budget deficits in many countries have lowered national saving rates, tending to lead to higher real interest rates worldwide. https://fraser.stlouisfed.org/title/economic-report-president-45/1983-8154

- **February 1984, under Ronald Reagan, Economic Report of the President 1984 (p. 6) on the Economic Recovery Tax Act of 1981:** The Economic Recovery Tax Act of 1981 went beyond reducing tax rates to establish important reforms in the structure of the tax system. For businesses, the Accelerated Cost Recovery System increased the after-tax profitability of investments in plant and equipment. The sharp fall in inflation has also increased after-tax profit ability. As a result, investment in business equipment has recently been quite strong despite the high real interest rates. https://fraser.stlouisfed.org/title/economic-report-president-45/1984-8155

- **October 22, 1986, Ronald Reagan, Remarks on Signing the Tax Reform Act of 1986:** And what about fairness for families? It's in our families that America's most important work gets done: raising our next generation. But over the last 40 years, as inflation has shrunk the personal exemption, families with children have had to shoulder more and more of the tax burden. With inflation and bracket-creep also eroding incomes, many spouses who would rather stay home with their children have been forced to go looking for jobs. And what of America's promise of hope and opportunity, that with hard work even the poorest among us can gain the security and happiness that is the due of all Americans? You can't put a price tag on the American dream. That dream is the heart and soul of America; it's the promise that keeps our nation forever good and generous, a model and hope to the world. For all these reasons, this tax bill is less a freedom—or a reform, I should say, than a revolution. Millions of working poor will be dropped from the tax rolls altogether, and families will get a long-overdue break with lower rates and an almost doubled personal exemption. We're going to make it economical to raise children again. Flatter rates will mean more reward for that extra effort, and vanishing loopholes and a minimum tax will mean that everybody and every corporation pay their fair share. And that's why I'm certain that the bill I'm signing today is not only an historic overhaul of our tax code and a sweeping victory for fairness, it's also the best antipoverty bill, the best profamily measure, and the best job-creation program ever to come out of the Congress of the United States. https://www.presidency.ucsb.edu/documents/remarks-signing-the-tax-reform-act-1986

- **January 29, 1987, under Ronald Reagan, Economic Report of the President 1987 (p. 21) on the Tax Reform Act of 1986:** This Act improves overall incentives for economic activity and reduces disparities in rates of taxation on different forms of economic activity. In the long run, after the transition problems of some sectors are resolved, this Act is estimated to increase net national product by approximately 2 percent. Evaluated at current levels of national income and product, this implies approximately a $600 gain in the annual income of the average American family, without any loss of Federal revenue. https://fraser.stlouisfed.org/title/economic-report-president-45/1987-8158

- **March 30, 1987, under Ronald Reagan, Annual Report of the Board of Trustees of the Federal Old Age and Survivors Insurance Trust Fund 1987 (p. 11) on the Tax Reform Act of 1986:** Other features of the Tax Reform Act, such as the elimination or restriction of several deductions and exemptions, will tend to raise contribution income as would possible favorable impacts on earnings and hours worked. Numerous other changes affecting business income and expenses for tax purposes may also affect Social Security contributions, especially from self-employed persons. https://www.ssa.gov/oact/TR/historical/1987TR.pdf

- **January 10, January 1989, under Ronald Reagan, Economic Report of the President 1989 (pp. 7–8) on the Tax Reform Act of 1986:** The Tax Reform Act of 1986 improved efficiency by eliminating many tax preferences that distort private decision-making. By reducing tax rates and tax loopholes, we have encouraged people to make money the old-fashioned way—by producing goods and services that people want, not by finding new ways to avoid taxes. The tax reforms have increased equity as well, as an estimated 4 million low-income individuals and families have been removed from the income tax rolls by 1988. https://fraser.stlouisfed.org/title/economic-report-president-45/1989-8160

- **January 10, 1989, under Ronald Reagan, Economic Report of the President 1989 (p. 63) on the Tax Reform Act of 1986:** The Tax Reform Act of 1986 did much to even effective tax rates between equipment and structures. However, tax reform raised effective corporate tax rates on business investment and removed the preferential treatment of business capital gains while retaining much of the advantage of investment in housing and consumer durables. https://fraser.stlouisfed.org/title/economic-report-president-45/1989-8160

- **January 10, 1989, under Ronald Reagan, Economic Report of the President 1989 (p. 86) on the Economic Recovery Tax Act of 1981:** The act significantly reduced the average burden of taxation for American families compared with what it would have been without a change in the tax law. https://fraser.stlouisfed.org/title/economic-report-president-45/1989-8160

- **January 10, 1989, under Ronald Reagan, Economic Report of the President 1989 (p. 87) on the The Economic Recovery Tax Act of 1981:** The provision to allow expensing of up to $5,000 worth of equipment in 1982 and 1983 is likely to have increased the return to all types of small business investment. https://fraser.stlouisfed.org/title/economic-report-president-45/1989-8160

- **January 10, 1989, under Ronald Reagan, Economic Report of the President 1989 (p. 88) on the Tax Reform Act of 1986:** The Tax Reform Act of 1986 also resulted in a somewhat higher effective marginal tax rate on capital income because it changed depreciation rules, the tax treatment of long-term capital gains, and repealed the investment tax credit. However, more uniform tax rates on alternative types of investments also resulted from a change in depreciation rules designed to improve the allocation of investment. Phasing out tax preferences such as the deduction of nonmortgage consumer interest on personal income tax returns was designed to change the allocation of private spending away from consumer durables toward business investment. https://fraser.stlouisfed.org/title/economic-report-president-45/1989-8160

- **February 6, 1992, under George Bush, Economic Report of the President 1992 (pp. 132–133) on the Tax Reform Act of 1986:** The earned income tax credit (EITC) was expanded, and along with increased personal exemptions and standard deductions, exempted more than 4 million low-income taxpayers from having to pay Federal income taxes https://fraser.stlouisfed.org/title/economic-report-president-45/1992-8163

- **February 6, 1992, under George Bush, Economic Report of the President 1992 (p. 133) on the Omnibus Budget Reconciliation Act of 1990:** The Omnibus Budget Reconciliation Act of 1990 installed a variety of tax policy changes, in addition to the spending and deficit limitations discussed in last year's Economic Report of the President. The EITC was expanded, with supplemental credits added for families with young children and for health care expenses. Statutory marginal tax rates for the highest levels of income were equalized at 31 percent. A phase-out of personal exemptions, limitations on itemized deductions, and new excise taxes levied on furs, jewelry, and expensive cars effectively raised taxes for the affluent. https://fraser.stlouisfed.org/title/economic-report-president-45/1992-8163

- **February 6, 1992, under George Bush, Economic Report of the President 1992 (pp. 138–139):** By any of a variety of measures, the income tax and Social Security reforms beginning in the late 1970s have not significantly changed the redistributional effect of the tax system. The Individual Income Tax- Tax Chart 4-7 shows estimates from the Department of the Treasury of average Federal individual income tax rates for hypothetical four-member families with the median, half the median, and double the median income level, as reported by the Bureau of the Census. Median income for 1991 was estimated on the assumption that the real level of median income would not change from its 1990 level. Families are assumed to have only wage and salary income earned by one person. Comparisons made for the same type of family over time help to isolate the effect of changes in the tax system from changes in the sources and distribution of income and in demographics. The chart shows that the Federal individual income tax is progressive in each of the years because the average tax rate rises with income. In 1991, for example, the average estimated income tax rate rises from 5.1 for families with half the median income to 15.1 for families with twice the median income. The average Federal income tax rate has fallen since 1980 for all three groups. The percentage change in average tax rates between 1980 and 1991 was virtually the same at all three relative income levels. `https://fraser.stlouisfed.org/title/economic-report-president-45/1992-8163`

- **February 6, 1992, under George Bush, Economic Report of the President 1992 (pp. 140–141):** CBO estimates in Table 4-4 indicate that the share of all Federal taxes paid by the highest income groups has increased since 1977, while the share paid by middle and lower income families has fallen. Thus, data developed separately by the Treasury Department and the Congressional Budget Office indicate that the Federal individual income tax and the overall Federal tax system redistribute income from high-income households to low-income households and thus are progressive. The degree of progressivity of, and the amount of redistribution within, the tax system has not changed significantly since the mid-1970s. `https://fraser.stlouisfed.org/title/economic-report-president-45/1992-8163`

- **February 7, 1994, under Bill Clinton, US Budget Fiscal Year 1995 (p. 4) on the Omnibus Budget Reconciliation Act of 1993:** In addition to budget discipline, we made dramatic changes that restored fairness to the tax code. We made the distribution of the income tax burden far more equitable by raising income tax rates on only the richest 1.2 percent of our people—couples with income over $180,000—and by substantially increasing the Earned Income Tax Credit for 15 million low-income working families. Thus, nearly 99 percent of taxpayers will find out this year that their income tax rates have not been increased. `https://fraser.stlouisfed.org/title/budget-united-states-government-54/fiscal-year-1995-19045`

- **February 7, 1994, under Bill Clinton, US Budget Fiscal Year 1995 (p. 56) on the Omnibus Budget Reconciliation Act of 1993:** In addition to these and some smaller tax increases, OBRA-93 also contained a number of tax incentives. Expansion of the earned income tax credit (EITC) is one of the most important anti-poverty actions in recent history; when fully phased in, the increased EITC plus food stamps will lift from poverty families with children where at least one parent works full time. The EITC expansion is also a major step toward welfare reform - by making work pay. • Small businesses received important tax incentives. The expensing allowance for investment, especially important for small business, was substantially increased. A targeted capital gains provision for new small businesses was enacted. The deduction for health insurance premiums of the self-employed was extended. • Extension of the credit for research and experimentation encourages technological advancement. Alternative minimum tax relief was provided for business investment depreciation. • Empowerment Zones were enacted for the first time, to help in the renewal of targeted urban and rural areas. The low-income housing credit, mortgage revenue bonds, and small-issue industrial development bonds were made permanent. `https://fraser.stlouisfed.org/title/budget-united-states-government-54/fiscal-year-1995-19045`

- **February 7, 1994, under Bill Clinton, US Budget Fiscal Year 1995 (p. 58) on the Omnibus Budget Reconciliation Act of 1993:** Fairness in OBRA-93. OBRA-93 achieved the Administration's objective of placing the heaviest tax burden on those most able to carry it, while lightening the load on those least able to pay. As a result, the tax system is more progressive than at any time since 1977, according to the Congressional Budget Office (CBO). OBRA-93 provisions affecting taxes are outlined above. The distributional impact of these and other provisions is shown in Table 2-1. Whether measured by the change in average taxes, the share of total new taxes raised, or the change in effective tax rates, the message is the same: The tax system has been made fairer. • At the top of the income distribution, families with $200,000 or more in annual income (1.3 percent of all families) will pay on average about $23,500 in additional taxes per family, according to CBO estimates. In total, they will pay 80 percent of the taxes raised by OBRA-93 ($33 billion out of $41 billion). The effective tax rate for the average family in this upper income bracket is likely to increase from about 28 percent to almost 33 percent. • Families with $100,000 to $200,000 in income (5.2 percent of all families) will pay on average about $650 more in taxes, raising their effective tax rates by one-half of one percentage point. In aggregate, they will pay about $3.6 billion more in taxes. Thus, families with incomes over $100,000 will shoulder about 90 percent of the taxes raised by OBRA-93. • Families with $30,000 to $100,000 in annual income will pay only slightly more in taxes, ranging on average from $50 for families at the low end of this range, to $312 for those nearer the top. The effective tax rates for families in this range will be increased by only a few tenths of a percentage point. • Families with incomes below $30,000 will have their tax payments lowered on aver-age $41 to $86 per year for a total decrease of $3.3 billion—due largely to the historic increase in the earned income tax credit. The effective tax rates for families with incomes below $20,000 will be lowered by about one-half to one percentage point. In other words, those at the low end of the income distribution will be better off because of OBRA-93. (See Chart 2-1.) Low and middle-income families are still protected by inflation indexing of the income tax rate brackets. `https://fraser.stlouisfed.org/title/budget-united-states-government-54/fiscal-year-1995-19045`

- **February 14, 1994, under Bill Clinton, Economic Report of the President 1994 (p. 34) on the Omnibus Budget Reconciliation Act of 1993:** Finally, OBRA93 increased the top corporate tax rate and closed a variety of business tax loopholes, but also enhanced or created several tax incentives for investment. The net effect of these increases and decreases in business taxes should yield about $8 billion in revenue by fiscal 1998. `https://fraser.stlouisfed.org/title/economic-report-president-45/1994-8093`

- **February 1, 1995, under Bill Clinton, US Budget Fiscal Year 1996 (p. 34) on the Omnibus Budget Reconciliation Act of 1993:** OBRA also included tax incentives to make the tax system fairer. It expanded the EITC—which, as discussed in Chapter 1, guarantees that any family with children and at least one parent who works full time eventually will rise above the poverty line. Today, the tax system is more progressive than at any time in 18 years. `https://fraser.stlouisfed.org/title/budget-united-states-government-54/fiscal-year-1996-19046`

- **February 13, 1995, under Bill Clinton, Economic Report of the President 1995 (p. 22) on the Omnibus Budget Reconciliation Act of 1993:** The Administration's first response to the dwindling income prospects of many working Americans took the form of a substantial expansion of the earned income tax credit (EITC). The EITC expansion, included in the Omnibus Budget Reconciliation Act of 1993 (OBRA93), increased the after-tax incomes of over 15 million American workers and their families. The EITC is a refundable tax credit that provides a bonus to eligible low-income workers—a bonus that can amount to over $3,000 a year for a family with two children. Through the EITC these workers may realize after-tax incomes well in excess of their wages. `https://fraser.stlouisfed.org/title/economic-report-president-45/1995-8094`

- **August 5, 1997, Bill Clinton, Statement on Signing the Balanced Budget Act of 1997:** These bills will balance the budget in a way that honors our values, invests in our people, and cuts taxes for middle-class families. They are a victory for all parents who want a good education for their children and for all families working to build a secure future. This package is the best investment we can make in America's future, and it prepares our Nation for the 21st century. [. . .] First, it strengthens our families by extending health insurance coverage to up to 5 million children. By investing $24 billion, we will be able to provide quality medical care for these children—everything from regular check-ups to major surgery. I want every child in America to grow up healthy and strong, and this investment takes a major step toward that goal. I am also pleased that the Congress agreed to pay for this investment in our Nation's children in part with a 15-cents-a-pack tax increase on cigarettes. `https://www.presidency.ucsb.edu/documents/statement-signing-the-balanced-budget-act-1997`

- **May 16, 2001, under George W. Bush, Statement Of Administration Policy - (House) - (Rep. Thomas (R) California):** By reducing marginal tax rates, this bill would reduce the penalty on work, savings, and investment, begin the process of providing much needed immediate tax relief to the American people, and lay a foundation for further long-term economic growth. No one should be forced to pay more than a third of what they earn in taxes. In fact, 77 percent of the tax relief associated with cutting the top rate in H.R. 1836 would go to small business owners and entrepreneurs - the engines of growth in our economy. https://www.presidency.ucsb.edu/documents/statement-administration-policy-hr-1836-economic-growth-and-tax-relief-reconciliation-act

- **June 07, 2001, George W. Bush, Remarks on Signing the Economic Growth and Tax Relief Reconciliation Act of 2001:** Some months ago, in my speech to the joint session of Congress, I had the honor of introducing Steven Ramos to the Nation. Steven is the network administrator for a school district. His wife, Josefina, teaches at a charter school. They have a little girl named Lianna, and they're trying to save for Lianna's college education. High taxes made saving difficult. Last year they paid nearly $8,000 in Federal income taxes. Well, today we're beginning to make life for the Ramos' a lot easier. Today we start to return some of the Ramos' money and not only their money but the money of everybody who paid taxes in the United States of America. [...] With us today are 15 of the many families I met as I toured our country making the case for tax relief—hard-working Americans. I was able to talk about their stories and their struggles and their hopes, which made the case for tax relief much stronger than my words could possible convey. [...] Tax relief is an achievement for families struggling to enter the middle class. For hard-working lower income families, we have cut the bottom rate of Federal income tax from 15 percent to 10 percent. We doubled the per-child tax credit to $1,000 and made it refundable. Tax relief is compassionate, and it is now on the way. Tax relief is an achievement for middle class families squeezed by high energy prices and credit card debt. Most families can look forward to a $600 tax rebate before they have to pay the September backto-school bills. And in the years ahead, taxpayers can look forward to steadily declining income tax rates. Tax relief is an achievement for families that want the Government tax policy to be fair and not penalize them for making good choices, good choices such as marriage and raising a family. So we cut the marriage penalty. Tax relief makes the code more fair for small businesses and farmers and individuals by eliminating the death tax. Over the long haul, tax relief will encourage work and innovation. It will allow American workers to save more on their pension plan or individual retirement accounts. Tax relief expands individual freedom. The money we return, or don't take in the first place, can be saved for a child's education, spent on family needs, invested in a home or in a business or a mutual fund or used to reduce personal debt. [...] This tax relief plan is principled. We cut taxes for every income-tax payer. We target nobody in; we target nobody out. And tax relief is now on the way. https://www.presidency.ucsb.edu/documents/remarks-signing-the-economic-growth-and-tax-relief-reconciliation-act-2001

- **February 5, 2002, under George W. Bush, Economic Report of the President 2002 (p. 45) on the Economic Growth and Tax Relief Rec-**

onciliation Act of 2001: In short, the President delivered important tax relief in 2001, providing a solid foundation for renewed growth in consumer spending once confidence rebounds, and for an improved investment climate for businesses. The boost in aggregate demand should help provide a foundation for economy-wide recovery in 2002. `https://fraser.stlouisfed.org/title/economic-report-president-45/2002-8101`

- **February 15, 2002, under George W. Bush, Council of Economic Advisers' Report on the Economic Growth and Tax Relief Reconciliation Act of 2001:** In 2010 the estate tax will be eliminated. Small businesses have benefited from the lowering of individual income tax rates for owners of flow-through business entities such as sole proprietorships and partnerships. In 1998 there were close to 24 million flow-through businesses in the United States, including 17.1 million sole proprietors, 2.1 million farm proprietorships, 1.9 million partnerships, and 2.6 million S corporations. By 2006, when the tax cut will be fully phased in, the Treasury Department estimates that over 20 million tax filers with income from flow-through entities will receive a tax reduction. Finally, the President's tax cut strengthened families and has reduced the burden of financing education. `https://www.presidency.ucsb.edu/documents/council-economic-advisers-report`
- **May 9, 2003, under George W. Bush, STATEMENT OF ADMINISTRATION POLICY, (House), (Rep. Thomas (R) California and 52 sponsors), Statement of Administration Policy: H.R. 2 - Growth and Jobs Tax Act of 2003:** H.R. 2 accelerates the reductions in individual income tax rates that were enacted in the Economic Growth and Tax Relief Reconciliation Act of 2001 but that are not scheduled to take effect for some years. The legislation similarly accelerates the 2001 Act's increase in the child credit and its reduction of the marriage penalty. The legislation also increases small business expensing and significantly reduces the double taxation of dividends. This bill is a strong and positive step forward that will help the economy create new jobs today while permanently raising the wages and living standards of American workers now and in the future. `https://www.presidency.ucsb.edu/documents/statement-administration-policy-hr-2-growth-and-jobs-tax-act-2003`
- **May 28, 2003, George W. Bush, Remarks on Signing the Jobs and Growth Tax Relief Reconciliation Act of 2003:** We are helping workers who need more take-home pay. We're helping seniors who rely on dividends. We're helping small-business owners looking to grow and to create more new jobs. We're helping families with children who will receive immediate relief. By ensuring that Americans have more to spend, to save, and to invest, this legislation is adding fuel to an economic recovery. We have taken aggressive action to strengthen the foundation of our economy so that every American who wants to work will be able to find a job. [...] The Jobs and Growth Act reduces Federal income taxes across the board. And today the Internal Revenue Service will post new withholding tax tables so that employers can begin leaving more

money in the paychecks of American workers, starting next month. The Jobs and Growth Act increases the per-child tax credit from $600 to $1,000. So today I'm directing the Department of Treasury to issue checks of up to $400 per child to 25 million eligible families. And those checks will begin arriving in July. This combination of income-tax rate reductions, a higher child credit, and a reduction in the marriage penalty will make a difference for families in every part of this country. A family of four with a total income of $75,000 will receive a 19-percent reduction in Federal income taxes, saving $1,122 per year, per family. A family of four with an income of $40,000 will see their income taxes drop from $1,178 to $45, a 96-percent tax cut. And under this new law, 3 million individuals and families will have their Federal income-tax liability completely eliminated. Altogether, 34 million families with children, including 6 million single moms, will receive an average tax cut of $1,549 per year. Tax relief matters a lot to the average citizen here in America. This tax bill will make it easier for moms and dads to save for their children's education, and that's vitally important for the future of this country. The benefits of the Jobs and Growth Act will also go to investors. The top capital gains tax rate will be reduced by 25 percent, which will encourage more investment and risk taking, and that will help in job creation. The bill also allows for dividend income to be taxed at a lower rate. This will encourage more companies to pay dividends, which in itself will not only be good for investors but will be a corporate reform measure. It's hard to pay dividends unless you've actually got cashflow. The days when people could say, "Invest with me because the sky's the limit," will be changed by dividend policy. It's hard to promote the sky being the limit and pay dividends unless you're actually profitable and have cashflow. Getting—reducing the tax rate on dividends will also increase the wealth effect around America and will help our markets. And the good news is, a lot of senior citizens rely on dividend income to meet their daily needs, and under this legislation, 12 million seniors will receive an average tax reduction of $1,401. We're delivering substantial tax relief to small-business owners and entrepreneurs. Most small-business owners are Subchapter S—own Subchapter S corporations or sole proprietorships or limited partnerships, so the small business pays taxes at the individual tax rate. By cutting individual tax rates and by delivering other incentives for investment in new equipment, 23 million small-business owners will receive an average tax cut of $2,209. `https://www.presidency.ucsb.edu/documents/remarks-signing-the-jobs-and-growth-tax-relief-reconciliation-act-2003`

- **July 24, 2003, under George W. Bush, Fact Sheet: President Visits Philadelphia to Discuss Economy and Child Tax Credit, Background: Jobs and Growth Tax Relief Reconciliation Act of 2003:** On May 28, 2003, President Bush signed the Jobs and Growth Tax Relief Reconciliation Act of 2003, an enormous victory for American workers, American families, American investors, and American entrepreneurs and small businesses. This law will enable the American people and small businesses to keep more of their own money. The more money families and small businesses have to save and invest, the more likely it is that people looking for work will find a job. `https://www.presidency`

.ucsb.edu/documents/fact-sheet-president-visits-philadelphia-discuss-economy-and-child-tax-credit

- **January 30, 2004, under George W. Bush, Economic Report of the President 2004 (pp. 44–45) on the Jobs and Growth Tax Relief Reconciliation Act of 2003 and other tax cuts:** The tax cuts provided further stimulus by increasing incentives for business investment. Some of these incentives came in the form of bonus depreciation for business investment, an expansion in the amount of expensing of investment available for small businesses. [...] The 2003 tax cut (JGTRRA)[10] raised the bonus depreciation to 50 percent of the price of new equipment and extended the period of eligibility so that investments made by the end of 2004 would be covered. It also increased the cap on small-business expensing from $25,000 to $100,000 per year through 2005, effectively lowering the cost of investment for small businesses. These tax changes lowered firms' cost of capital and likely provided support for investment at a crucial time. The tax cuts also reduced the cost of capital and increased incentives for business investment by lowering tax rates on personal capital income. The 2001 tax cut (EGTRRA)[11] phased out the estate tax and reduced marginal tax rates on all forms of income. These steps lowered the tax burden on capital income received from corporations and also on income received through sole proprietorships, partnerships, and S corporations (corporations for which income is taxed through individual tax returns). [...] According to one study, the cut in taxes on capital income in the 2003 tax package (JGTRRA) reduced the marginal effective total tax rate on income from corporate investment by 2 to 4 percentage points. Lower taxes on dividends and capital gains also move the tax system toward a more equal treatment of debt and equity, of dividends and capital gains, and of corporate and noncorporate capital. This move increases economic efficiency because it promotes the allocation of capital based on business fundamentals rather than a desire for tax avoidance. https://fraser.stlouisfed.org/title/economic-report-president-45/2004-8103

- **February 2, 2004, under George W. Bush, US Budget Fiscal Year 2005 (p. 33) on the Jobs and Growth Tax Relief Reconciliation Act of 2003:** Enabling Families and Businesses to Plan for the Future with Confidence. America's families and businesses need certainty to plan effectively for the future. And while the future holds many uncertainties, Government policies should not needlessly add to them. Right now, key elements of the tax relief passed by the Congress and signed into law by President Bush—including the increase in the child tax credit, the marriage penalty relief, and the increased incentives for small business investing—will expire in a few years. For example, a married couple with two children and an annual income of $40,000 would face a $922 tax increase in 2005 if the provisions of the Jobs and Growth Act are not made permanent. This family needs to know today that it will have that $922 in 2005 for its own needs, not the Government's. President Bush urges the Congress to make these vital tax

[10] Refers to the Job Creation and Worker Assistance Act
[11] Refers to the Economic Growth and Tax Relief Reconciliation Act

reductions permanent. https://fraser.stlouisfed.org/title/budget-united-states-government-54/fiscal-year-2005-19051

- **February 2, 2004, under George W. Bush, US Budget Fiscal Year 2005 (p. 333) on the Jobs and Growth Tax Relief Reconciliation Act of 2003:** The Jobs and Growth Tax Relief Reconciliation Act of 2003 provided major benefits for small business: • Small business owners receive 79 percent—about $9.7 billion—of the tax relief from accelerating (from2006 to 2003) the reduction in the top income tax bracket to 35 percent. • The amount of investment eligible for expensing quadruples—to $100,000—beginning in 2003 for firms with investments less than $400,000. This provides a large tax saving and investment incentive, and also reduces record-keeping burdens. https://fraser.stlouisfed.org/title/budget-united-states-government-54/fiscal-year-2005-19051

CHAPTER 2

Fatal Austerity: The Economic Consequences of Heinrich Brüning

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2.1 Introduction

Faced with crushing reparation obligations from World War I, alongside rising unemployment and dwindling GDP due to the Great Depression, as well as the need to stay on the gold standard, Heinrich Brüning, Germany's Chancellor from March 30, 1930, to May 30, 1932, opted for deflation and implemented, via presidential decrees, one of modern history's most extreme series of tax increases and cuts in government spending and transfers. Although economic hardship spurred political radicalization in the already conflict-laden Weimar Republic, politically isolated Brüning was determined to implement his harsh belt-tightening policies. When Brüning was forced to resign in July 1932, the German Nazi party, who had campaigned heavily against Brüning's austerity course and exploited mass frustration, had already gathered enough momentum to consolidate and even enhance their widely unexpected election result of 18.3 percent in September 1930: In the parliamentary elections of July 1932 the Nazi party scored strongest. From then, it was only half a year before Adolf Hitler was sworn in as Germany's new chancellor in January 1933.

Surprisingly, even today, the macroeconomic consequences of Brüning's austerity measures at this momentous turning point in history rests merely on anecdotal evidence, otherwise overlooked by economists. This paper aims to close this gap and quantifies, for the first time, the macroeconomic effects of Brüning's austerity measures. The backbone of our empirical approach is the narrative identification of the austerity shock instrument variable and a newly constructed monthly dataset on historical government finances and macroeconomic time series. With these ingredients, we determine, in a vector autoregressive model (VAR), the causal effects of Brüning's belt-tightening policy.

We use the vast historical record of Brüning's fiscal policy decisions to derive an austerity shock instrument, extending the narrative line of austerity research started by Guajardo et al. (2014) and Alesina et al. (2018, 2019). Primary and secondary sources uniformly delineate Brüning's budget cuts and tax increases as exogenous policy actions, driven either by his political aspiration to end Germany's reparation payments (Holtfrerich, 1982; Büttner, 1989; Evans, 2003, among others), or by his intent to please Germany's debtors to ensure the country's access to foreign credits (Borchardt, 1979; James, 1986; Ritschl, 2002b, 2016). The five austerity decrees issued between July 1930 and December 1931 by Brüning provide us a quasi-experiment for an exogenous austerity intervention during a period when Germany's economy was in a recession state. We exploit the knowledge on the direction and the timing of these shocks to construct an austerity shock instrument variable in the spirit of Romer and Romer (1989), Ramey and Shapiro (1998), Budnik and Rünstler (2020), and Boer and Lütkepohl (2021). As we take into account the announcement and implementation date of each austerity decree, our shock instrument safeguards our identification against any econometric concerns related to fiscal foresight effects (Ramey, 2011; Mertens and Ravn, 2012; Leeper et al., 2013).

For the period April 1927 to February 1935, we construct a granular, monthly dataset of German federal government spending and tax revenues. We employ a range of statistical publications to decompose the total budget numbers into consistent categories over time. The expenditure side is disaggregated into nine categories, among them social transfers, transfers to federal states, spending related to debt, or reparation payments. The revenue side consists of four categories, among them capital income, taxes, duties, and levies. A data contribution in itself, the monthly frequency of our dataset and the budget decomposition constitute a crucial prerequisite for a clean identification of the causal effects of Brüning's austerity. In an economic turbulent time, like during Brüning's term of office, in which fiscal policy did not follow the regular budgeting process, but implemented impulsively by emergency decrees, only monthly data allow us to set the austerity shock observations' timing precisely. The granular structure of our dataset enables us to construct government spending and tax revenue variables free of budget items moving with the business cycle, thus strengthening the relevance of our austerity shock instrument.
Monthly macroeconomic data, like prices or interest rates for Germany's interwar period, is published in Wagemann (1935). We digitized the entire compendium, including more than 500 time series, releasing this source together with the detailed budget accounts for future research that goes beyond the contribution of our study.

Our findings speak a clear language in the sense that the estimates suggest that austerity aggravated the Great Depression. We show that Brüning's austerity policy decreased German GDP per capita by 4.46 percent relative to total GDP in 1932, a loss that corresponds to 239 percent of all reparations Germany paid in 1930. As 1930 is the year in which Germany paid the highest amount of reparations during the interwar period, our results confirm what economic historians have assumed for decades without empirical evidence - Brüning's austerity policy was indeed detrimental for the German economy and gave the already crisis-shaken economic system an additional blow. Quantifying the effects of the austerity measures' in terms of unemployment paints the same grim picture. Between March 1930 and May 1932, 3.31 million people, or nine percent of Germany's average monthly labor force of 1932, lost their jobs due to Brüning's belt-tightening.

Research on fiscal policy, is a highly active field and our paper relates to a large literature. Unlike Alesina et al. (2012), Fetzer (2019), Galofré-Vilà et al. (2021), or Ponticelli and Voth (2020), who study the political costs of austerity, or Bianchi et al. (2019), and Born et al. (2020), who examine the relation between austerity and sovereign risk, we focus on the effects of austerity on macroeconomic outcomes like GDP and unemployment. Our study of Brüning's belt-tightening during the Great Depression also relates to the literature that investigates the state-dependent effects of fiscal policy and can be seen as an empirical case study on the effects of fiscal consolidations in a recession state. Barro and Redlick (2011) allow for the possibility that fiscal policy has different effects during times of high unemployment, but find no significant differences between high and low unemployment states. Owyang et al. (2013) and Ramey and Zubairy (2018), using a military news variable for the US to identify fiscal policy shocks, also find no systematically different fiscal multipliers during normal times versus times of economic slack. On the other hand, Auerbach and Gorodnichenko (2012) and Auerbach and Gorodnichenko (2013) find evidence for larger multipliers during recessions than expansions. Similarly, Jordà and Taylor (2016) investigate whether fiscal consolidations have larger effects on aggregate output if undertaken during boom or slump periods in an annual panel of OECD countries. Their findings suggest that when the economy is in a slump, fiscal consolidations lead to significantly larger output losses.

Empirical investigations on the role of fiscal policy during the Weimar Republic have a long tradition. Cohn (1992), by using annual budget data, show that between 1929 and 1932 fiscal policy became more restrictive with every year. Borchardt (1979) argues prominently that Brüning lacked the means and political backing to effectively combat the economic slump. His hypothesis is complemented by the conclusions drawn in Borchardt and Ritschl (1992), who build their empirical analysis on annual data. Fisher and Hornstein (2002) investigate fiscal policy during the Great Depression in a neoclassical growth model. Their analysis gives fiscal policy an important role inc causing Germany's economic downturn. Ritschl (2013) evaluates Germany's macroeconomic performance between 1924 and 1938 in a time-varying VAR model framework and focuses on the transfer problem. Our study contributes not only a new monthly data source for the Weimar Republic, but is also the first to quantify the economic consequences of Brüning's drastic austerity policy.

The remainder of this paper is structured as follows. Section 2 delineates the historical background. Section 3 describes our new data and our empirical strategy. The results are presented in Section 4. Section 5 concludes.

2.2 Historical setting: Brüning's chancellorship

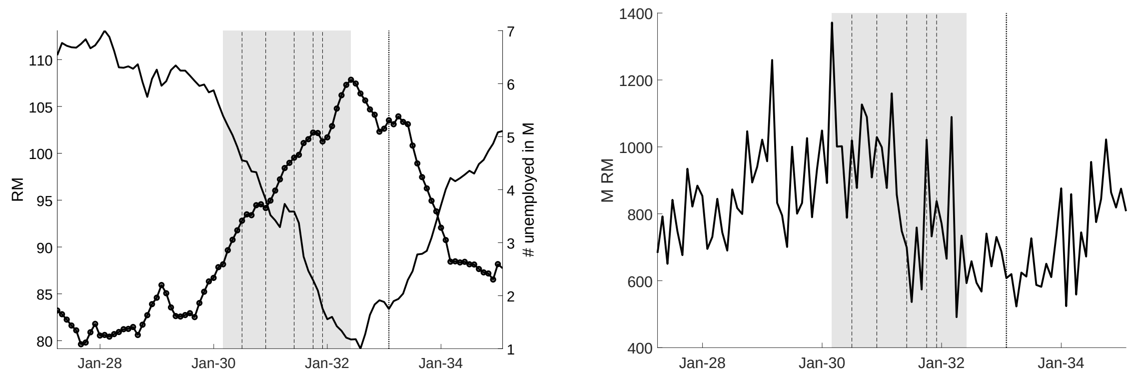
Wait a while and just you'll see,
And Brüning will come up to you
With the ninth emergency decree
And make mincemeat out of you.
(German nursery rhyme, cited in Evans (2003))

Political and economic realities were gloomy when Brüning, a conservative, patriotic veteran of World War I and member of the Catholic Centre Party, was appointed chancellor of Weimar Republic on March 30, 1930. Instability and gridlock had already brought down 16 governments in the 12 years of the young German democracy. Hitler and his Nazi Party had become acceptable and was fueling the political radicalization in the country. Soon, in the parliamentary elections of September 1930, they would poll in second place and rise to become the strongest party within two years. Further, even from the inside, the constitutional system was threatened by President Hindenburg's tense relation to the parliament and his aspiration to restore Germany's standing in Europe after World War I.

Additionally, in terms of economic conditions, Brüning faced some difficult headwinds. The 1919 Treaty of Versailles required Germany to accept full responsibility for causing the war. In later negotiations, the allies set Germany's reparation debt to 132 billion Goldmark. Although Germany's reparation payments were eased in 1924 by the Dawes Plan, and even reduced in 1929 by the Young Plan to 114 billion Reichsmark to be paid till 1988, reparations were limiting Germany's financial scope (Borchardt, 1979; Feldman, 2005; Ritschl, 2013).[1]
Already in 1928, one year before the stock market crash in New York, German economic activity had lost momentum. Concerned by the ever rising US stock market, the Federal Reserve shifted to a tighter monetary policy, with consequences for Germany. US investors, who provided since 1924 an important fraction of capital to Germany's large-scale enterprises and public sector, reacted to the increase in US interest rates and reduced foreign lending (Eichengreen, 2015). Only four years after the hyperinflation, raising capital by issuing bonds denominated in Reichsmark was still difficult due to the lacking confidence in the currency and could not completely substitute the ceased foreign credit. As a consequence, economic activity in Germany slowed and unemployment rose (Figure 2.1, panel a). During the winter season 1928/29, two million Germans were already out of work. When Brüning finally took office in March 1930, the German economy was shaken by the turmoil of the Great Depression. It certainly did not help that German monetary policy was by any means capable of taking an accommodative stance to boost the economy. Constrained by the gold standard, the fear of further international capital withdrawals and depleting reserves forced the Reichsbank regularly to raise the discount rate.

During his term in office, from March 30, 1930, to May 30, 1932, Brüning was head of two minority governments comprising mostly conservative ministers. The previous government, the grand coalition under Herrmann Müller, already broke up due to

[1] In comparison, Germany's GNP in 1929 was at 88.448 billion Reichsmark (Ritschl, 2002b).



(a) German real GDP per capita in Reichsmark (RM)(left y-axis, bold line) and seasonal-adjusted unemployment in million (right y-axis, bold line with circles). Data sources: GDP: Albers (2018); unemployment: Humann (2011).

(b) German total budget expenditures in million Reichsmark. Data source: Authors' series.

Figure 2.1: GDP, unemployment, and total budget expenditures between April 1927 and February 1935. The grey-shaded area marks Brüning's term in office. The announcement of Brüning's austerity decrees (July and December of 1930, and June, October, and December of 1931) is indicated by the dashed lines. The dotted line marks January 1933, when Hitler became Chancellor.

economic policy disagreements. In the first days of Brüning's chancellorship, economic topics set the agenda, creating disaccord in parliament. Not even 48 hours in office, in his first government declaration on April 1, 1930, Brüning signaled the parliament that he was willing to exploit all constitutional means to push through his vision of an adequate economic policy.[2] Affirmed by President Hindenburg's support, Brüning routinely circumvented finding parliamentary majorities, by basing his governance on presidential emergency decrees. Further, as his harsh austerity policy at the height of the Great Depression in Germany was extremely unpopular, facing major pushback from both the general public and the parliament, they were implemented exclusively by emergency decree.

Brüning's austerity decrees Brüning implemented his austerity course through a total of five emergency decrees. Panel b of Figure 2.1 shows the timing of the austerity decrees and the decline in government expenditures during Brüning's term in office. Total expenditures in fiscal year 1931/1932 were, on average, 22 percent lower than in the previous fiscal year:[3]

July 26, 1930: The emergency decree announced in late July 1930 was the first in a series of extreme spending cuts and tax rises. It introduced, among others, an additional income tax on workers in the public sector (the so-called Reichshilfe - "federal

[2]cf. Reichstagsprotokolle, 1928/30, p. 4730

[3]A fiscal year extends from April 1 to March 31 the following year. For instance, the fiscal year 1930/1931 goes from April 1930 to March 1931.

support") and established stricter entitlement criteria for social benefits. In addition, contributions to unemployment insurance were raised.[4]

Four additional emergency decrees followed:[5]
December 1, 1930: The decree imposed further salary and pension cuts on civil servants, and reduced unemployment and health insurance benefits. Additionally, rates of existing taxes were increased, including income tax, and new taxes, like a beer tax or the so-called citizen tax ("Bürgersteuer"), introduced.
June 5, 1931: The decree raised a crisis tax. In addition, the decree introduced a salary cut for public sector employees and reduced unemployment insurance benefits and crisis support by 5 percent. It also increased the time span until eligibility for unemployment insurance payments and cut back on child supplements.
October 6, 1931: The decree further cut salaries, increased unemployment insurance contributions, lowered the eligibility period, increased the eligibility age for social benefits, and announced a stop for constructing public buildings. Moreover, extensive pension cuts for public sector employees were inaugurated.
December 8, 1931: The final austerity decree, again, cut back on public wages, and forced price, wage, and interest rate drops. All wages and salaries were cut to their prevailing level in 1927. Additionally, the period of unemployment insurance eligibility was lowered to a maximum of 20 weeks.

There is a long-running debate about potential alternatives to Brüning's deflationary policy. In an influential essay, Borchardt (1979) challenges the postwar consensus that Brüning's failed economic policy was the main reason for the decline of the Weimar Republic (Kroll, 1958; Kindleberger, 1973). He argued that Brüning, facing a crushing public debt, had no room to maneuver and, consequently, could only opt for austerity. Borchardt's reasoning is firmly rebutted by Holtfrerich (1982), who particularly disputes the thesis that the debt burden originated, to some extent, from excessive wages and social transfers prior to 1929. The extensive discussion that developed among international scholars, the so-called Borchardt Debate, was declared to be over by Ritschl (2001). Ritschl saw most of Borchardt's theses confirmed, arguing that Germany's high foreign private debt service and obligatory reparation payments imposed by the Young Plan put an extra strain on the country's balance of payments and made reflationary economic policies impossible (Ritschl, 2002b). The recent revival of the debate suggests that a definitive interpretation of the economic problems of the Weimar Republic and Brüning's role is still a work in progress (Köppen, 2014; Müller, 2014; Borchardt, 2015; Kailitz, 2015; Köster, 2015, amongst others). What is lacking from the more than 40-years-long discussion of Brüning's constraints and economic alternatives are quantitative estimates on the macroeconomic effects of Brüning's austerity measures. Our analysis closes this longstanding gap.

[4] James (1986) and Winkler (2018), among others, include a comprehensive treatment of the emergency decrees' content.

[5] These are called *Verordnung des Reichspräsidenten zur Sicherung von Wirtschaft und Finanzen* and numbered consecutively.

2.3 Empirical strategy

In this section, we describe how we combine the historical knowledge on the austerity decrees with newly collected data sources to quantify, for the first time, the macroeconomic effects of Brüning's austerity policy.

2.3.1 New data

We bring our narrative identification strategy to bear on a new, detailed monthly dataset of the German federal government budget and macroeconomic and financial variables collected from Wagemann (1935). Two features make this newly collected data essential for quantifying the effects of Brüning's austerity policy. First, the data's *monthly* frequency. In an economically turbulent time, like during Brüning's term of office, during which fiscal policy did not follow the regular budgeting process, but implemented impulsively by emergency decrees, only monthly data allows us to set the austerity shock observations' timing precisely enough. Second, our data sources enable us to decompose the total budget numbers into consistent categories over time. We use this decomposition and construct government spending and tax revenue variables free of components that move with the business cycle directly, thereby strengthening the mapping between our fiscal variables and the austerity shock instrument.

Germany's monthly federal government budget Up to now, in terms of data, the gold standard to study questions related to the public sector in the Weimar Republic are the quarterly budget figures compiled by Ritschl (2002b). Building on this information, we extend the existing time series evidence on the German budget and construct a monthly dataset on federal revenues and expenditures.[6]

The starting point for our dataset constitute the aggregated monthly series of revenues and expenditures in Wagemann (1935).[7] They comprise the regular and the extraordinary budget and are organized in fiscal years. However, as the aggregated budget data also includes reparations and debt service, as well as cyclical components like social transfers and transfer payments to states and municipalities, we have to correct for these positions. Starting from April 1927, we are able to decompose the total budget numbers into explicit items of the federal government budget and adjust the spending and revenue data accordingly. To decompose the aggregated series, we use the detailed accounts of the German federal government budget as published from April 1927 to 1931 in the *Statistisches Jahrbuch für das Deutsche Reich*. From 1932 on, we gather this information in various editions of *Wirtschaft und Statistik*.[8] Appendix 2.B shows an extract from the primary sources.

As the item's declarations and compositions change over time in the statistical publications, we summarize them consistently in broader categories. Government expenditures splits up in nine categories and tax revenues in four. Table 2.1 provides an overview

[6]As a consistency check, in Appendix 2.A, we aggregate our monthly budget data to quarterly frequency and find that it corresponds well with the series in Ritschl (2002b).

[7]In particular, "Monatliche Einnahmen und Ausgaben des Reich", section XVIII. Öffentliche Finanzwirtschaft; A.

[8]After February 1935, detailed budget accounts are no longer reported.

and Appendix 2.C contains more details on the categories and the spending and tax revenue variables' composition.

Table 2.1: Federal budget: categories

Government expenditures	Tax revenues
1E. Transfers to federal states	1R. Taxes, duties, levies
2E. Social transfers	2R. Capital income
3E. Remuneration of civil servants and employees	3R. Extraordinary taxes
4E. Housing, assets	4R. Other revenue
5E. Military, police, transportation	
6E. Debt and coverage of public deficit	
7E. War burdens	
8E. Reparations	
9E. Other expenditure	

Crucial and new to the literature, this budget decomposition finally allows us to construct a revenue and spending measure free of cyclical components suitable for the empirical analysis: The tax revenue measure consists of taxes, duties, and levies (1R) minus the sum of tax transfers to federal states (1E), social transfers (2E), and interest and debt repayments (item of 6E). Our government spending measure includes remuneration of civil servants and employees (3E; 61 percent of spending variable), outlays on housing and assets (4E; 2.5 percent), expenditures for military, police, and transportation (5E; 23.7 percent), and outlays summarized as other expenditure (9E; 12.8 percent). With our revenue and expenditure measures, we capture 43 and 41 percent of the total budget numbers.[9]

Wagemann's handbook Monthly data on economic activity, prices, and interest rates for the last years of the Weimar Republic comes from a new statistical database that we compiled by digitizing the *Konjunkturstatistische Handbuch* of Wagemann (1935). The database contains well over 500 monthly time series on macroeconomic and financial variables of the German economy between 1925 and 1935: in particular, general statistical indicators on Germany's public sector, labor market, investment, traffic, trade, wages and income, prices, credit system, and interest rates and yields, but also industry-specific time series. From this database we have assembled a ready-to-use monthly dataset that is accessible to the public.

[9]In Appendix 2.D, we show that federal and local government entities were similarly affected by Brüning's austerity measures. Hence, budget cuts at the federal level could not be compensated for by Germany's local governments.

2.3.2 The austerity shock instrument

Nearly 90 years after Brüning stepped down as chancellor, the economic effects of his deflationary policy still are opaque and quantitative empirical evidence is missing. However, Brüning's extreme fiscal policy actions in the 25 months of his chancellorship have been extensively researched and documented by historians and other experts. We use this narrative record describing the history and motivation of Brüning's austerity course to construct a new austerity shock instrument (IV, also known as proxy variable), thereby building on the approach pioneered by Ramey and Shapiro (1998), Romer and Romer (2010), and Ramey (2011).

The first step in the analysis is to identify all major legislated austerity measures during Brüning's term of office between March 1930 and May 1932. As Brüning's austerity packages were exclusively issued by the five emergency decrees discussed in Section 2.2, this step is straightforward.

The second step in the analysis is to determine the austerity packages' size. The spending cuts and tax increases of Brüning's austerity decrees were considered as devastating and extremely cruel by the German public and foreign observers. For instance, *The Economist* comments in an article on December 12, 1931, only four days after the announcement of the last decree:

> "Coming on top of three[10] previous Emergency Decrees, which have already reduced terribly the German standard of life, and imposed, as it is, in the middle of a crisis in which Germany has five million unemployed, her stock markets closed, her tale of bankruptcies mounting to catastrophic figures, and her whole economic system 'frozen' by credit restrictions and standstill agreements, this latest 'turn of the screw' will undoubtedly place a dangerous strain on the psychology of the German people."

Surprisingly, the actual size of the government spending cuts and tax increases implied by each emergency decree received only little attention in the public discourse. The *Vossische Zeitung*, one of Germany's leading national dailies, reports authoritative forecasts for spending reductions and revenue increases only for the decrees announced in July 1930 and June 1931. However, the presented figures remain inconclusive to a large extent and do not cover the full set of regulations. For instance, the evening edition of June 4, 1931, quantifies the reduction in civil servants' salaries of 160 million Reichsmark without specifying the time horizon. The evening edition of June 6, 1931, states that 100 million Reichsmark in civil servants' salaries are going to be saved within the next nine months, hence through the end of the fiscal year. However, the decree itself states that the reduction in civil servants' salaries stays in effect until January 1934. Thus, given this conflicting evidence, the figures remain hard to interpret. Consulting governmental statements also does not lead to quantitative data. Neither the government declaration accompanying the emergency decree of June 1931, the famous Tributaufruf, nor Büning himself, in his radio address on the occasion of the December

[10] The article refers to *Verordnungen des Reichspräsidenten zur Sicherung von Wirtschaft und Finanzen* 1–3.

1931 decree, refers to concrete amounts and sums, but stresses the measures' severity only generally.

Additionally, deriving the implied reduction in government spending and tax increases *ex-post* from the law texts is impossible due to the emergency decrees' complexity. For instance, the size of a civil servant's salary or pension reduction implemented in the emergency decree of summer 1931 depended on her employer, income category, family status, and the place of residence, among others. Quantifying these cuts would require detailed micro-level data that is not available for the Weimar Republic. To address this data gap, we use qualitative information on the date and sign of the shock to construct the austerity shock instrument, thereby building on the works of Romer and Romer (1989), Ramey and Shapiro (1998), and Budnik and Rünstler (2020). A theoretical justification for the qualitative identification is given by Boer and Lütkepohl (2021), who show that proxies relying on qualitative information can lead to impulse response estimates of the impact effects of the structural shock of interest that are nearly as efficient as, or even more efficient than, estimators based on more sophisticated quantitative proxies that also take into account the size of the shock.
In particular, we use our historical knowledge of the austerity packages and set the proxy variable to minus one on the announcement dates of Brüning's emergency decrees (July 1930, December 1930, June 1931, October 1931, and December 1931), and zero otherwise. This variable has a reasonable amount of predictive power for the government budget. A regression of spending on the austerity instrument and ten of its lags has an R-squared of 0.26.

Some words concerning the timing of the dummy events are in order. The consensus in modern macroeconomics is that expectations of economic agents play a pivotal role in the working of fiscal policy (Perotti, 1999; Ramey, 2011; Corsetti et al., 2012; Kriwoluzky, 2012; Leeper et al., 2013, among others). According to this view, Brüning's austerity measures influenced agents' economic decisions already at the moment they were announced, and not when they were implemented and realized. By combining our narrative identification scheme with our monthly dataset, we can address this issue: setting the dummy events precisely in the month of the decrees' announcement eliminates any econometric concerns related to fiscal foresight effects.

Historical evidence supports the view that Brüning's austerity measures were not taken in response to factors likely to affect the economy in the near future and, hence, can be considered exogenous. In the last step of the analysis, we summarize the historical debate about Brüning's motives. Appendix 2.E contains an extensive list of further historical references providing evidence that Brüning's austerity decrees were motivated by reasons exogenous to the business cycle.
Two perspectives on Brüning's motivation for his deflationary policy course have shaped the historical debate. Both support the view that Brüning's austerity decrees can be used to study the macroeconomic effects of austerity measures because they were not systematically correlated with developments affecting the economy in the short- or medium-terms. According to the first view, Brüning's political agenda was essentially defined by his aspiration to end Germany's reparation payments and achieve a revision of the Treaty of Versailles to reintegrate Germany in the world economy. Thus,

the harsh austerity measures Brüning inflicted on the German economy were deliberately chosen to deepen Germany's recession. Brüning's intention was to demonstrate to the allies that Germany was already at its economic limits and had to be relieved from its reparation burden. Once reparations were abandoned, Brüning's plan was to devalue the currency considerably to restore Germany's competitiveness (Holtfrerich, 1982; Büttner, 1989; Evans, 2003; Ferguson and Temin, 2003; Winkler, 2018, among others). Proponents of the second view argue that Brüning already realized at the beginning of his chancellorship that spending cuts would not bring the necessary relief to stabilize Germany's depression economy. Instead, Brüning was convinced that the only remedy to break the deflationary spiral was to enable Germany to access foreign credit markets, which made a revision of the Young Plan inevitable in long-term. Thus, according to this view, deflation was the self-inflicted scourge to maintain Germany's participation in the international economic order (Borchardt, 1979; James, 1986; Ritschl, 2002b, 2016).
Both perspectives support the reasoning that Brüning's austerity cuts were not an endogenous response to stabilize the business cycle in short- or medium-term: while, according to the first view, the austerity measures were purely motivated by Brüning's political preferences, the second view sees them as an result of Germany's reparation debt and, hence, to outside forces. Even though Brüning was convinced that ending reparations and renewed access to foreign credits would jump-start Germany's shattered economy, this business cycle motive is clearly long-term oriented. One of the Weimar Republic's tragedies is that Brüning was no longer chancellor when Germany's reparation payments were finally suspended during the Lausanne Conference in the summer of 1932.

2.3.3 Estimation

To identify the effect of Brüning's austerity on the German economy, we order the qualitative IV first in a VAR model, a strategy pioneered by Kilian (2006) and Ramey (2011), and theoretically discussed in Plagborg-Møller and Wolf (2021). Generally, the VAR model with n endogenous variables expresses the observables y_t as projection on its past values and a reduced-form innovation:

$$y_t = B_0 + B(L)y_{t-1} + u_t, \quad u_t \sim \mathcal{N}(0, \Sigma_u), \tag{2.1}$$

where $B(L)$ denotes the reduced form VAR model coefficients, and B_0 the intercept term. u_t denotes the $n \times 1$ vector of reduced form errors with the corresponding variance-covariance matrix Σ_u. The reduced form errors u_t are related to the structural errors ϵ_t as follows:

$$u_t = A\epsilon_t, \quad \epsilon_t \sim \mathcal{N}(0, I_n). \tag{2.2}$$

The $n \times 1$ vector y_t collects the observables:

$$y_t = \begin{bmatrix} IV_t & g_t & tax_t & gdp_t|ue_t & p_t & i_t \end{bmatrix}. \tag{2.3}$$

IV_t denotes the qualitative austerity proxy variable with value minus one at the announcement dates of Brüning's emergency decrees; g_t denotes the logarithm of real government consumption and, tax_t the logarithm of real tax revenues. We rotate the fourth variable in the system and estimate the VAR model sequentially with (i) the logarithm of GDP per capita (gdp_t) or (ii) the unemployment rate (ue_t). p_t is the logarithm of a wholesale price index (WPI) and i_t denotes the Reichsbank discount rate.[11] To account for the peculiarities of the German budgeting process, we seasonally adjust the spending and tax data by regressing the variables on a dummy variable that takes the value of one in March of each year.[12] Our budget data covers the sample 1927:M4 to 1935:M2. Because of the relatively short sample size, we adopt a Bayesian estimation. We employ a lag order of ten and use the procedure with dummy observations suggested by Bańbura et al. (2010) to implement the modified Minnesota prior of Kadiyala and Karlsson (1997). Appendix 2.G outlines the details of the prior distribution. For inference, we use stationary draws from a Gibbs-sampler.[13]

We compute the dynamic responses of the austerity shock and evaluate the effect of Brüning's austerity policy on the German economy by analyzing the size and timing of the decrease in economic activity and the increase in unemployment associated with the emergency decrees. Representing the VAR model estimates in the form of counterfactuals allows us to examine how much change of GDP per capita and the unemployment rate can be attributed to positive or negative fiscal shocks at a given point in our sample. We follow Kilian and Lee (2014) and, in a first step, compute the historical decomposition during Brüning's term of office

$$y_t = \sum_{s=0}^{t-1} \Phi_s \epsilon_{t-s} + \sum_{s=t}^{\infty} \Phi_s \epsilon_{t-s} \tag{2.4}$$

where Φ_s denotes the 6×6 matrix of structural impulse responses at lag $s = 0, 1, 2, ...$ We estimate Φ_s and ϵ_t from the data and express the fitted value of the structural VAR model as:

$$\hat{y}_t \approx \sum_{s=0}^{t-1} \hat{\Phi}_s \hat{\epsilon}_{t-s}. \tag{2.5}$$

We are interested in the fourth element of y_t, denoted by $y_{gdp,t|ue,t}$, which corresponds to GDP per capita or the unemployment rate. Let $y^s_{gdp,t|ue,t}$ denote the contribution of structural shock s to GDP per capita or unemployment at date t. Then, the counterfactual is defined as $y_{gdp,t|ue,t} - \hat{y}^s_{gdp,t|ue,t}$, where $\hat{y}^s_{gdp,t|ue,t}$ denotes the fitted value of GDP (unemployment) associated with shock s. For our analysis, we are interested in the effect of the first shock, the shock to the austerity proxy. The counterfactual series

[11] Appendix 2.F includes a detailed account on the data sources.

[12] March constitutes the last month in the fiscal year in which all still open items were posted. Each March, we observe spikes in the revenue and expenditure data. By seasonally adjusting the budget data, we avoid, because of these spikes, overestimating the effects of fiscal policy.

[13] In Appendix 2.H, we show that our estimation results are robust to various specifications, including varying lag length and alternative variables for economic activity and the price level.

then indicates how GDP per capita or the unemployment rate would have evolved, had one been able to replace all realizations of the austerity shock in our sample with zeros, while keeping the remaining five structural shocks in the VAR model. If the counterfactual exceeds the observed time series, the austerity shock lowered the time series in this period. If it lies below the actual series, the austerity shock increased that series. The distance between the observed series and the counterfactual series tells us by how much austerity affected GDP or the unemployment rate at this point in time.

2.4 Results

2.4.1 Transmission mechanism

How does the austerity shock we identify propagate to the macroeconomy? We find that it is in line with theory.

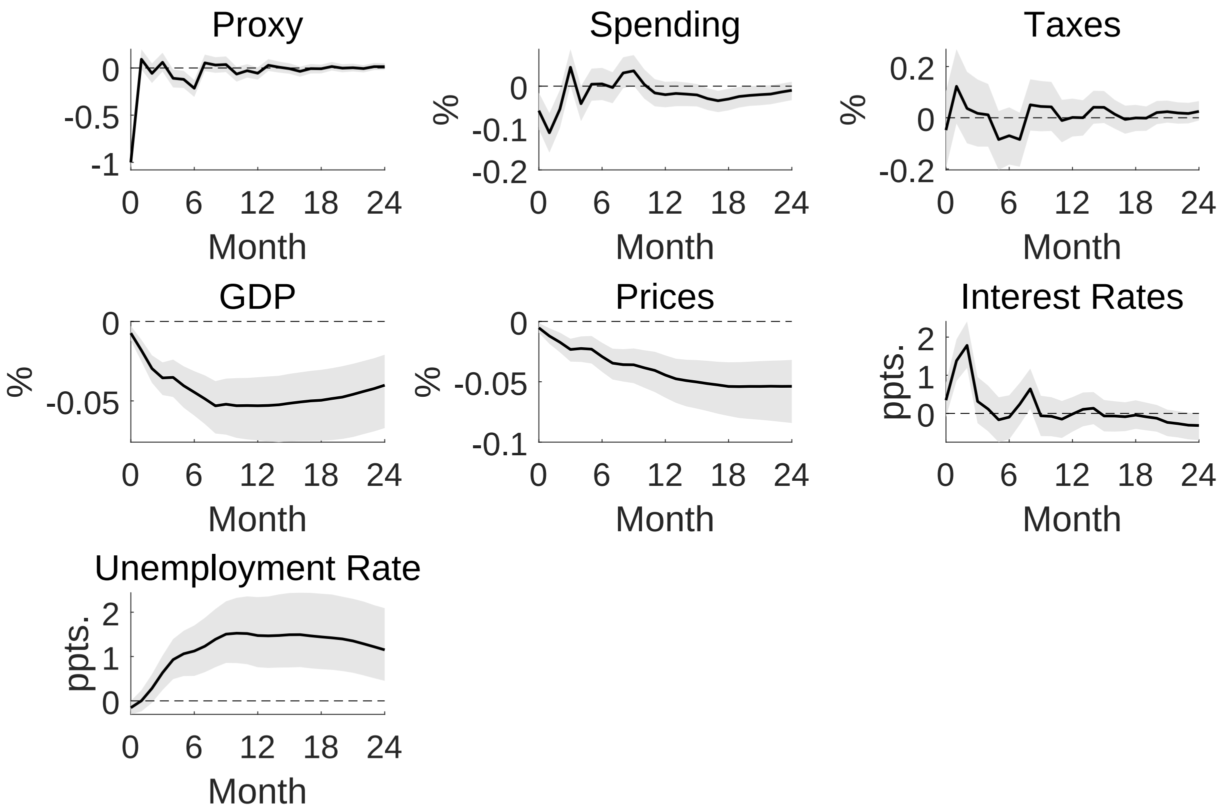


Figure 2.2: Impulse responses to an austerity shock. The solid line depicts the median impulse response of the specified variable to a one-unit austerity shock. Shaded bands denote the 68 percent credible sets.

Figure 2.2 shows impulse responses to a one percent austerity shock. The bold line depicts the posterior median response, the grey-shaded area shows the 68 percent credible intervals. Consistent with theory, the austerity shock identified with the qualitative proxy variable decreases government spending statistically significantly, increases taxes, and has recessionary effects. GDP per capita experiences a sharp decrease in the first eight months and does not convert back to its initial level within two years. Austerity has increasing and long-lasting statistically significant effects on the unemployment rate. After ten months, the increase in unemployment reaches its maximum at 1.5 percentage points, but the rate stays above its initial level for more than two years. Prices decrease on impact. Consistent with price rigidities, the decline in prices is rather slow at the beginning, but steady and long-lasting. Interest rates increase on impact, but the response is essentially insignificant and fluctuates around zero. From a contemporary perspective, with the implementation of a Taylor rule on the side of the central bank and price rigidities, we would expect interest rates to decrease in response to austerity to match the deflationary effects. The German Reichsbank in the 1920s and 1930s, however, was not relying on Taylor-type rules for conducting monetary policy - and our identification scheme correctly picks this up.

2.4.2 Counterfactual GDP and unemployment

What would have been the state of Germany's economy in summer 1932 without Brüning's austerity measures? This section presents the answer provided by our counterfactual exercise.

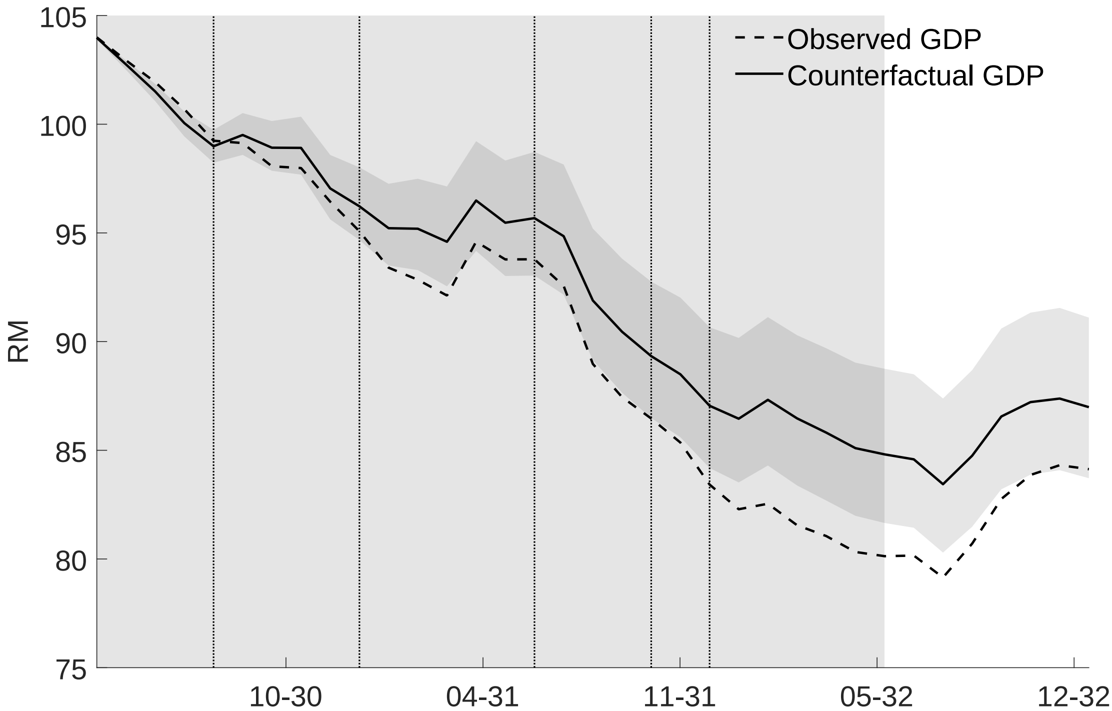


Figure 2.3: Counterfactual for GDP per capita between March 1930 and January 1933. The bold line depicts median counterfactual GDP in the absence of austerity shocks and the dark-grey shaded area shows 68 percent credible bands. The dashed line illustrates observed GDP. The light-grey shaded area marks Brüning's term of office. The dotted lines indicate the emergency decrees' announcement dates.

Figure 2.3 shows counterfactual GDP per capita (bold line: median estimate; dark-grey shades: 68 percent credible sets) and observed GDP per capita (dashed line) between

Brüning's term of office (light-grey background) and Hitler's appointment as chancellor in January 1933. For the first months of the sample, the two lines coincide almost perfectly, meaning that austerity barely had an impact on the evolution of GDP. Then, starting with the first emergency decree in summer 1930 until the end of the sample, counterfactual GDP exceeds observed GDP. Hence, for the lion's share of Brüning's chancellorship, austerity shocks had an decreasing effect on economic activity. The difference between counterfactual and observed GDP becomes statistically significant from August 1931 onward, coinciding with the implementation of the second emergency decree in the midst of the German banking crisis. Summing up the significantly estimated loss in GDP during Brüning's term of office, hence foregone GDP between August 1931 and June 1932, yields a loss equivalent to 4.46 percent of total GDP in 1932; or, put differently, because of Brüning's austerity policy, Germany suffered a loss in GDP amounting to 239 percent of all reparations paid by Germany in 1930 - with 1930 being the year in which Germany paid the highest amount of reparations before the Lausanne Conference.

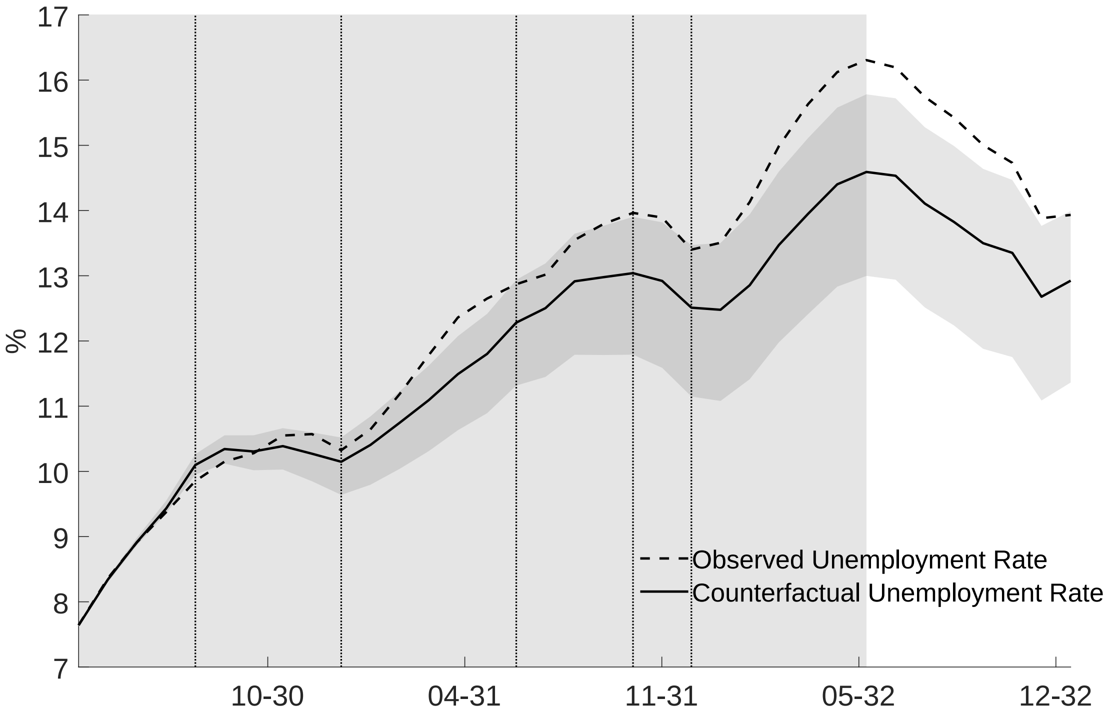


Figure 2.4: Counterfactual for the unemployment rate between March 1930 and January 1933. The bold line depicts the median counterfactual unemployment rate in the absence of austerity shocks and the dark-grey shaded area shows 68 percent credible bands. The dashed line illustrates the observed unemployment rate. The light-grey shaded area marks Brüning's term of office. The dotted lines indicate the emergency decrees' announcement dates.

For the labor market, the picture looks equally bleak. Figure 2.4 shows the counterfactual and realised unemployment rate between March 1930 and January 1933. Over spring 1930, the two lines are congruent; thus, austerity shocks were not driving the unemployment rate in the first months of Brüning's term of office. Starting from October

1930, counterfactual unemployment falls short of the observed rate and remains below the realised value through the end of the sample. Hence, without Brüning, German unemployment would have been lower in the last years of the Weimar Republic. In addition, the gap between the observed and counterfactual unemployment rate widens over time, meaning that Brüning's fiscal policy increasingly drove up unemployment. With the implementation date of the fourth emergency decree in January 1932, the difference between the counterfactual and observed unemployment rate becomes statistically significant. Considering again only the significantly estimated unemployment effects between January and June 1932, we find that Brüning's austerity policy brought 3.31 million people in Germany into unemployment, or nine percent of the monthly average labor force of 1932.

Was Brüning really a "Hunger Chancellor"? The outcomes of the counterfactual analysis speak a clear language. We find that Brüning's austerity course made matters worse and put an additional drag on Germany's crisis-shaken economy. The five emergency decrees issued between July 1930 and December 1931 account for a loss in GDP of 4.5 percent and cost 3.3 million people their jobs. Looking at the sheer macroeconomic losses, despite their dimension, however, underestimates the true damage caused by Brüning's budget cuts. The extreme economic circumstances in the last years of the Weimar Republic made the German electorate turn away from Weimar's ruling parties and vote for opponents that promised an economic reboot (Kaltefleiter, 1968; King et al., 2008; Galofré-Vilà et al., 2021). Fatally enough, the Nazis were the party that capitalized most on this insight.

2.5 Conclusion

Was Brüning's cost cutting policy an appropriate crisis remedy or did it aggravate Germany's economic situation? In this paper, we provide answers on a long-standing and unresolved question in economic history and quantify modern history's most consequential austerity intervention: Chancellor Brüning's budget cuts and tax increases in Germany between 1930 and 1932. Our findings lend support to the concern that fiscal consolidations aggravated the Great Depression. Brüning's imposed belt-tightening brought 3.31 million people into unemployment and lowered Germany's GDP per capita by 4.5 percent, exactly at a time in which the country was already hit hard by the Great Depression and a banking crisis. These sizeable macroeconomic numbers even obscure the psychological effects of Brüning's austerity policy on the German electorate. Years of extreme economic hardship made the people turn away from the established democratic ruling parties and seek political movements that promised economic alternatives. Fatally enough, the Nazis were the party that capitalized most on this insight. Under these circumstances, Brüning's austerity policy can be marked as a fatal fire accelerant.

Appendices

2.A Comparison to Ritschl's federal government spending data

In Figure 2.5, we aggregate our monthly budget data to quarterly frequency and find that it corresponds well with the series in Ritschl (2002b).[14] During the late 1920s, we underestimate total Reich expenditures; however, both series move closely together.

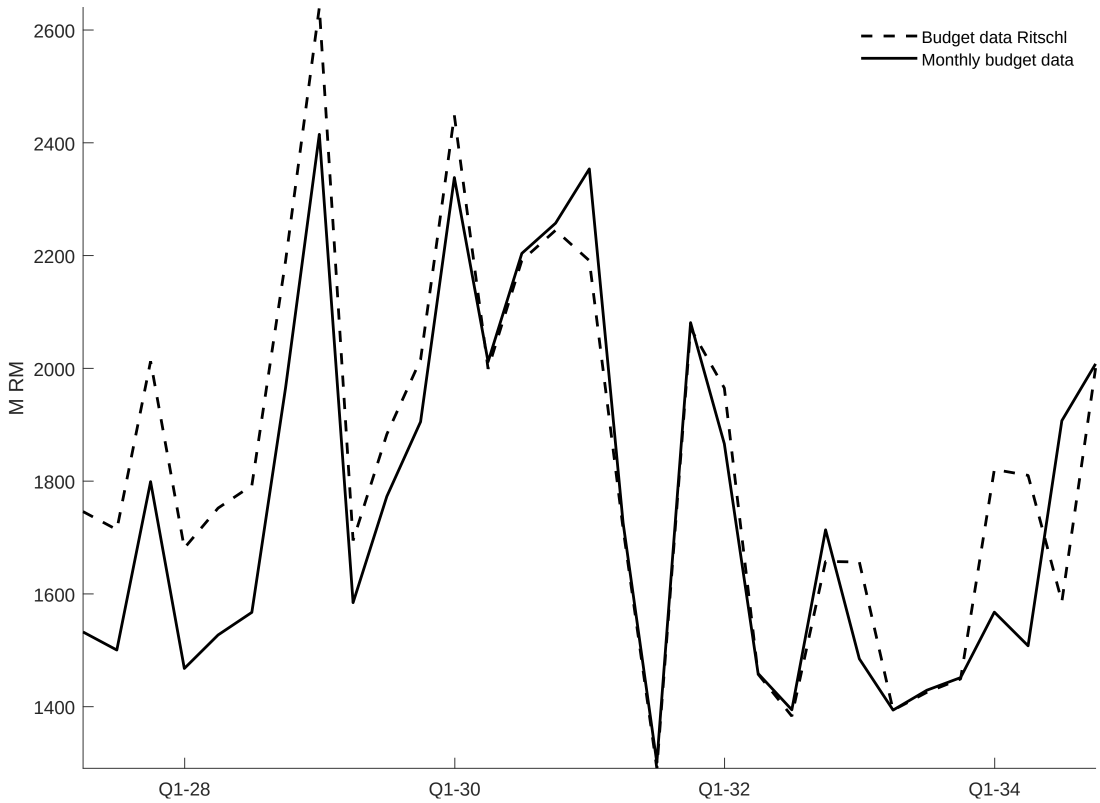


Figure 2.5: The dashed lines shows quarterly total federal expenditures as compiled by Ritschl (2002b). The bold line shows our monthly measure of total expenditures aggregated to quarterly frequency.

As Ritschl (2002a) notes, the official budgeting process somewhat masks the true extend of public finances because the German government tried to hide some of its outlays from international monitors. During the early 1930s and, hence, during Brüning's term of office, the series coincide almost perfectly. This comparison shows that the monthly data provides a very good account of federal government expenditures. If anything, the fact that we do not account for the hidden spending positions places a higher bar for our results.

[14]The benchmark series in Ritschl (2002b) consists of total expenditures by the federal government net of transfer payments to local governments and municipalities (Table A.6, "Reiner Finanzbedarf", A.6.35).

2.B Federal budget decomposition: extract from primary sources

Einnahmen und Ausgaben des Reichs	1931 Juli	1931 Sept.	1931 Oktober	1931 April/Okt.
A. Ordentlicher Haushalt.				
I. Einnahmen	Mill. ℛℳ			
1. Steuern				
Steuern, Zölle usw. (Reichsanteil)[1]	673,7	324,4	676,7	3 376,0
Reparationssteuer der Reichsbahn	—	—	—	165,0
2. Erwerbsvermögen				
Aus den Vorzugsaktien der Reichsbahn	—	—	—	28,7
Überschuß v. Post u. Reichsdruckerei	14,6	19,9	19,8	129,5
Aus der Münzprägung[2]	— 0,1	— 4,3	— 3,0	— 13,7
3. Verwaltungseinnahmen	12,9	14,9	16,8	103,8
Summe der Einnahmen	701,1	354,9	710,3	3 789,3
II. Ausgaben				
1. Bezüge d. Beamten u. Angestellten[3]	59,6	60,9	61,5	433,2
2. Versorgung u. Ruhegehälter (einschl. Kriegsbeschädigtenrenten)	127,0	119,0	119,7	909,2
3. An die Länder für Schutzpolizei	15,8	15,8	16,1	111,1
4. Soziale Ausgaben				
Sozialversicherung	46,7	34,5	35,4	260,4
Zuweisung an die knappschaftliche Pensionsversicherung	—	—	26,3	28,0
Kleinrentnerfürsorge	8,0	—	10,0	18,0
Krisenunterstützung für Arbeitslose	54,6	49,6	61,6	357,5
Wertschaffende Arbeitslosenfürsorge	3,2	0,7	0,2	6,3
An Reichsanstalt f. Arbeitsvermittl.	2,7	2,4	3,1	17,7
Schaffung von Arbeitsmöglichkeiten u. Verstärkung der Krisenfürsorge	[6] .	[6] .	22,0	[6] 46,0
Zur Erleichterung der Wohlfahrtslasten der Gemeinden (GdeVbde)	—	—	32,0	32,0
5. Reichsschuld				
Verzinsung und Tilgung	24,2	5,0	12,9	104,4
Außerordentliche Tilgung der schwebenden Schuld	—	—	245,0	245,0
Anleiheablösung	2,4	2,1	5,3	48,2
6. Sächliche und sonstige Ausgaben (außer Kriegslasten)				
Heer	19,9	20,1	24,9	138,7
Marine	9,6	12,4	12,0	69,4
Verkehrswesen	14,6	11,6	10,5	75,1
Übrige Reichsverwaltung	[6] 22,2	[6] 40,9	[6] 24,7	[6] 162,2
7. Innere Kriegslasten[4]	16,3	22,4	53,3	196,9
8. Äußere Kriegslasten				
Reparationszahlungen[5]	6,1	6,0	6,8	428,6
Sonstige äußere Kriegslasten	9,1	8,3	8,3	62,5
Summe der Ausgaben	442,0	411,7	791,6	3 750,4
Ergibt Mehreinnahme (+), Mehrausgabe (—)	+259,1	—56,8	—81,3	+ 38,9
B. Außerordentlicher Haushalt.				
I. Einnahmen				
1. Verwaltungseinnahmen	0,5	0,3	0,8	10,6
2. Aus Anleihen	—	—	—	—
3. Aus dem Verkauf von Vorzugsaktien der Deutschen Reichsbahn-Gesellsch.	—	—	1,2	15,9
Summe der Einnahmen	0,5	0,3	2,0	26,5
II. Ausgaben				
1. Wohnungs- und Siedlungswesen	2,0	1,4	0,5	9,0
2. Verkehrswesen	8,4	7,4	7,5	46,8
3. Rückkauf v. Schuldverschreibungen usw. des Reichs	0,7	1,9	—	2,6
4. Innere Kriegslasten	1,3	0,9	5,0	11,3
5. Übrige Reichsverwaltung	2,0	— 2,1	0,1	11,7
Summe der Ausgaben	14,4	9,5	13,1	81,4
Ergibt Mehreinnahme (+), Mehrausgabe (—)	—13,9	— 9,2	—11,1	— 54,9

Figure 2.6: Detailed federal budget decomposition for selected months in the fiscal year 1931/1932, published in *Wirtschaft und Statistik* from January 1932.

2.C Constructing a monthly dataset of the German federal government

In this appendix, we not only specify how we group the various budget items on the expenditure and revenue sides but also outline how we construct the nominal government spending and tax revenues variables for estimating the macroeconomic effects of austerity. The grouping becomes necessary because the budget item's declarations and compositions change over time in the statistical publications (April 1927 - December 1931: Statistisches Jahrbuch für das Deutsche Reich; January 1932 - February 1935: Wirtschaft und Statistik). The budget items are listed by its original German term. The abbreviation "EO" in parenthesis behind selected items indicates that the item is part of the extraordinary budget.

2.C.1 Total expenditures

Total federal revenues are split into nine broad categories. The monthly nominal government spending variable corresponds to the sum of "Remuneration of civil servants and employees" (3E), "Housing, assets "(4E), "Military, police, transportation"(5E), and "Other expenditure" (9E).

1E Transfers to federal states

Steuerüberweisungen an die Länder

Überweisungen an die Länder

2E Social transfers

Sozialversicherung

Zuweisung an die knappschaftliche Pensionsversicherung

Für die Befreiung der Untertagearbeiter von der Arbeitslosenversicherung

Erwerbslosenfürsorge (unterstützende)

Kleinrentnerfürsorge

Krisenunterstützung für Arbeitslose

Arbeitslosenhilfe und Arbeitsbeschaffung

Schaffung von Arbeitsmöglichkeiten und Verstärkung der Krisenfürsorge

Wertschaffende Arbeitslosenfürsorge

Arbeitslosenversicherung

An Reichsanstalt für Arbeitsvermittlung und Arbeitslosenversicherung

Freiwilliger Arbeitsdienst usw.

Fettverbilligung

Zur Erleichterung der Wohlfahrtslasten der Gemeinden

Arbeitslosenversicherung (EO)

Wertschaffende Arbeitslosenfürsorge (EO)

Erwerbslosenfürsorge (produktive) (EO)

3E Remuneration of civil servants and employees

Besoldungen

Pensionen

Bezüge der Beamten und Angestellten (ausschl. Ruhegehälter)

Versorgung und Ruhegehälter einschl. der Kriegsbeschädigtenrenten

4E Housing, assets

Vorstädtische Kleinsiedlung für Erwerbslose

Wohnungs- und Siedlungswesen

Beteiligung an der Dresdner Bank

Beteiligung an der Akzept-Bank

Stützung der Landesbank der Rheinprovinz

Erwerb von Gelsenkirchen-Aktien

Wohnungs- und Siedlungswesen (EO)

5E Military, police, transportation

Heer - sächliche Ausgaben

Marine - sächliche Ausgaben

Verkehrswesen

Schutzpolizei

Verkehrswesen (EO)

6E Debt and coverage of public deficit

Reichsschuld: Verzinsung und Tilgung

Reichsschuld: Anleiheablösung

Ausserordentliche Tilgung der schwebenden Schuld

Tilgung in Ausführung des Gesetzes vom 23.10.1930

Rücklauf von Schuldverschreibungen

Zur Deckung der Fehlbeträge früherer Jahre

Rücklauf von Schuldverschreibungen usw. des Reiches (EO)

Einlösung von Schatzanweisungen usw. (EO)

7E War burdens

Innere Kriegslasten

Sonstige äußere Kriegslasten

Innere Kriegslasten (EO)

8E Reparations

Reparationszahlungen

Reparationszahlungen (EO)

9E Other expenditure

Münzprägung

Sonstiges

An die Bank für internationalen Zahlungsabgleich (Sondereinlage) (EO)

Zuschuß an den ordentlichen Haushalt (EO)

Sonstiges (EO)

2.C.2 Total revenues

Total federal revenues are split into four broad categories. The monthly nominal tax revenues variable is constructed as "Taxes, duties, levies" (1R) minus the sum of "Transfers to federal states" (1E), "Social transfers" (2E), and "Reichsschuld: Verzinsung und Tilgung"[15] in category 6E.

1R Taxes, duties, levies

Aus Steuern, Zöllen und Abgaben

2R Capital income

Aus der Münzprägung

Aus Anleihe

Anteil des Reichs am Reingewinn der Reichsbank

[15]Translation: *Reich debt: interest and debt repayments*

Überschuss der Post und Reichsdruckerei

Vorzugsdividende aus den Vorzugsaktien der Deutschen

Reichsbahn-Gesellschaft

Verzinsung aus den Vorzugsaktien der Deutschen Reichsbahn-Gesellschaft

Einnahmen aus Verkauf von Vorzugsaktien der Deutschen

Reichsbahn-Gesellschaft

Erlös aus der 5 % Anleihe von 1927 (EO)

Aus Anleihen und Betriebsmitteln (EO)

Aus dem Verkauf von Vorzugsaktien der Deutschen Reichsbahn-Gesellschaft (EO)

3R Extraordinary taxes

Reparationssteuer der Deutschen Reichsbahn-Gesellschaft

4R Other revenue

Sonstige Verwaltungseinnahmen

Verwaltungseinnahmen (EO)

Sonstiges (EO)

2.D Federal versus local government spending

In this appendix, we discuss how government spending in the Weimar Republic was divided between the federal government and local governments. We show that Brüning's austerity measures affected not only the federal government budget, but, in the same manner, the finances of states and municipalities. Hence, budget cuts at the federal level were not compensated by the local government.

In a first step, we use data from Ritschl (2002b) to examine the relative importance of federal and local authorities in total government expenditures. Table 2.2 provides an overview of how total expenditures were distributed across federal and local governments. Until 1933 the shares are remarkably constant, with the Reich accounting for about 40 % of total expenditures, while states and municipalities accounted for the remaining 60 %. Only in the last year of the sample does this pattern reverse.

Table 2.2: Share in spending (%) by Reich and local government

Year	Reich	Local
1925	37.19	62.81
1926	37.59	62.41
1927	36.78	63.22
1928	36.3	63.7
1929	38.21	61.79
1930	39.47	60.53
1931	38.16	61.84
1932	39.03	60.97
1933	42.54	57.46
1934	52.03	47.97

Notes: Ratios of government spending by Reich and local government. Data comes from Ritschl (2002b).

The fact that spending at both governmental levels was similarly affected by Brüning's austerity measures is illustrated in Figure 2.7, which plots nominal expenditures for the federal government as well as for all states and municipalities over time. Both series show drastic cutbacks in spending after 1930, which is consistent with the discussion in Galofré-Vilà et al. (2021) that the austerity policies trickled down from federal to local government. Between 1930 and 1932, Reich expenditures decreased by 28 %, while the corresponding drop at the local level was similarly high at 26 %. The data clearly does not support the idea that spending cuts at the Reich level were offset by expansionary fiscal policy at the local level. What is equally interesting from Figure 2.7 is that expenditures by states and municipalities did not revert back to their pre-crisis levels, but remained low. Hence, given these considerations, investigating the economic impact of austerity with federal government data is ideal for two reasons. First, federal government data is available at the monthly frequency, while local government data exists only at annual basis. Second, federal budget data is not confounded by offsetting trends at the local government level.

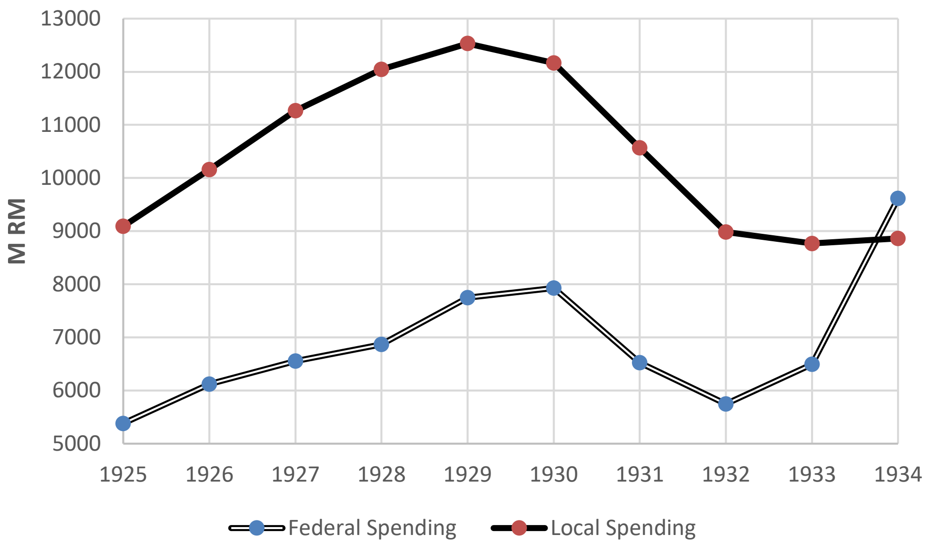


Figure 2.7: Nominal expenditures by the federal government and local authorities in million Reichsmark. Data comes from Ritschl (2002b).

2.E Brüning's motivation for his austerity policy - historical evidence

In this appendix, we provide further historical evidence that Brüning's austerity decrees were not related to developments affecting the economy in short or medium-term.

1. Brüning's personal statements:

    - Brüning himself supports the view that ending reparations ranked high among his political preferences when he reflects in his memoirs his time as chancellor, that "(...) from the disease we could create our weapon" (cite, p. 309).[16]
    - At a meeting with state secretary von Bülow and the ambassadors to Germany representing France, Italy, and UK in January 1932, the earlier Brüning already shared this view when stating that "(...) the catastrophic world economic crisis has also positive effects for us in terms of reparations" (Winkler, 2018, p. 438).[17]
    - While members of Brüning's cabinet, like the minister of interior Joseph Wirth, pushed in negotiations with the allies for interim solutions, which would have waived some of Germany's reparation obligations, Brüning insisted on a complete solution to the reparation problem (Büttner, 1989; Winkler, 2018, p. 405).

2. The stabilizing effects of expansionary fiscal policy were well-known during Brüning's term of office:

    - At least since the banking crisis in summer 1931, reflationary economic policies were openly discussed in Germany as an alternative to Brüning's austerity mandate. Some proposals came directly from Brüning's cabinet and political confidants, like the plan of Hans Schäffer, secretary of state in the Finance Ministry and one of Brüning's policy advisers, to counter the deflation by state-financed investment programs, or the plan of Wilhelm Laudenbach, civil servant in the Ministry of Economics, to jump-start the economy by expanding credit. Other proposals were submitted by political actors close to the government, like the one of Ernst Wagemann, founder of the Institute for Business Cycle Research and president of the Statistical Reich Agency, to give up partially the gold parity of the Reichsmark (Holtfrerich, 1982).[18] The fact that Brüning did not invest energy to find political majorities for these widely-discussed reflationary proposals, as well as his commitment to the deflationary policy in the second half of 1931, supports the view that fostering Germany's economic growth ranked very low

[16] Own translation. German original text: "Aus der Krankheit konnten wir unsere Waffe machen."

[17] Own translation. German original text: "die katastrophale Weltwirtschaftskrise reparationspolitisch für uns auch ihr Gutes habe."

[18] Holtfrerich (1982) contains a comprehensive summary of the alternative policy proposals, and Holtfrerich (2016), among others, contains a more detailed presentation of the Laudenbach and Wagemann proposal.

in Brüning's political priorities. citeFeldman1994 points out that Brüning was implementing a variety of small-scale work creation programs that were paid for by savings from social expenditures to cushion the decline of the German economy.

- Holtfrerich (2016) points out that in spring 1932, after the economic situation in Germany deteriorated again, even Brüning was considering large-scale work creation programs financed by the Reichsbank under the condition they did not interfere with Germany's foreign affairs. The plan, however, never went into effect because Reichsbank President Luther opposed the idea.

3. Brüning's symbolic rhetoric and political actions:

   - The emergency decree of June 5, 1931 was announced right before Brüning's departure to an English-German meeting in Chequers, taking place between June 6 and 7. According to Winkler (2018, p. 404), the intention of Brüning's careful timing was to demonstrate to England the severity of Germany's economic situation. The announcement was accompanied by an official statement of Brüning on the reparation question in which he stressed the importance of a revision of Germany's reparation obligations and the dangers of a German default (Ritschl, 2002b, p. 146f).

   - Germany's financial relief through the Hoover Moratorium of June 20, 1931 was downplayed by Brüning. In a radio speech on June 23, Brüning declared, that the Germans "should not think, after accepting President Hoover's proposal, that all hardship in Germany would be relieved (...). (...) President Hoover's sign of confidence can only bear fruits, if the German people is determined to continue on her own strength the path of austerity in all areas."(Winkler, 2018, p. 415).[19] Then, in the morning edition of the *Vossische Zeitung* on July 7, 1931, the government made once again clear that the saved reparation payments could not be made available to ease the suffering endured by the people, and that Germany "(...) must not wane in its efforts to save. The entire relief must and will be used to consolidate public finances."[20]

   - Brüning ordered officials to downplay and understate the positive outcomes for Germany at a conference in London in July 1931 in which seven nations participated and Germany's reparation situation was debated (Winkler, 2018, p. 419f).

[19] Own translation. German original text: "Zu glauben, daß nach Annahme des Vorschlags des Präsidenten Hoover alle Nöte in Deutschland beseitigt wären, wäre die gefährlichste Illusion, in der sich das deutsche Volk wiegen könnte (...). (...) Der Vertrauensbeweis, der in dem weltgeschichtlichen Schritt des Präsidenten Hoover liegt, kann nur Früchte tragen, wenn das deutsche Volk fest entschlossen ist, aus eigener Kraft den Weg der grössten Sparsamkeit auf allen Gebieten weiterzugehen."

[20] Own translation. German original text: "Es [Deutschland] darf nicht in seinen äußeren Antstrengungen zu Sparen nachlassen. Die gesamten Erleichterungen, die der Hoover-Plan Deutschland bringen wird, werden zur Konsolidierung der öffentlichen Finanzen benötigt und verwendet werden.

2.F Data description

In this appendix, we describe the variables that we use to estimate the VAR model. The frequency of all data is monthly.

Consumer prices: The CPI comes from Wagemann (1935), p. 107, "Reichsindexziffern der Lebenshaltungskosten", "Lebenshaltung insgesamt" (1913/14 = 100).

Industrial production: Industrial production is taken from Wagemann (1935), p. 52. The index is chained to 1928 and seasonally-adjusted for estimation.

Interest rate: The Reichsbank discount rate (Reichsbankdiskontsatz) is retrieved from Wagemann (1935), p. 109.

Government spending: Government spending is constructed from our newly assembled dataset on the German government budget. Appendix 2.C contains the details. For estimation, the time series is seasonally adjusted and deflated by dividing through the arithmetic mean of the consumer price index (CPI) (Wagemann, p. 107) and the wholesale price index (WPI) (Wagemann, p. 99) to capture prices' demand and supply side.

GDP per capita: Monthly GDP per capita comes from Albers (2018), who constructs time series of real economic activity for a large panel of countries during the Great Depression. For details, we refer to his description of the estimation process. The basic idea is to estimate a common latent factor from a large number of monthly time series from Wagemann (1935) and use the estimated factor loadings to assign weights to the individual series.

Unemployment rate: The unemployment rate is computed as the ratio of unemployed over the labor force. Unemployment data comes from Humann (2011). The labor force is computed as the sum of unemployment and employment. Historical employment data for Germany is given in Pierenkemper (2015) on p. 145.

Tax revenues: Tax revenues are constructed from our newly assembled dataset on the German government budget. Appendix 2.C contains the details. For estimation, the time series is seasonally adjusted and deflated by dividing through the arithmetic mean of the CPI and the WPI.

Wholesale prices: The WPI comes from Wagemann (1935), p. 99, "Indexziffern der Großhandelspreise", "Großhandelspreise insgesamt" (1913 = 100).

2.G Prior distribution

Bayesian estimation of the reduced-form VAR is based on the description in Bańbura et al. (2010), who show how to implement a natural-conjugate prior using dummy observations. We start by writing the reduced-form VAR model in matrix from as

$$Y = ZB + U$$

where $Y = \begin{bmatrix} y_1 & \dots & y_T \end{bmatrix}'$, $B = \begin{bmatrix} c & B_1 & \dots & B_p \end{bmatrix}'$, $Z = \begin{bmatrix} z_1 & \dots & z_T \end{bmatrix}'$, $z_t = \begin{bmatrix} 1 & y'_{t-1} & \dots & y'_{t-p} \end{bmatrix}'$, $U = \begin{bmatrix} u_1 & \dots & u_T \end{bmatrix}'$ and $u_t \sim \mathcal{N}(0, \Sigma_u)$. For the prior distributions we specify that the residual covariance matrix follows an inverse Wishart distribution and that, conditional on the covariance matrix, the remaining parameters have a normal distribution:

$$\begin{aligned} \Sigma_u &\sim \mathcal{IW}(\underline{S}, Np+1) \\ vec(B)|\Sigma_u &\sim \mathcal{N}(vec(\underline{B}), \Sigma_u \otimes \underline{\Omega}) \end{aligned}$$

where N is the number of variables in the VAR model and p denotes the lag length. The matrix $\underline{S}$ is diagonal with the prior residual variances of each variable on the diagonals, scaled by the hyperparameter λ that determines the overall tightness of the prior (see below). The matrix $\underline{\Omega}$ is also diagonal and determines the prior variances of the VAR parameters, which are shrunk with the lag length. As discussed below, our prior specifies the individual variables as independent random walks, so the matrix $\underline{B}$ has zeros everywhere except at entries that correspond to first lags of own variables in each equation, at which the entry is one.

As shown in Bańbura et al. (2010), this prior can be implemented by adding dummy observations to the data. Specifically, the following dummy observations are added:

$$Y_d = \begin{bmatrix} 0_{1\times N} \\ diag(\delta_1\sigma_1, \dots, \delta_N\sigma_N)/\lambda \\ 0_{N(p-1)\times N} \\ diag(\sigma_1, \dots, \sigma_N) \end{bmatrix} \qquad X_d = \begin{bmatrix} \nu_0 & 0_{1\times Np} \\ 0_{Np\times 1} & J_p \otimes diag(\sigma_1, \dots, \sigma_N)/\lambda \\ 0_{N\times 1} & 0_{N\times Np} \end{bmatrix}$$

where the number of elements in Y_d is denoted by T_d. Note that these are the same elements, just with a different ordering compared to Bańbura et al. (2010) because we order the deterministic terms first in the VAR. Defining $Y_o = \begin{bmatrix} Y' & Y'_d \end{bmatrix}'$ and $Z_o = \begin{bmatrix} Z' & Z'_d \end{bmatrix}'$, the posterior distributions are then given by:

$$\begin{aligned} \Sigma_u|Y &\sim \mathcal{IW}(\overline{S}, T_d + T + 2 - (Np+1)) \\ vec(B)|\Sigma_u, Y &\sim \mathcal{N}(vec(\overline{B}), \Sigma_u \otimes (Z'_oZ_o)^{-1}) \\ \overline{B} &= (Z'_oZ_o)^{-1}Z'_oY_o \\ \overline{S} &= (Y_o - Z_o\overline{B})'(Y_o - Z_o\overline{B}) \end{aligned}$$

Lastly, it remains to specify the parameters that make up the prior distributions. As is standard in the literature, we replace σ_j with the residual standard deviation from an OLS regression of variable y_j on a constant and p of its own lags. As mentioned in the main text, we set the lag length to $p = 10$. The prior coefficients on the first lag for each variable are set to $\delta_j = 1$, reflecting the prior belief that the individual series follow a random walk. The parameter λ denotes the overall tightness of the prior and is set to $\lambda = 0.5$. The prior becomes uninformative for $\lambda \to \infty$. Lastly, the prior on the constant is controlled by ν_0, to which we assign a small value of $\nu_0 = 0.01$, reflecting an uninformative prior for the vector of constants.

2.H Robustness

In this appendix, we show that our main results are robust to various alternatively plausible specifications, like lag length selected by an information criterion (Akaike), as well as alternative variables for economic activity and the price level.

2.H.1 Robustness results: VAR model with GDP

2.H.1.1 Lag length of 12 selected by information criterion

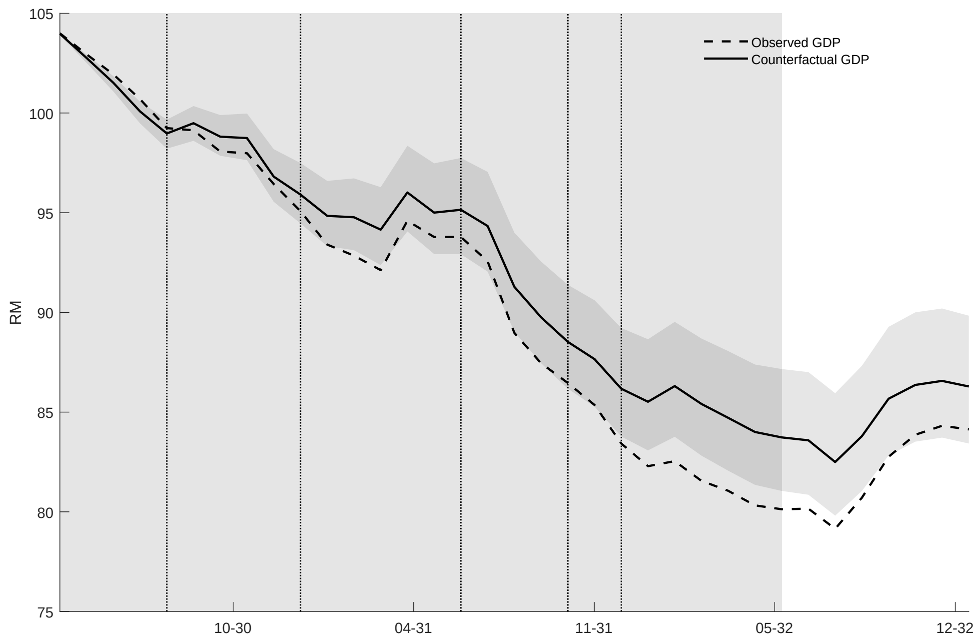


Figure 2.8: Counterfactual for GDP per capita between March 1930 and January 1933. The bold line depicts median counterfactual GDP in the absence of austerity shocks and the dark-grey shaded area shows 68 percent credible bands. The dashed line illustrates observed GDP. The light-grey shaded area marks Brüning's term of office. The dotted lines indicate the emergency decrees' announcement dates.

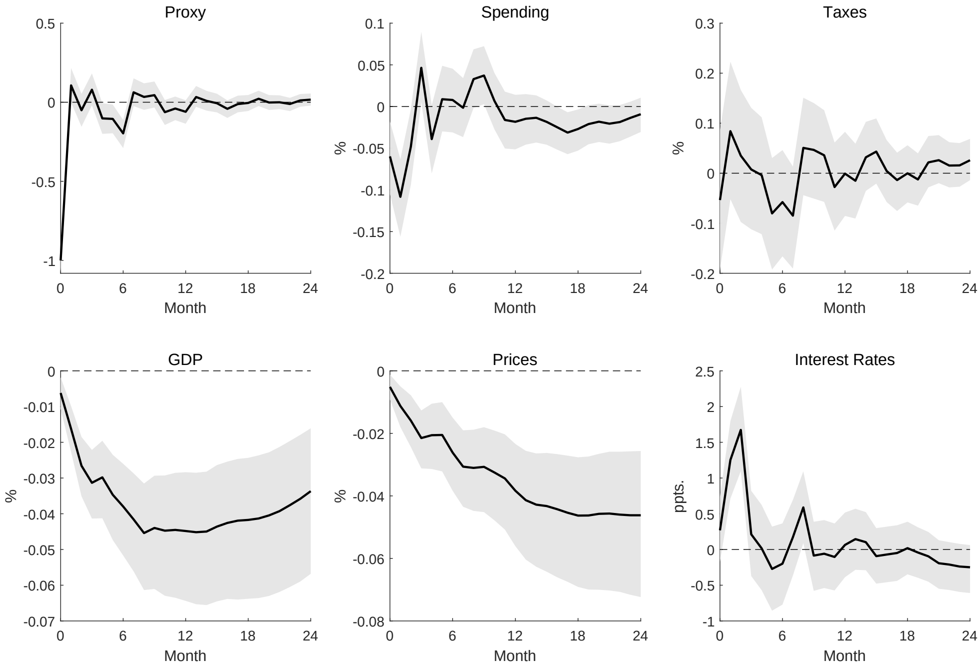


Figure 2.9: Impulse responses to an austerity shock. The solid line depicts the median impulse response of the specified variable to a one-unit austerity shock identified in the VAR model with GDP per capita. Shaded bands denote the 68 percent credible sets.

2.H.1.2 CPI, instead of WPI, as price indicator

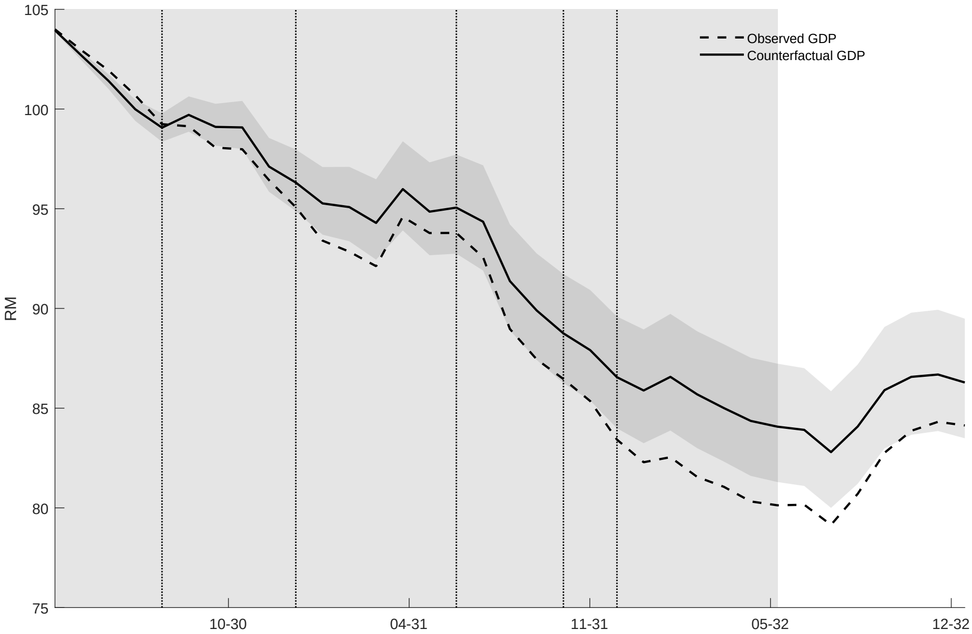


Figure 2.10: Counterfactual for GDP per capita between March 1930 and January 1933. The bold line depicts median counterfactual GDP in the absence of austerity shocks and the dark-grey shaded area shows 68 percent credible bands. The dashed line illustrates observed GDP. The light-grey shaded area marks Brüning's term of office. The dotted lines indicate the emergency decrees' announcement dates.

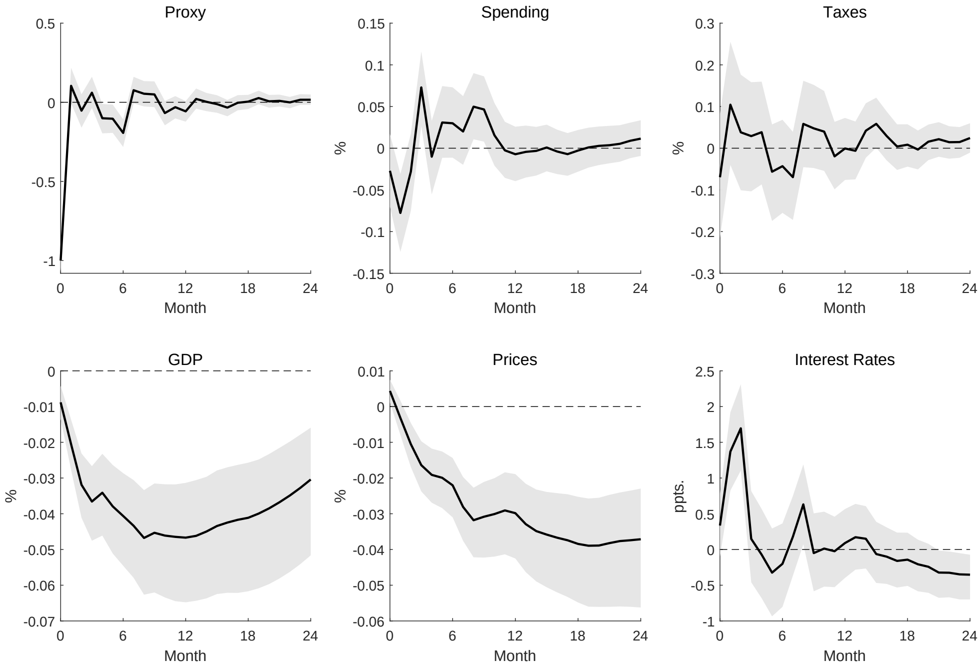


Figure 2.11: Impulse responses to an austerity shock. The solid line depicts the median impulse response of the specified variable to a one-unit austerity shock identified in the VAR model with GDP per capita. Shaded bands denote the 68 percent credible sets.

2.H.1.3 Industrial production instead of GDP per capita

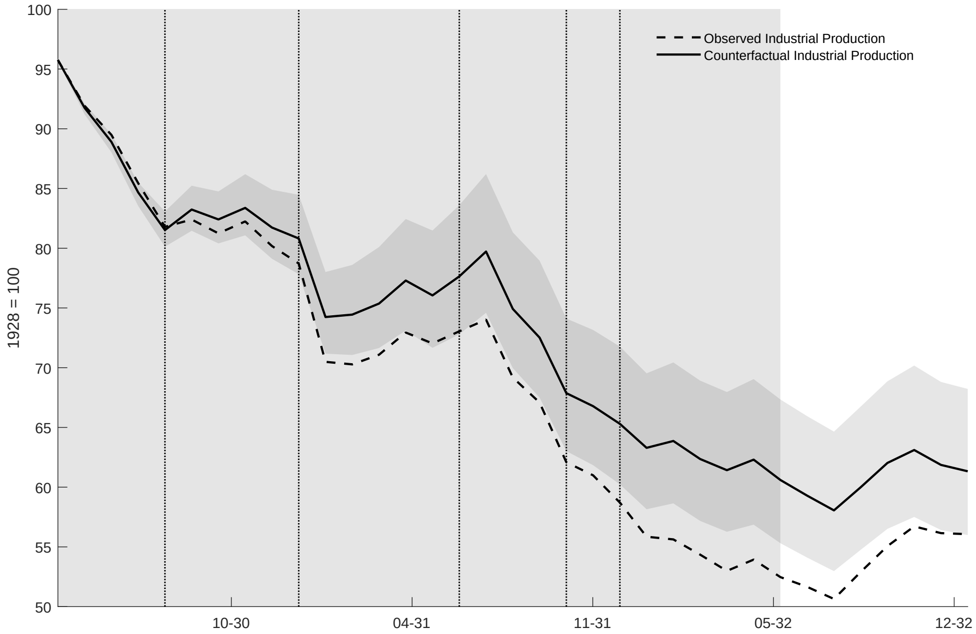


Figure 2.12: Counterfactual for industrial production between March 1930 and January 1933. The bold line depicts median counterfactual industrial production in the absence of austerity shocks and the dark-grey shaded area shows 68 percent credible bands. The dashed line illustrates observed industrial production. The light-grey shaded area marks Brüning's term of office. The dotted lines indicate the emergency decrees' announcement dates.

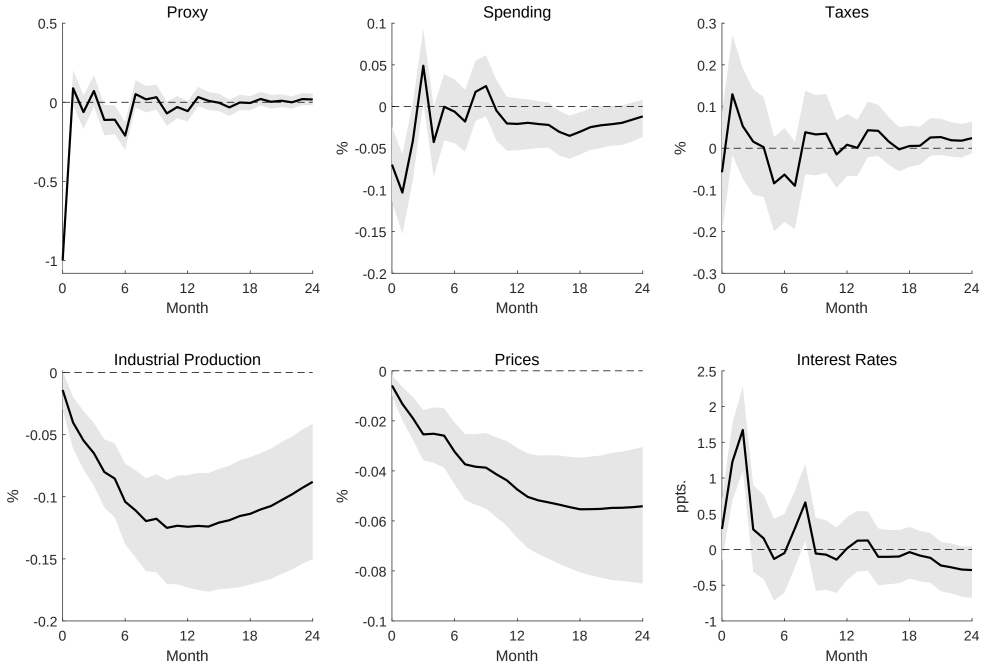


Figure 2.13: Impulse responses to an austerity shock. The solid line depicts the median impulse response of the specified variable to a one-unit austerity shock identified in the VAR model with industrial production. Shaded bands denote the 68 percent credible sets.

2.H.2 Robustness results: VAR model with unemployment

2.H.2.1 Lag length of 12 selected by information criterion

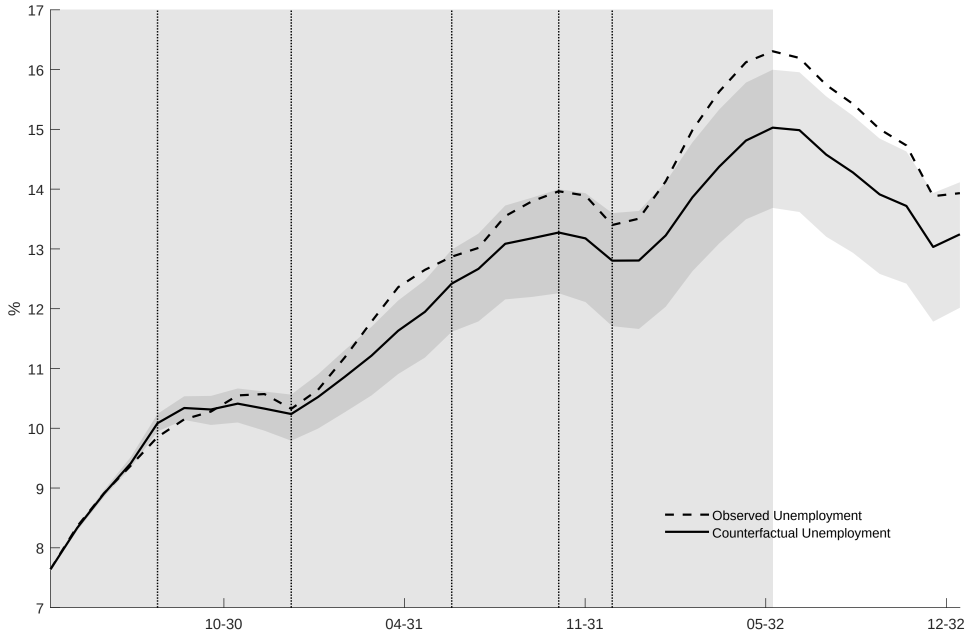


Figure 2.14: Counterfactual for the unemployment rate between March 1930 and January 1933. The bold line depicts the median counterfactual unemployment rate in the absence of austerity shocks and the dark-grey shaded area shows 68 percent credible bands. The dashed line illustrates the observed unemployment rate. The light-grey shaded area marks Brüning's term of office. The dotted lines indicate the emergency decrees' announcement dates.

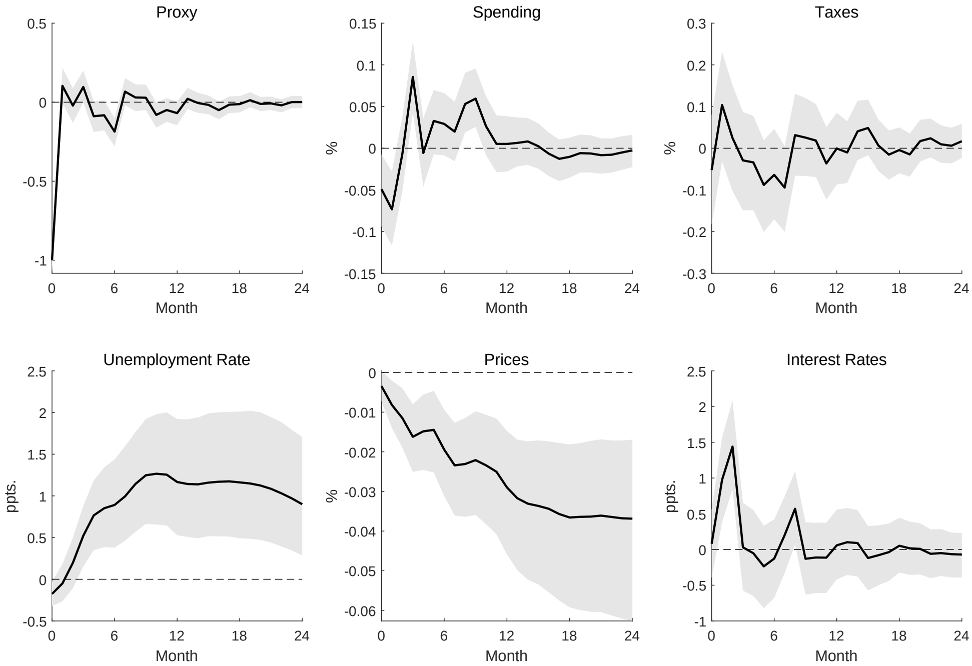


Figure 2.15: Impulse responses to an austerity shock. The solid line depicts the median impulse response of the specified variable to a one-unit austerity shock identified in the VAR model with unemployment. Shaded bands denote the 68 percent credible sets.

2.H.2.2 CPI, instead of WPI, as price indicator

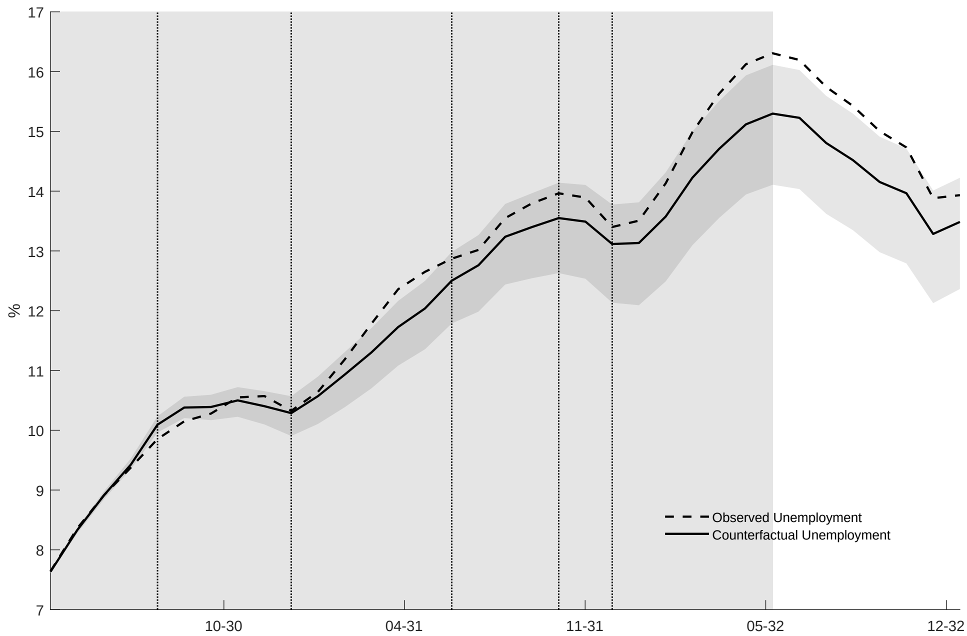


Figure 2.16: Counterfactual for the unemployment rate between March 1930 and January 1933. The bold line depicts the median counterfactual unemployment rate in the absence of austerity shocks and the dark-grey shaded area shows 68 percent credible bands. The dashed line illustrates the observed unemployment rate. The light-grey shaded area marks Brüning's term of office. The dotted lines indicate the emergency decrees' announcement dates.

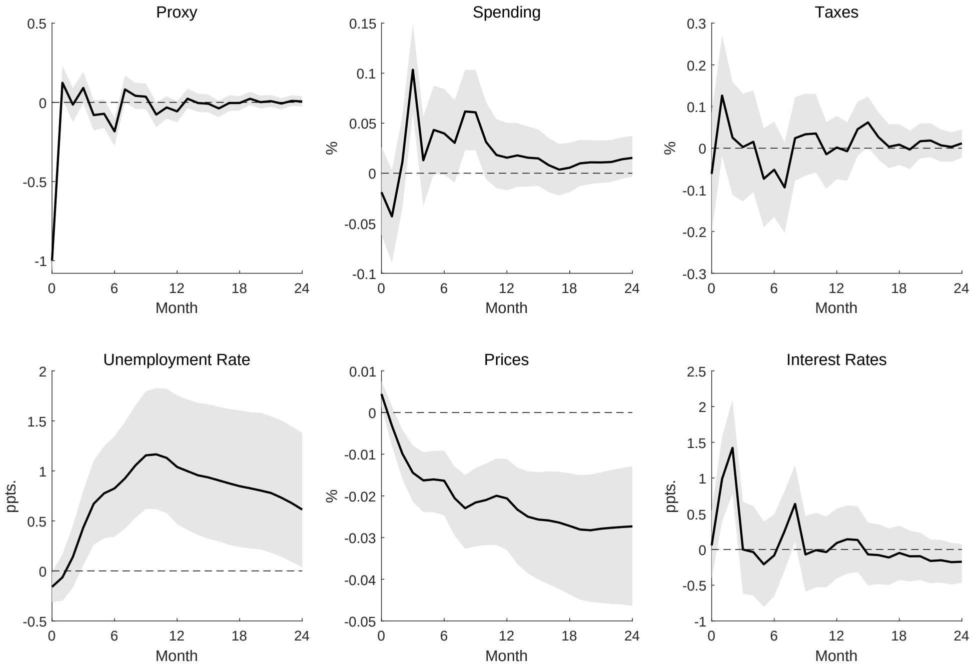


Figure 2.17: Impulse responses to an austerity shock. The solid line depicts the median impulse response of the specified variable to a one-unit austerity shock identified in the VAR model with unemployment. Shaded bands denote the 68 percent credible sets.

CHAPTER 3

Same, but Different? Testing Monetary Policy Shock Measures

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CHAPTER 4

Active or Passive? Revisiting the Role of Fiscal Policy in the Great Inflation

Stephanie Ettmeier and Alexander Kriwoluzky

4.1 Introduction

After decades of generally stable prices, 2021 marked a turning point with a global surge of inflation. However, the specific drivers of price increases differ across countries, while Covid-19 supply-chain disruptions alongside shocks to energy and food prices have aggravated the inflation problem ubiquitously. In advanced economies, heavy fiscal stimulus in response to the pandemic, most notably US President Biden's $ 1.9 trillion of federal government spending included in the American Rescue Plan Act, added to the resurging demand and eroded the fiscal authorities' credibility in stabilizing the accumulated fiscal imbalances (Bianchi and Melosi, 2022). In consideration of the multiple factors behind the price increase, a coordinated effort of central banks and fiscal authorities is needed to tackle inflation.

For one historical episode, which is very instructive for all these aspects, the debate about the monetary-fiscal policy mix is still unsettled. This episode is usually referred to as the Great Inflation of the 1960s and 1970s in the US. In our study, we revisit the role of fiscal policy during the Great Inflation to obtain insights for potential policy options in the current economic crisis. We estimate a DSGE model with three distinct monetary/fiscal policy regimes using a Sequential Monte Carlo algorithm (SMC) - a posterior sampler established in the DSGE literature by Herbst and Schorfheide (2014, 2015). The SMC is able to deal with multimodal posterior surfaces and enables us to estimate a fixed-regime DSGE model with distinct monetary/fiscal policy regimes over its entire parameter space. We find that the macroeconomic dynamics during the pre-Volcker period were almost similarly driven by a passive monetary/passive fiscal policy regime and fiscal dominance. This new result calls for a more differentiated perspective on the causes of the Great Inflation. Not only did non-policy shocks create inflationary pressure, but fiscal policy actions, in particular government spending, were also an equally important driver of US inflation in the 1960s and 1970s.

Our findings contribute to the still open role of US fiscal policy during the Great Inflation. The literature largely agrees that monetary policy in the pre-Volcker period was passive and, hence, unable to stabilize prices.[1] However, concerning the stance of fiscal policy, the evidence is mixed. Bhattarai et al. (2016), who apply random walk Metropolis-Hastings sampling (RWMH) to estimate a fixed-regime DSGE model with monetary and fiscal policy interactions, find that the fiscal authority was passive and strongly increased taxes to debt.[2] On the contrary, studies relying on regime-switching DSGE models like Davig and Leeper (2006), Bianchi (2012), Bianchi and Ilut (2017), and Chen et al. (2019) mainly attribute the leading role in the pre-Volcker period to the fiscal authority.

By re-estimating the fixed-regime model of Bhattarai et al. (2016) with the more suitable SMC posterior sampler, we finally dissolve the persisting dissonance between these two model classes. As demonstrated by Herbst and Schorfheide (2014, 2015) and Cai et al. (2020), the SMC sampler outperforms the RWMH in the presence of multimodal posteriors, an outcome that is highly likely in a DSGE model with monetary-fiscal policy interactions. The model's different policy regimes exhibit different model dynamics and, hence, lead to discontinuous likelihood functions around the policy regimes. Compared to models with a single policy regime, this feature makes it harder for posterior samplers to transition between areas of the parameter space with similar fit. We contrast the RWMH's and SMC's performance in such a model and show that the choice of the posterior sampler determines the estimation outcome. While the SMC sampler can deal with the irregular posterior surface and can navigate through the entire parameter space, the RWMH produces posterior regime probabilities that highly depend on the sampler's starting value.

While Bhattarai et al. (2016) circumvented these issues by estimating each regime separately with RWMH and determining the prevailing policy mix by model comparison, we can execute the same estimation in one step using SMC.[3] Estimating the model over its continuous parameter space allows us to determine the posterior probability of each policy regime directly and to draw a more nuanced conclusion: in line with

[1] Clarida et al. (2000) and Mavroeidis (2010) estimate monetary policy reaction functions. Lubik and Schorfheide (2004) consider a monetary DSGE model that allows for indeterminacy, Boivin and Giannoni (2006) combine evidence from vector autoregressive and general equilibrium analysis, while Coibion and Gorodnichenko (2011), including the trend level of inflation in their study, arrive at a similar conclusion. Bilbiie and Straub (2013) rationalize the Fed's passive policy response in the pre-Volcker period with limited asset market participation and find it was consistent with equilibrium determinacy. Ascari et al. (2019) also find evidence for passive monetary policy in the pre-Volcker period. However, their analysis explains the Great Inflation with temporary unstable inflation dynamics due to expectations, which were independent from monetary policy behavior.

[2] In an earlier study, Traum and Yang (2011) find no evidence for an active US fiscal authority in the pre-Volcker period. Tan and Walker (2015) point out potential for observational equivalence across active and passive fiscal policy in a cashless version of the model of Leeper (1991).

[3] Bianchi and Nicolò (2021) propose a novel solution method that is particularly relevant for models with an unknown degree of indeterminacy and/or unknown boundaries of the determinacy region. For inference, they suggest the SMC algorithm, as used in this study, or, as an alternative, a hybrid Metropolis-Hastings algorithm. Ascari et al. (2019), Hirose et al. (2020), and Haque et al. (2021) are applications of the SMC algorithm for estimating a DSGE model with multiple regimes. However, all three studies exclusively examine the role of monetary policy and omit the fiscal side from the model.

Bhattarai et al. (2016), we find that equilibrium indeterminacy indeed played an important role pre-Volcker. However, echoing the conclusion of regime-switching DSGE models, regime F, at 37 % posterior probability, mattered as well. Hence, putting all weight on indeterminacy is misleading for understanding the mechanism behind the Great Inflation.

The remainder of this paper is as follows. Section 4.2 describes the DSGE model with monetary-fiscal policy interactions and in Section 4.3, we outline our empirical approach. We describe the prior distributions and the dataset and contrast the two posterior sampler we employ, RWMH and SMC sampling. Section 4.4 provides the estimation results. We determine the monetary-fiscal policy mix in the pre-Volcker period sequentially with RWMH and SMC, comparing the two samplers' performances. In light of our new findings, in Section 4.5, we re-examine what caused the build-up of US inflation in the 1960s and 1970s. The final section concludes the study.

4.2 A DSGE model with monetary-fiscal policy interactions

In this section, we outline the fixed-regime DSGE model with monetary-fiscal policy interactions of Bhattarai et al. (2016), our reference model, characterize its distinct monetary-fiscal policy regimes, and present the solution method for the model.

4.2.1 Model description

We use the fixed-regime DSGE model set up in Bhattarai et al. (2016). It features a complete description of fiscal policy, a time-varying inflation and debt-to-output target, partial dynamic price indexation, and external habit formation in consumption. Here, we only present the first-order approximations of the model equations that determine equilibrium dynamics. For a detailed analysis of the model's characteristics, we refer the reader to the original study.

Consumption behavior of households is given by the consumption Euler equation:

$$\begin{aligned}\hat{C}_t = \frac{\bar{a}}{\bar{a}+\eta}E_t\hat{C}_{t+1} + \frac{\eta}{\bar{a}+\eta}\hat{C}_{t-1} - \left(\frac{\bar{a}-\eta}{\bar{a}+\eta}\right)\left(\hat{R}_t - E_t\hat{\pi}_{t+1}\right) + \frac{\bar{a}}{\bar{a}+\eta}E_t\hat{a}_{t+1} - \\ -\frac{\eta}{\bar{a}+\eta}\hat{a}_t + \left(\frac{\bar{a}-\eta}{\bar{a}+\eta}\right)\hat{d}_t,\end{aligned} \tag{4.1}$$

where $\hat{C}_t$ is aggregate consumption, $\hat{R}_t$ is the interest rate on government bonds, $\hat{a}_t$ is the growth rate of technology, $\hat{\pi}_t$ is the inflation rate, and $\hat{d}_t$ stands for preferences.[4] The parameters $\bar{a}$ and η denote the steady-state value of a_t and external habit formation, respectively.

[4]We define the log-linear deviation of a detrended variable from its corresponding steady state as $\hat{X}_t = lnX_t - ln\bar{X}$. Only the fiscal variables $\hat{b}_t = b_t - \bar{b}$, $\hat{g}_t = g_t - \bar{g}$, $\hat{\tau}_t = \tau_t - \bar{\tau}$, and $\hat{s}_t = s_t - \bar{s}$ are normalized by output and linearized around their steady states.

The New Keynesian Phillips curve is denoted by

$$\hat{\pi}_t = \frac{\beta}{1+\gamma\beta}E_t\hat{\pi}_{t+1} + \frac{\gamma}{1+\gamma\beta}\hat{\pi}_{t-1} + \kappa\left[\left(\varphi + \frac{\bar{a}}{\bar{a}-\eta}\right)\hat{Y}_t - \frac{\eta}{\bar{a}-\eta}\hat{Y}_{t-1} + \frac{\eta}{\bar{a}-\eta}\hat{a}_t - \right.$$
$$\left. - \left(\frac{\bar{a}}{\bar{a}-\eta}\right)\left(\frac{1}{1-\bar{g}}\right)\hat{g}_t + \left(\frac{\eta}{\bar{a}-\eta}\right)\left(\frac{1}{1-\bar{g}}\right)\hat{g}_{t-1}\right] + \hat{u}_t, \tag{4.2}$$

where $\hat{Y}_t$ is aggregate output, $\hat{g}_t$ represents the government spending-to-output ratio, and $\hat{u}_t$ can be interpreted as cost-push shock. The parameters β, γ, φ, and $\bar{g}$ are, respectively, the discount factor, the degree of price indexation, the inverse of the Frisch elasticity of labor supply, and the steady-state value of government spending. Furthermore, $\kappa := \frac{(1-\alpha\beta)(1-\alpha)}{\alpha\left(1+\varphi\bar{\theta}\right)(1+\gamma\beta)}$. α stands for the degree of price rigidity in the economy and $\bar{\theta}$ for the steady-state value of the elasticity of substitution between intermediate goods.

Monetary policy is characterized by the following rule:

$$\hat{R}_t = \rho_R\hat{R}_{t-1} + (1-\rho_R)\left[\phi_\pi(\hat{\pi}_t - \hat{\pi}_t^*) + \phi_Y(\hat{Y}_t - \hat{Y}_t^*)\right] + \epsilon_{R,t}. \tag{4.3}$$

$\hat{\pi}_t^*$ is the inflation target and $\hat{Y}_t^*$ is potential output. The idiosyncratic monetary policy shock $\epsilon_{R,t}$ is assumed to evolve as i.i.d. $N(0, \sigma_R^2)$. The parameters ρ_R, ϕ_π, and ϕ_Y represent, respectively, interest rate smoothing, responses to deviations of inflation from its target, and responses to deviations of output from its natural level.

The fiscal authority sets lump-sum taxation by a rule:

$$\hat{\tau}_t = \rho_\tau\hat{\tau}_{t-1} + (1-\rho_\tau)\left[\psi_b(\hat{b}_{t-1} - \hat{b}_{t-1}^*) + \psi_Y(\hat{Y}_t - \hat{Y}_t^*)\right] + \epsilon_{\tau,t}. \tag{4.4}$$

$\hat{\tau}_t$ stands for the tax-revenue-to-output ratio, $\hat{b}_t$ is the debt-to-output ratio, and $\hat{b}_t^*$ is the debt-to-output ratio target. The non-systematic tax policy shock $\epsilon_{\tau,t}$ is assumed to evolve as i.i.d. $N(0, \sigma_\tau^2)$. The tax policy rule features tax smoothing (ρ_τ), systematic reactions of tax revenues to deviations of lagged debt from its target (ψ_b), and to deviations of output from natural output (ψ_Y).

The government spending rule is modeled as

$$\hat{g}_t = \rho_g\hat{g}_{t-1} - (1-\rho_g)\chi_Y\left(\hat{Y}_{t-1} - \hat{Y}_{t-1}^*\right) + \epsilon_{g,t}. \tag{4.5}$$

$\hat{g}_t$ stands for the government spending-to-output ratio. The exogenous shock to government spending $\epsilon_{g,t}$ is assumed to follow an i.i.d.-process with $N(0, \sigma_g^2)$. ρ_g represents smoothing in government purchases and χ_Y is the response of government spending to the lagged output gap. Under the assumption of flexible prices, the natural level of government spending is:

$$\hat{g}_t^* = \rho_g \hat{g}_{t-1}^* + \epsilon_{g,t}. \tag{4.6}$$

The government budget constraint is given by:

$$\hat{b}_t = \frac{1}{\beta}\hat{b}_{t-1} + \frac{\bar{b}}{\beta}\left(\hat{R}_{t-1} - \hat{\pi}_t - \hat{Y}_t + \hat{Y}_{t-1} - \hat{a}_t\right) + \hat{g}_t - \hat{\tau}_t + \hat{s}_t. \tag{4.7}$$

$\hat{s}_t$ is the ratio of government transfers to output and the parameter $\bar{b}$ is the steady-state value of the debt-to-output ratio.

The aggregate resource constraint is given by:

$$\hat{Y}_t = \hat{C}_t + \frac{1}{1-\bar{g}}\hat{g}_t. \tag{4.8}$$

The natural level of output is:

$$\hat{Y}_t^* = \frac{\eta}{\varphi(\bar{a}-\eta)+\bar{a}}\hat{Y}_{t-1}^* + \frac{\bar{a}}{[\varphi(\bar{a}-\eta)+\bar{a}](1-\bar{g})}\hat{g}_t^* - \frac{\eta}{[\varphi(\bar{a}-\eta)+\bar{a}](1-\bar{g})}\hat{g}_{t-1}^* - \\ - \frac{\eta}{\varphi(\bar{a}-\eta)+\bar{a}}\hat{a}_t. \tag{4.9}$$

Finally, six additional exogenous shocks drive economic fluctuations. These are all assumed to evolve according to univariate AR(1) processes.
Preferences evolve as

$$\hat{d}_t = \rho_d \hat{d}_{t-1} + \epsilon_{d,t} \qquad \text{with } \epsilon_{d,t} \sim i.i.d.\ N(0, \sigma_d^2). \tag{4.10}$$

Technology evolves as

$$\hat{a}_t = \rho_a \hat{a}_{t-1} + \epsilon_{a,t} \qquad \text{with } \epsilon_{a,t} \sim i.i.d.\ N(0, \sigma_a^2). \tag{4.11}$$

Markup shocks are assumed to follow

$$\hat{u}_t = \rho_u \hat{u}_{t-1} + \epsilon_{u,t} \qquad \text{with } \epsilon_{u,t} \sim i.i.d.\ N(0, \sigma_u^2). \tag{4.12}$$

Government transfers are given by

$$\hat{s}_t = \rho_s \hat{s}_{t-1} + \epsilon_{s,t} \qquad \text{with } \epsilon_{s,t} \sim i.i.d.\ N(0, \sigma_s^2). \tag{4.13}$$

The inflation target evolves as

$$\hat{\pi}_t^* = \rho_\pi \hat{\pi}_{t-1}^* + \epsilon_{\pi,t} \qquad \text{with } \epsilon_{\pi,t} \sim i.i.d.\ N(0, \sigma_\pi^2). \tag{4.14}$$

The debt-to-output ratio target follows

$$\hat{b}_t^* = \rho_b \hat{b}_{t-1}^* + \epsilon_{b,t} \qquad \text{with } \epsilon_{b,t} \sim i.i.d.\ N(0, \sigma_b^2). \tag{4.15}$$

4.2.2 Model solution under different policy regimes

A unique equilibrium of the economy arises if either monetary policy is active while fiscal policy is passive (regime M or AMPF) or monetary policy is passive while fiscal policy is active (regime F or PMAF). If both monetary and fiscal policy are passive, multiple equilibria exist (PMPF). No stationary equilibrium exists if both authorities act actively (AMAF). The boundaries of the distinct policy regimes can be characterized analytically in Bhattarai et al. (2016)'s model. In particular, monetary policy is active if

$$\phi_\pi > 1 - \phi_Y \left(\frac{1 - \tilde{\beta}}{\tilde{\kappa}} \right), \tag{4.16}$$

where $\tilde{\beta} = \frac{\gamma+\beta}{1+\gamma\beta}$ and $\tilde{\kappa} = \frac{(1-\alpha\beta)(1-\alpha)}{\alpha(1+\varphi\theta)(1+\gamma\beta)} \left(1 + \varphi + \frac{\chi_Y}{1-\bar{g}}\right)$, while fiscal policy is active if

$$\psi_b < \frac{1}{\beta} - 1. \tag{4.17}$$

We collect the parameters of the loglinearized model in the vector ϑ with domain Θ and solve the system of equations for its state-space representation.[5] Under determinacy (regime F, regime M), we employ the solution algorithm for linear rational expectations models of Sims (2002), which expresses the model solution as

$$z_t = \Gamma_1^*(\vartheta) z_{t-1} + \Psi^*(\vartheta)\epsilon_t, \tag{4.18}$$

where z_t is a vector of state variables, ϵ_t is a vector of exogenous variables, while both Γ_1^* and Ψ^* are coefficient matrices that depend on the model parameters collected in the vector ϑ. Under indeterminacy, we apply the generalization of this procedure suggested by Lubik and Schorfheide (2003, 2004):

$$z_t = \Gamma_1^*(\vartheta) z_{t-1} + \left[\Gamma_{0,\epsilon}^*(\vartheta) + \Gamma_{0,\zeta}^*(\vartheta)\tilde{M}\right] \epsilon_t + \Gamma_{0,\zeta}^*(\vartheta) M_\zeta \zeta_t. \tag{4.19}$$

Under indeterminacy, the transmission of fundamental shocks ϵ_t is no longer uniquely determined as it depends not only on the coefficient matrix $\Gamma_{0,\epsilon}^*$, but also on the matrices $\tilde{M}$ and $\Gamma_{0,\zeta}^*$.[6] Second, an exogenous sunspot shock ζ_t, unrelated to the fundamental shocks ϵ_t, potentially affects the dynamics of the model variables z_t. This effect depends on the coefficient matrices $\Gamma_{0,\zeta}^*$ and M_ζ.

[5] More details on the implementation of the model solution are given in Appendix 4.A.1.

[6] In accordance with Lubik and Schorfheide (2004), we replace $\tilde{M}$ with $\tilde{M} = M^*(\vartheta) + M$ to prevent that the transmission of fundamental shocks changes drastically when the boundary between the determinacy regimes and the indeterminacy regime is crossed. We choose $M^*(\vartheta)$ such that the impulse responses $\partial z_t / \partial \epsilon_t'(\vartheta, M)$ become continuous on the boundary and estimate the vector M. Appendix 4.A.2 describes the approach in more detail.

Table 4.1: Prior distributions of monetary and fiscal policy parameters

Parameter	Range	Distribution	Mean	SD	90 percent int.
ϕ_π, active / passive monetary policy	$\mathbb{R}^+$	N	0.8	0.6	$[0.14, 1.84]$
ψ_b, active / passive fiscal policy	$\mathbb{R}$	N	0	0.1	$[-0.16, 0.16]$

4.3 Empirical Strategy

In this section, we present the Bayesian empirical strategy. We describe the prior distributions and the dataset, and motivate the procedures for posterior sampling we choose to determine the monetary-fiscal policy mix in the pre-Volcker period.

Prior distributions and calibrated parameters

In line with Bhattarai et al. (2016), we fix a few model parameters. We calibrate the inverse of the Frisch elasticity of labor supply to $\varphi = 1$ and the steady-state value of the elasticity of substitution between goods to $\bar{\theta} = 8$, since these cannot be separately identified from the Calvo parameter α. We also fix the parameters measuring the persistence of the time-varying policy targets to $\rho_\pi = \rho_b = 0.995$. Our prior distributions extend over a broad range of parameter values.[7] As we initialize the SMC algorithm from the prior, we used prior predictive analysis to carefully tailor a prior that results in realistic model implications, but nevertheless remains agnostic about the prevailing policy regime.[8] In the following, we discuss only the key parameters of our analysis.

Specifically, the policy parameters in the monetary and fiscal policy rule, ϕ_π and ψ_b, play a central role in our analysis as they determine the policy regime. Table 4.1 summarizes the details. For ϕ_π, we choose a Normal distribution restricted to the positive domain with an implied 90 % probability interval from 0.14 to 1.84, while the interval extends from -0.16 to 0.16 for ψ_b. Our choice is motivated by the consideration to construct prior distributions that yield more or less equal probabilities for regime F and the PMPF regime. In particular, as we initialize the SMC algorithm from the prior, we do not want to impose artificially a certain policy regime before confronting the model with the data. The implied prior probabilities of the policy regimes presented in Table 4.2 support our choice. Regime F and the PMPF regime receive almost identical support.

A second group of parameters we want to highlight are those necessary to characterize the indeterminacy model solution. For the parameters in the vector M, representing agents' self-fulfilling beliefs, we choose, as Bhattarai et al. (2016), priors centered

[7] Table 4.4 in Appendix 4.B.1 specifies the prior distributions of all model parameters.

[8] In Appendix 4.B.2 we show results from the prior predictive analysis. Specifically, we take 20,000 draws from the prior, simulate the model's observables and plot these simulated time series against the actual data from 1960:Q1 to 1979:Q2 that we use for estimating the model.

Table 4.2: Prior probability of pre-Volcker policy regimes

	AMPF	PMAF	PMPF
Probability	25.64	37.88	36.48

Note: The prior probabilities of the policy regimes are obtained from a prior predictive analysis. We drew ϑ 20,000 times from the priors specified in Table 4.4, solved the model with each draw, and computed the shares of each policy regime.

around zero in order to let the data decide if and how indeterminacy changes the propagation mechanism of the fundamental shocks.

Data

We use the dataset of Bhattarai et al. (2016).[9] We fit the loglinearized DSGE model to six quarterly US time series and estimate the model for the pre-Volcker sample 1960:Q1 to 1979:Q2. The list of observables includes output, inflation, nominal interest rates, the tax-revenue-to-output ratio, the market value of the government debt-to-output ratio, and the government spending-to-output ratio.

RWMH vs. SMC posterior sampling

Posterior inference in DSGE models relies on sampling techniques as the moments of the posterior cannot be characterized in closed forms. Compared to Bhattarai et al. (2016), our reference study, we do not estimate each regime separately with a RWMH, but choose the SMC algorithm introduced to the DSGE literature by Creal (2007), then further enhanced and theoretically justified by Herbst and Schorfheide (2014, 2015).[10] As shown by Herbst and Schorfheide (2014, 2015), and Cai et al. (2020), the SMC algorithm outperforms the workhorse RWMH sampler in cases of multimodal posteriors, an outcome that is highly likely in the case of the DSGE model with monetary-fiscal policy interactions with a discontinuous likelihood function.[11] Due to this feature, neither are we obliged to estimate the model separately, nor must we compare model fit across

[9] The dataset is downloadable from the supplemental material of their study `https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/OHUWKM`. More details on the data and the corresponding measurement equations are given in Appendix 4.C.

[10] Chopin (2002), Del Moral et al. (2006), and Creal (2012), among others, provide further details on SMC algorithms. Cai et al. (2020) advance the tuning of the algorithm in the context of DSGE model estimation.

[11] In short, the RWMH is an iterative simulator that belongs to the class of Markov chain Monte Carlo (MCMC) techniques. Herbst and Schorfheide (2015, pp. 52-99), for instance, explain the sampler in detail.

regimes. Rather, we let the SMC algorithm explore the entire parameter space such that the probability of each policy regime is directly determined by the data.[12]

To evaluate the RWMH's and SMC's performance explicitly in a model with monetary-fiscal policy interactions, for comparison, we estimate the model over its unrestricted parameter space using RWMH and contrast the two samplers' findings. We choose a set-up that *a priori* puts the RWMH algorithm on equal grounds. In particular, we initialize (i) two chains à ten million draws at the mode of regime F and the indeterminacy regime, respectively, and pool these draws with (ii) four chains à ten million draws departing from a random value in the parameter space region of regime F and indeterminacy. Using the double number of draws from the randomly chosen starting values compared to the mode initialization, attributes the sampler a higher chance to explore the entire parameter space without getting stuck at a local mode and, hence, works in favor of the RWMH sampler. From this procedure, we obtain a total of 120 million posterior draws - an number much greater than usually computed for estimating medium-sized DSGE models.[13]

4.4 The monetary-fiscal policy mix in the pre-Volcker period

In this section, we determine the monetary-fiscal policy mix in the pre-Volcker period separately with the RWMH and the SMC and compare the performance of the two samplers. In the final discussion, we argue that the SMC, our preferred approach, is able to reconcile the empirical findings of the fixed-regime and regime-switching DSGE model literature, while also providing some intuition why restricting or not restricting the parameter space during estimation matters.

Posterior estimates

Figure 4.1 presents the posterior densities of the policy parameters ϕ_π and ψ_b from the unrestricted estimation with RWMH.[14] The values of ϕ_π and ψ_b determine the monetary-fiscal policy mix. $\phi_\pi < 1$ corresponds to a passive monetary authority, while $\phi_\pi > 1$ corresponds to an active central bank. The boundary of fiscal policy lies around zero. $\psi_b < 0$ refers to an active fiscal policy, while $\psi_b > 0$ is associated with a passive fiscal authority.

To evaluate the RWMH's performance, it is instructive to distinguish the posterior draws according to the initialization method described in Section 4.3. The blue solid and the blue dashed lines show the posterior draws obtained from initializing the

[12] The SMC algorithm generates weighted draws from a sequence of easy-to-sample proposal densities. The weighted draws are called particles. Appendix 4.D includes a more detailed description of the SMC algorithm and our choice of tuning parameters.

[13] From each chain we discard seven million draws as burn-in and use from the remainder each eighth draw to compute posterior results. In comparison, in Bhattarai et al. (2016), our reference study, a total of 21.6 million draws over all regimes is computed.

[14] For the RWMH, we monitored convergence by computing recursive means. Appendix 4.E.2 provides the corresponding plots.

RWMH at the mode of regime F and indeterminacy, respectively. The red solid line depicts the marginal posterior densities obtained from the runs started at random points in the parameter space of regime F and PMPF. The plot makes three points obvious. First, considering all draws jointly, the marginal posterior distribution of the policy parameters exhibit pronounced bimodalities. However, each initialization method taken individually generates a unimodal marginal posterior density that corresponds to a distinct policy regime. Second, starting the sampler at the mode of regime F results in posterior estimates corresponding to regime F, while starting the sampler at the mode of the indeterminacy regime produces draws exclusively from the indeterminacy region of the parameter space. Hence, initializing the RWMH at the mode of the policy regimes leads to posterior estimates that highly depend on the starting value as the sampler does not transition between regimes. Last, the indeterminacy regime is an absorbing regime. All runs started at random values, no matter if in regime F or PMPF, let the sampler draw uniquely from the indeterminacy region.

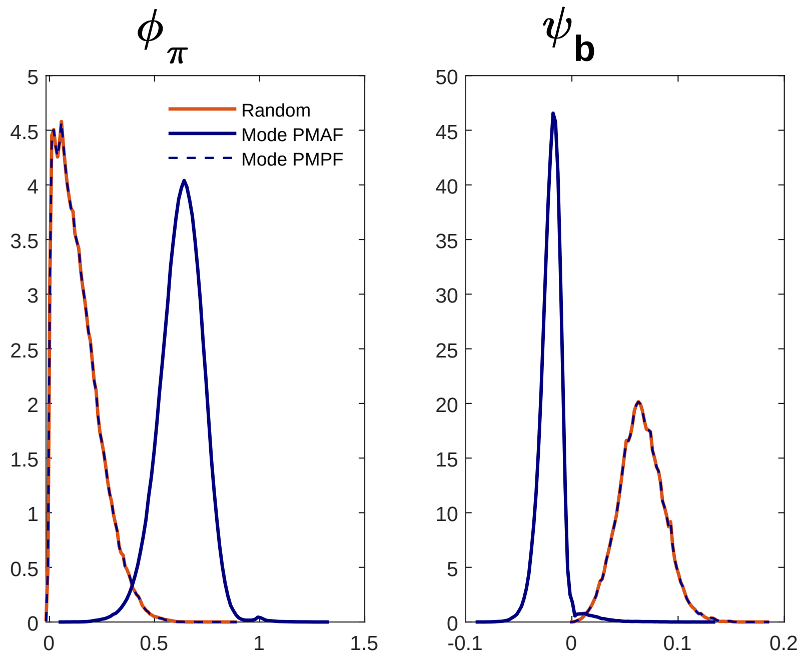


Figure 4.1: Posterior densities of the policy parameters obtained from RWMH sampling. The blue solid line depicts the posterior density obtained from initializing the sampler on the mode of regime F, the blue dashed line from initializing the sampler on the mode of regime PMPF, and the red solid line shows the posterior density obtained from the random initialization.

In Figure 4.2, we compare the marginal posterior densities of ϕ_π and ψ_b across the SMC and the RWMH samplers. The red dashed line corresponds to the posterior density obtained from SMC sampling,[15] while the blue solid line is the posterior density obtained from the pooled runs of the RWMH sampler. The black line shows the

[15]To ensure convergence of the SMC, we follow the practical recommendations given in Herbst and Schorfheide (2014) and produced 50 independent runs with the SMC sampler. We pooled the draws over the 50 runs to compute parameter means, standard errors, and credible sets.

marginal prior distribution. Similar to the RWMH, the posterior densities of ϕ_π and ψ_b from SMC sampling display pronounced bimodalities around the policy regimes. However, while the RWMH generates draws mainly in the immediate vicinity of the policy regimes' modes, the SMC sampler transitions more frequently between regimes and assigns more probability mass to parameter values between the two modes of ϕ_π and ψ_b.[16] It is also noticeable that the probability mass below each mode is unequally distributed across the samplers.

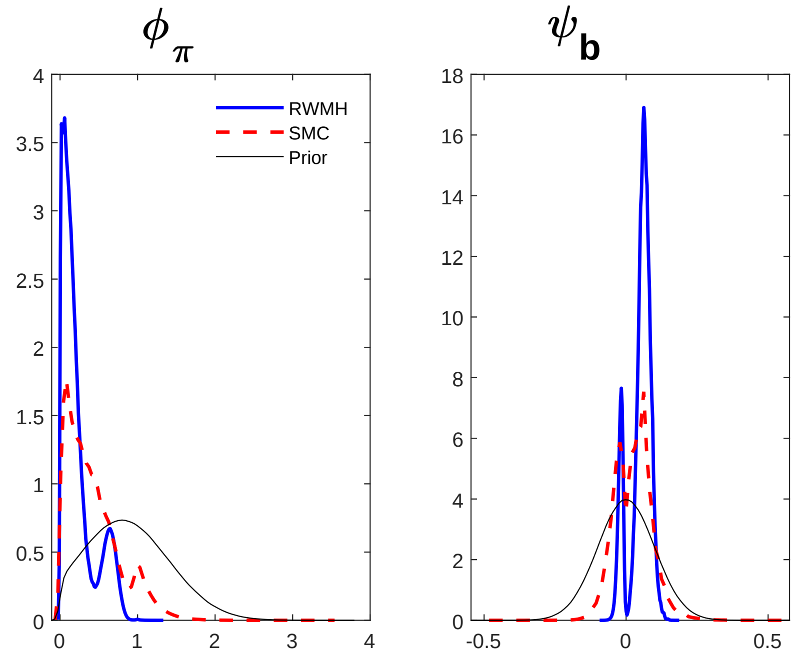


Figure 4.2: Posterior densities of the policy parameters obtained from SMC and RWMH sampling and prior densities. The blue solid line depicts the RWMH posterior density, the red dashed line the SMC posterior density, and the black line the prior density.

To shed more light on the estimated monetary-fiscal policy mix, we present the posterior probabilities of the policy regimes in the pre-Volcker period (Table 4.3). The two samplers agree that the dominant monetary-fiscal regime in the pre-Volcker period was the indeterminacy regime. However, while the RWMH attributes PMPF a posterior probability of 83.33 %, the SMC assigns the indeterminacy regime at 43.54 %, considerablye less. In contrast, regime F, receives in the SMC estimation, at 36.81 %, more than twice as much posterior probability as than in the RWMH estimation (16.32 %).

[16] Appendix 4.E.1 shows posterior estimates from an estimation in which we restrict the parameter space and apply SMC sampling to estimate each policy regime sequentially. The purpose of this exercise is to show (i) that the SMC sampler is able to replicate the RWMH estimation results of Bhattarai et al. (2016), our reference study, that the PMPF regime was the dominant regime pre-Volcker, and (ii) that our prior specification does not affect the probability of policy regimes in the posterior. Appendix 4.E.2 contains the density plots of the remaining parameters from the unrestricted estimation as well as tables with estimated means, standard deviations, and credible bands for all parameters.

In line with the literature, regime M obtaines for both samplers the least support from the data.[17]

Table 4.3: Posterior probability of pre-Volcker policy regimes

	AMPF	PMAF	PMPF
SMC	19.65	36.81	43.54
RWMH	0.35	16.32	83.33

Note: To obtain the posterior probabilities from SMC, we solved the model with each of the 20,000 particles and computed the shares of each policy regime over 50 independent runs of the algorithm. For the RWMH, the posterior regime probabilities are computed over 120 million draws.

Discussion

The comparison of posterior estimates across the RWMH and the SMC shows that the choice of the sampler influences the estimation outcome in DSGE models with monetary-fiscal policy interactions. While the RWMH produces estimates that depend on the starting value and fails to transition between the policy regimes' distinct posterior modes, the SMC can deal with irregular-shaped posterior surfaces and explores the entire parameter space. Although the two sampler coincide in finding indeterminacy to be the dominant regime in the pre-Volcker period, the general conclusion drawn from the sampler comparison is that the RWMH overstates the posterior probability of the dominant regime and underrepresents the other regimes. For that reason, the SMC is our preferred sampler to estimate DSGE models with monetary-fiscal policy interactions, like the model of Bhattarai et al. (2016).

Compared to the restricted estimation in Bhattarai et al. (2016), using SMC to estimate the model over its unrestricted parameter space allows us to draw a more differentiated conclusion. In line with Bhattarai et al. (2016), we find that the regime with the highest posterior probability in the pre-Volcker period is the PMPF regime. However, in contrast to their analysis, we find that regime F scores only slightly worse. Based on our findings, we argue that regime F also matters for the macroeconomic dynamics in the pre-Volcker period. First, in our analysis, regime F receives, at 36.81 %, considerable probability that is only seven percentage points less than, on average, the dominant PMPF regime. Due to this significant empirical support, regime F should not simply be neglected. Second, our results complement a range of studies that already convincingly discuss quantitative or narrative evidence for a leading fiscal authority during particular

[17] The finding that monetary policy in the pre-Volcker period was mainly passive, is also widely established in the literature. Therefore, in the following, we focus our discussion entirely on the still open role of fiscal policy and look exclusively on regime F and the PMPF regime. Appendix 4.E.3 contains posterior density plots of the unrestricted SMC estimation conditional on regime F and the PMPF regime.

periods in the pre-Volcker era. Sims (2011), for instance, refers to the emerging primary deficits in the US related to President Ford's tax cuts and rebates in 1975. Bianchi and Ilut (2017), in a regime-switching DSGE model, even provide empirical evidence for fiscal dominance in the US during the 1960s and 1970s, outlining the fiscal expansion due to the Vietnam War and Lyndon B. Johnson's Great Society reforms.[18] Our findings support their view that an active US fiscal policy played a substantial role in the build-up of pre-Volcker inflation.

The merit of our chosen SMC approach is that it can create new perspectives in a fixed-regime model environment. Since we can estimate the model over its entire parameter space, we remain agnostic and strictly let the data determine each policy regime's probability. In contrast, in our application, using RWMH sampling to estimate the model in one step overrepresents the posterior probability of the dominant PMPF regime as the sampler takes draws mainly around the associated mode and does not transition frequently enough to other regions of the parameter space with less likelihood. Comparably, restricting the parameter space and estimating the model sequentially for each regime with RWMH would force us to take a zero-one decision. As the model comparison results from the restricted estimation in Table 4.5 in Appendix 4.E.1 show, we would conclude that, like Bhattarai et al. (2016), only the PMPF regime was in place pre-Volcker. The other policy regimes would not be considered. Instead, our analysis allows us to draw a more nuanced conclusion: although the PMPF regime receives slightly more posterior probability throughout the 1960:Q1 to 1979:Q2 sample, regime F also mattered.

4.5 Revisiting the Great Inflation

The estimation in the previous section shows that the macroeconomic dynamics in the pre-Volcker period are similarly driven by a passive monetary/passive fiscal policy regime and fiscal dominance. In light of these results, we revisit one of the most pressing macroeconomic questions of this episode, namely, what caused the Great Inflation. In a first step, we use our findings to carry out a historical shock decomposition of pre-Volcker inflation. In a second step, we conduct a counterfactual analysis to quantify the importance of fiscal policy actions in the run up of inflation.

4.5.1 Shock decomposition

We partition the draws from the posterior according to the corresponding policy regimes determined by the SMC and conduct the historical decomposition for the PMPF regime and regime F separately.

Figure 4.3 shows the results for the PMPF regime. In line with the findings in Bhattarai et al. (2016), we find that, in the PMPF regime, pre-Volcker inflation was mainly driven by non-policy shocks, in particular, preference, markup, and technology shocks.

[18] Further references that provide evidence for fiscal dominance in the US in the pre-Volcker period include, among others, Davig and Leeper (2006), Bianchi (2012), and Chen et al. (2019). All these studies employ regime-switching model frameworks.

Importantly, sunspot shocks played only a minor role in the pre-Volcker inflation build-up.[19]

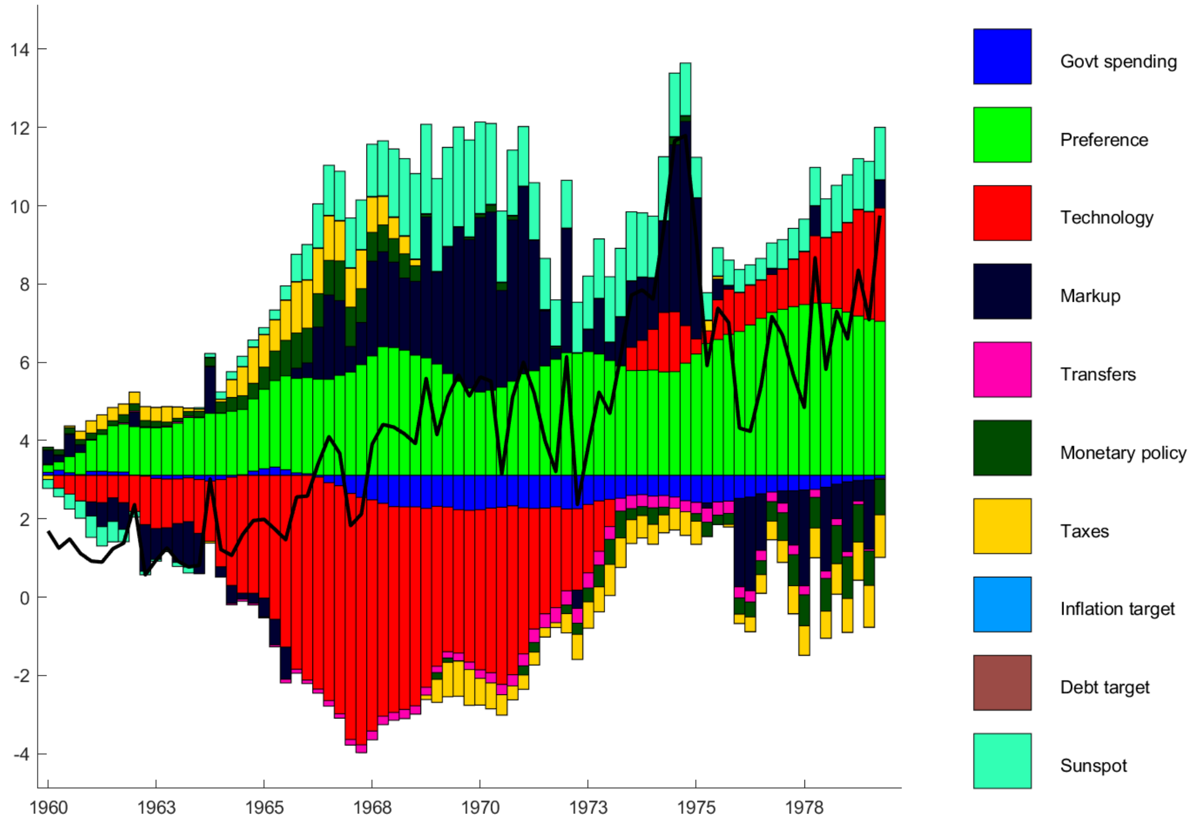


Figure 4.3: Contribution of each shock to inflation in the PMPF regime. The bold black line shows observed inflation. The historical decomposition is conducted at the posterior mean of the PMPF regime.

In regime F, the picture looks different. Figure 4.4 summarizes the findings. Technology and demand shocks played only a minor role in regime F. Instead, the mechanism of the Fiscal Theory of the Price Level (FTPL) is clearly present: fiscal actions, government spending in particular, lead to the build-up of inflation.

Summarizing our analysis, we find empirical evidence for the two most widely acknowledged explanations for the rising US inflation in the pre-Volcker period in the literature. First, fundamental non-policy shocks generated persistent inflationary pressure. Sunspot disturbances played no substantial role. Second, fiscal actions, in particular government spending, were an important driver of inflation.

[19] The fact that sunspot shocks did not play a substantial role in the pre-Volcker inflation build-up is, for instance, also confirmed in Nicolò (2020).

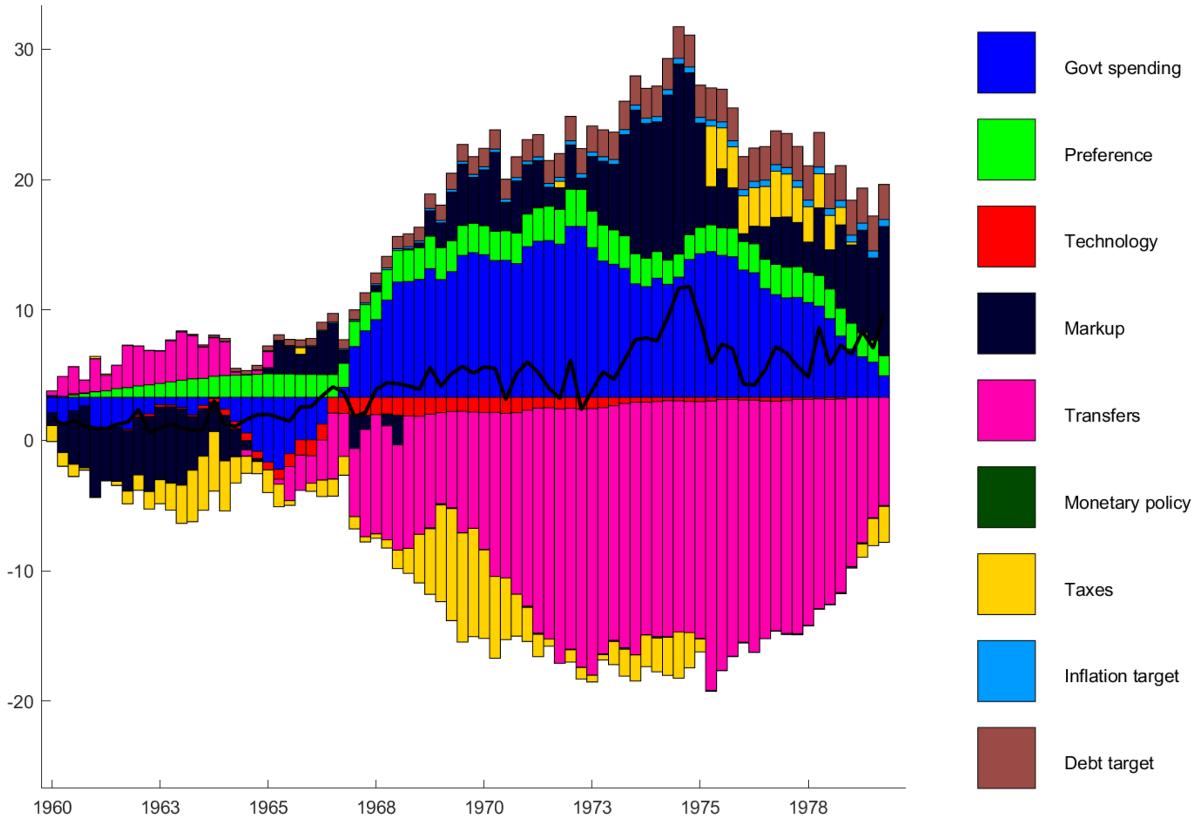


Figure 4.4: Contribution of each shock to inflation in regime F. The bold black line shows observed inflation. The historical decomposition is conducted at the posterior mean of regime F.

4.5.2 Counterfactual analysis

To further elaborate the role of government spending for pre-Volcker inflation, we carry out a counterfactual analysis. We set the contribution of government spending shocks in each regime to zero and simulate inflation with the remaining shocks. Figure 4.5 shows the result. In regime F, counterfactual inflation lies considerably below the observed time series. In the PMPF regime, on the other hand, the difference between actual and counterfactual inflation is almost negligible.

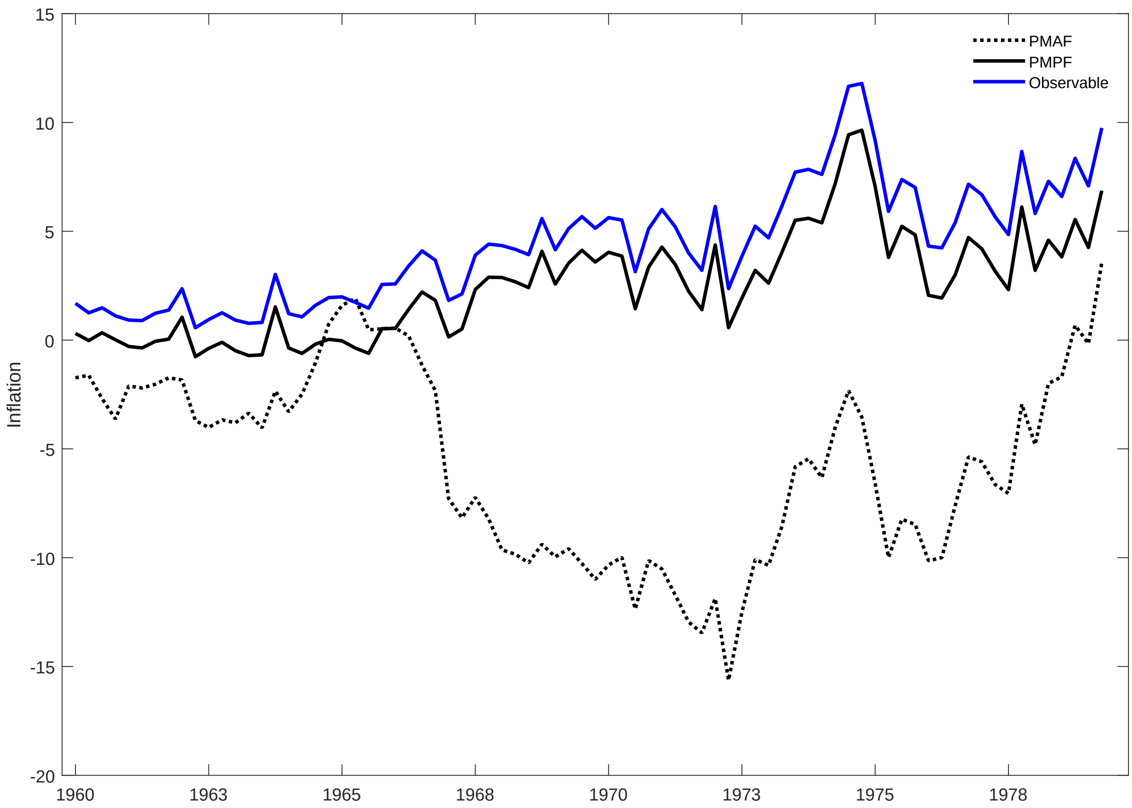


Figure 4.5: Evolution of inflation (in percentage points) without government spending shock in the PMPF regime and regime F. The counterfactual analysis is conducted at the posterior mean of each policy regime.

We can exclude that the trend of pre-Volcker inflation in regime F and the PMPF regime is due to the sheer size of the government spending shocks. Figure 4.6 shows that, pre-Volcker, the smoothed government spending shocks of regime F and the PMPF regime are nearly congruent.[20] Hence, the differing evolution of inflation is induced by the regimes themselves.

[20] Appendix 4.F shows plots of the remaining smoothed shocks for regime F and the PMPF regime, respectively.

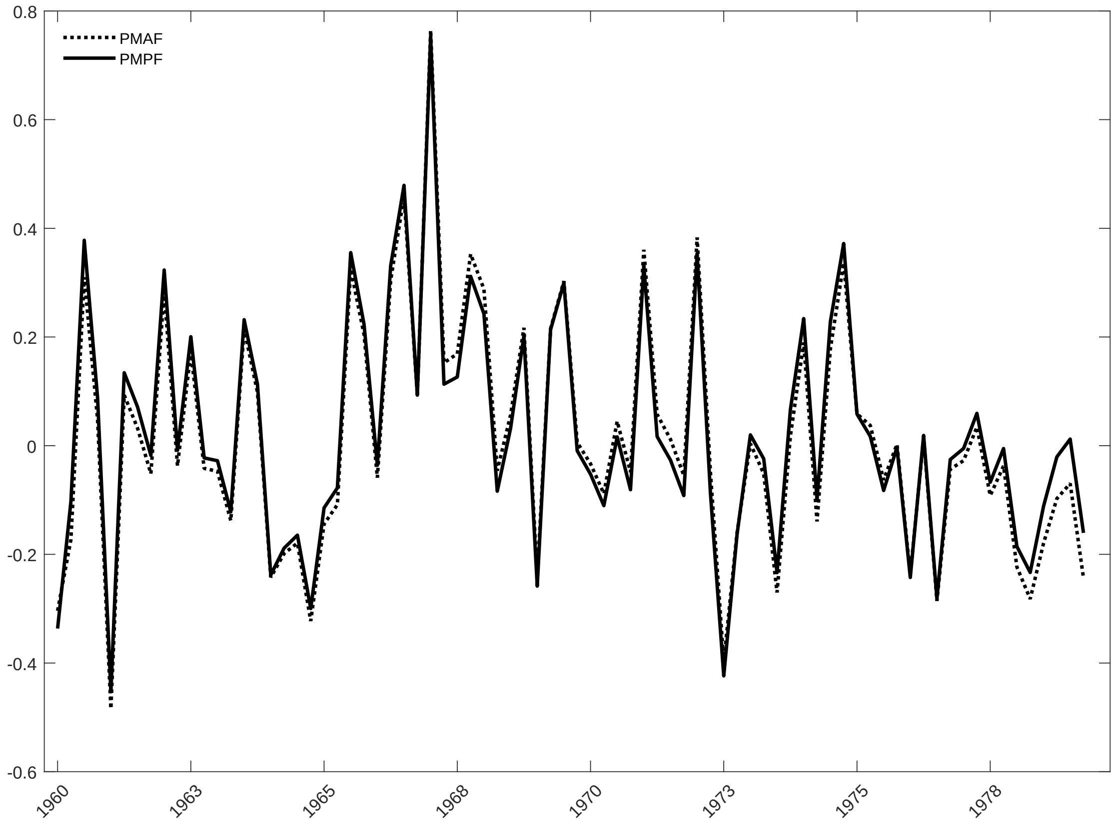


Figure 4.6: Smoothed government spending shock for 1960:Q1 to 1979:Q2 for regime F and the PMPF regime. The dotted line shows the shock computed at the posterior mean of regime F. The solid line shows the shock computed at the posterior mean of the PMPF regime.

The results of the counterfactual analysis are instructive for evaluating policy measures that effectively brought down pre-Volcker inflation. The Volcker action surely was one possible way to go. By increasing interest rates drastically, the central bank credibly signaled that it will take the lead role. Reagan complied and backed the monetary policy actions. As a result, the monetary-fiscal policy mix switched to regime M. However, conditional on the results in Figure 4.5, an alternative policy response crystallizes. Less consumption on the part of the fiscal authority during the 1970s would have also reduced the government spending-to-output ratio and, hence, countered the rising inflation.
Translating the experience of the Great Inflation to the ongoing economic disruption caused by the coronavirus, we show that monetary and fiscal policy must be determined and analyzed jointly when assessing the evolution of inflation.

4.6 Conclusion

Was fiscal policy a driver of US inflation in the pre-Volcker period? Using an SMC algorithm, we estimate a DSGE model with monetary-fiscal policy interactions over its entire parameter space. Our empirical findings reconcile two opposing strands in the literature. Similar to studies that rely on fixed-regime DSGE models, we find that the PMPF regime receives highest posterior probability throughout the 1960:Q1 to 1979:Q2 sample. However, in line with the regime-switching literature, we also find strong evidence that regime F mattered in the pre-Volcker period. Our analysis attributes fiscal policy, especially government spending, an essential role in the build-up of US inflation. This new result calls for a more differentiated perspective on the causes of the Great Inflation. Not only did non-policy shocks create inflationary pressure, but fiscal policy actions were also an equally important driver of US inflation in the 1960s and 1970s.

Appendices

4.A Model solution

4.A.1 Implementation of the model solution

The linear rational expectation form of the DSGE model presented in Section 4.2 is given by

$$\Gamma_0(\vartheta)z_t = \Gamma_1(\vartheta)z_{t-1} + \Psi(\vartheta)\epsilon_t + \Pi(\vartheta)\eta_t. \tag{4.20}$$

z is the vector of state variables, the vector ϵ includes the exogenous variables, and η is a vector of expectation errors. To apply the solution algorithm of Sims (2002), we define, for a generic variable $\hat{x}_t$, the corresponding one-step-ahead rational expectations forecast error as $\eta_{x,t} = \hat{x}_t - E_{t-1}[\hat{x}_t]$. In our application, the vectors of the general model form are defined as:

$$z_t = [\hat{c}_t\ \hat{\pi}_t\ \hat{a}_t\ \hat{R}_t\ \hat{d}_t\ \hat{Y}_t\ \hat{g}_t\ \hat{u}_t\ \hat{\pi}_t^*\ \hat{Y}_t^*\ \hat{\tau}_t\ \hat{b}_t\ \hat{b}_t^*\ \hat{s}_t\ \hat{g}_t^*\ \hat{c}_{t-1}\ \hat{\pi}_{t-1}\ \hat{g}_{t-1}\ \hat{Y}_{t-1}]',$$
$$\epsilon_t = [\epsilon_{g,t}\ \epsilon_{d,t}\ \epsilon_{a,t}\ \epsilon_{u,t}\ \epsilon_{s,t}\ \epsilon_{R,t}\ \epsilon_{\tau,t}\ \epsilon_{\pi,t}\ \epsilon_{b,t}]', \text{ and}$$
$$\eta_t = [\eta_{c,t}\ \eta_{\pi,t}]'.$$

4.A.2 Transmission mechanism around the regime boundaries

Equation 4.19 illustrates that indeterminacy changes the nature of the solution in two dimensions. First, the transmission of fundamental shocks ϵ_t is no longer uniquely determined as it additionally depends on the matrix $\tilde{M}$. Second, an exogenous sunspot shock ζ_t, unrelated to the fundamental shocks ϵ_t, potentially affects the dynamics of the model variables z_t. Thus, indeterminacy introduces additional parameters.

We denote the standard deviation of the sunspot shock as σ_ζ and normalize as Lubik and Schorfheide (2004) M_ζ to unity. Additionally, in accordance with Lubik and Schorfheide (2004), we replace $\tilde{M}$ with $\tilde{M} = M^*(\vartheta) + M$ to prevent that the transmission of fundamental shocks changes drastically when the boundary between the determinacy regimes and the indeterminacy regime is crossed. Around this boundary, small changes in ϑ should rather leave the propagation mechanism of structural shocks unaffected. That is why we choose $M^*(\vartheta)$ such that the impulse responses $\partial z_t/\partial \epsilon_t'$ become continuous on the boundary. Vector M, in contrast, which determines the relationship between fundamental shocks and forecast errors, is estimated. It can be interpreted as capturing agents' self-fulfilling beliefs and consists of the following entries: $M = \left[M_{g_\zeta}, M_{d_\zeta}, M_{a_\zeta}, M_{u_\zeta}, M_{s_\zeta}, M_{R_\zeta}, M_{\tau_\zeta}, M_{\pi_\zeta}, M_{b_\zeta}\right]$. For the parameters in M, we choose priors centered around zero and, thus, strictly let the data decide how indeterminacy changes the transmission mechanism of structural shocks.

To compute the matrix $M^*(\vartheta)$ that guarantees continuous model dynamics on the boundary, we proceed in several steps. First, we construct for every parameter vector $\vartheta \in \Theta^I$ (indeterminacy) a reparametrized vector $\vartheta^* = g^*(\vartheta)$ that lies on the boundary between the indeterminacy and the determinacy regimes. Then, $M^*(\vartheta)$ is chosen by a least-squares criterion such that the impulse responses $\frac{\partial z_t}{\partial \epsilon_t'}(\vartheta, M)$ conditional on ϑ

resemble the impulse responses conditional on the vector on the boundary $\frac{\partial z_t}{\partial \epsilon_t'}(g^*(\vartheta))$. However, the DSGE model, with monetary-fiscal policy interactions presented in Section 4.2, gives rise to two different determinate solutions (regime F and regime M) that are generally characterized by different transmission mechanisms. To deal with this ambiguity, we proceed as follows:

1. For every $\vartheta \in \Theta^I$, we construct a vector $\vartheta^M = g^M(\vartheta)$ that demarks the boundary between regime M and the indeterminacy regime and a vector $\vartheta^F = g^F(\vartheta)$ that lies on the boundary to regime F. The function $g^M(\vartheta)$ is obtained by replacing ϕ_π in the vector ϑ with

$$\tilde{\phi_\pi} = 1 - \phi_Y \left(\frac{1-\tilde{\beta}}{\tilde{\kappa}} \right). \tag{4.21}$$

   The function $g^F(\vartheta)$ is obtained by replacing ψ_b in the vector ϑ with

$$\tilde{\psi_b} = \frac{1}{\beta} - 1. \tag{4.22}$$

2. We solve the model successively with the reparametrized vectors ϑ^M and ϑ^F, then compute

$$M^M(\vartheta) = \left[\Gamma^M_{0,\zeta}(\vartheta)'\Gamma^M_{0,\zeta}(\vartheta)\right]^{-1} \Gamma^M_{0,\zeta}(\vartheta)' \left[\Gamma^M_{0,\epsilon}(g^M(\vartheta)) - \Gamma^M_{0,\epsilon}(\vartheta)\right], \text{ and} \tag{4.23}$$

$$M^F(\vartheta) = \left[\Gamma^F_{0,\zeta}(\vartheta)'\Gamma^F_{0,\zeta}(\vartheta)\right]^{-1} \Gamma^F_{0,\zeta}(\vartheta)' \left[\Gamma^F_{0,\epsilon}(g^F(\vartheta)) - \Gamma^F_{0,\epsilon}(\vartheta)\right]. \tag{4.24}$$

3. To choose the $M^*(\vartheta)$ that minimizes the discrepancy between $\frac{\partial z_t}{\partial \epsilon_t'}(\vartheta, M)$ and $\frac{\partial z_t}{\partial \epsilon_t'}(g^*(\vartheta))$, we compute the distances to the respective boundaries as

$$D^M = \left[\Gamma^M_{0,\epsilon}(g^M(\vartheta)) - \Gamma^M_{0,\epsilon}(\vartheta)\right] - \Gamma^M_{0,\zeta}(\vartheta)M^M(\vartheta), \text{ and} \tag{4.25}$$

$$D^F = \left[\Gamma^F_{0,\epsilon}(g^F(\vartheta)) - \Gamma^F_{0,\epsilon}(\vartheta)\right] - \Gamma^F_{0,\zeta}(\vartheta)M^F(\vartheta). \tag{4.26}$$

4. As, in our model, all fundamental shocks are assumed to be independent from each other, we compute the Euclidean norm of each column in D^*, sum them up, and, finally, choose the $M^*(\vartheta)$ that corresponds with[21]

$$min \left[\sum_{j=1}^{9} ||d_j^M||_2, \sum_{j=1}^{9} ||d_j^F||_2 \right].$$

Here we show plots to demonstrate that our approach delivers effectively continuous impulse response functions on the boundary between policy regimes. We draw 20,000

[21] For matrix $D^* = (d^*_{ij})$, its i-th row and j-th column are denoted by d^*_i and d^*_j, respectively.

times from the prior distribution outlined in Section 4.3 and, with each draw, solve the model. If a draw lies in the indeterminacy region, we first determine with the least-square criterion if it is closer to the monetary (regime M) or the fiscal boundary (regime F) of the determinacy region. Then we conduct the following steps:

If the draw's position in the parameter space is closer to the monetary boundary, we reparametrize the parameter vector to lie on the monetary boundary.

1. We solve the model on the boundary and compute impulse responses.
2. We step numerically from the boundary into the indeterminacy region, solve the model and compute impulse responses.
3. To check if the transmission mechanism changes when crossing the boundary, we compute the difference between the impulse responses on the boundary and the impulse responses from the indeterminacy region.

We repeat the three steps for the draws that are located closer to the fiscal boundary. Figures 4.7 and 4.8 show that the impulse responses (IRFs) are nearly congruent.

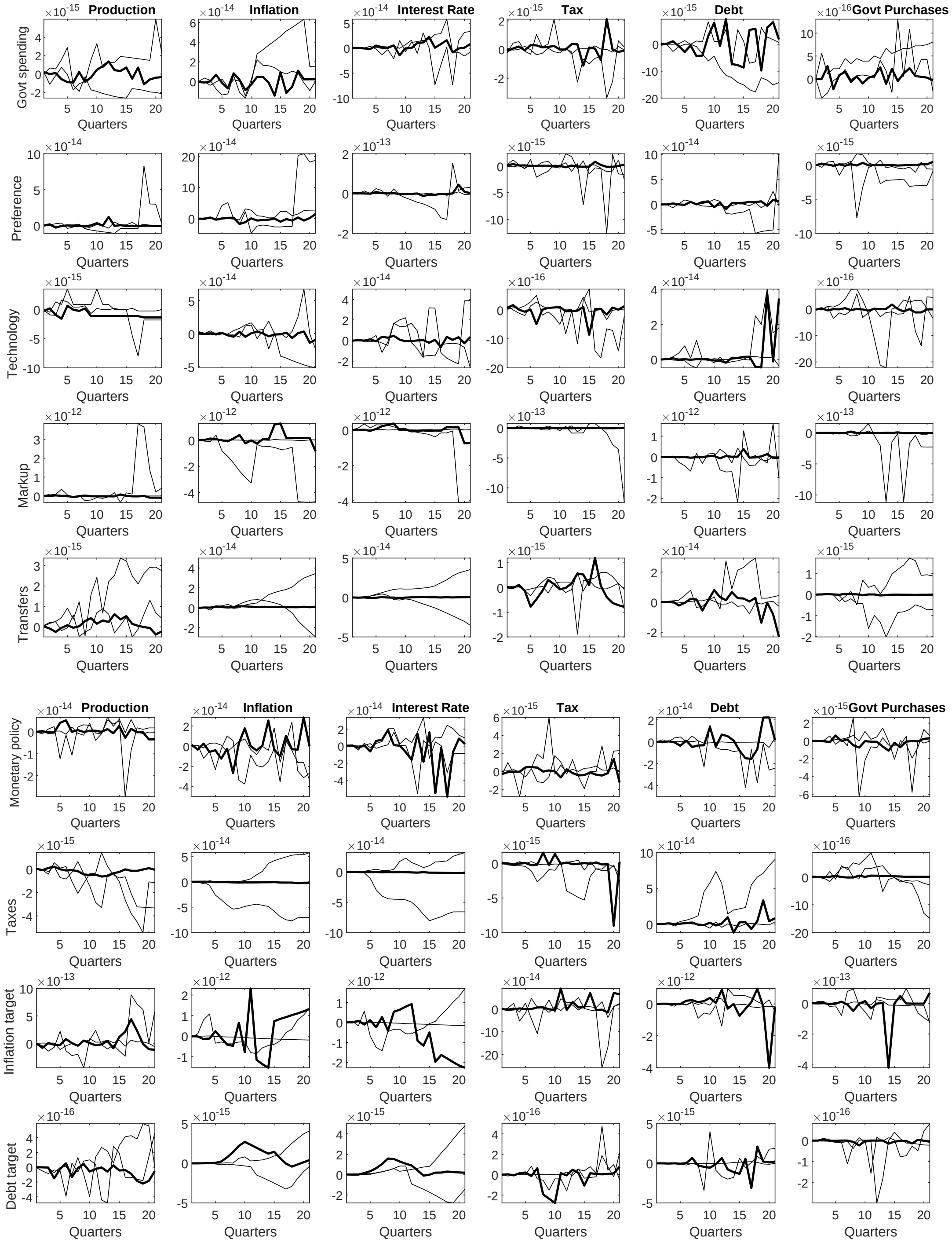


Figure 4.7: Difference of IRFs computed in the determinacy and the indeterminacy region around the monetary boundary. The bold line shows posterior means and the solid line 90 % credible sets.

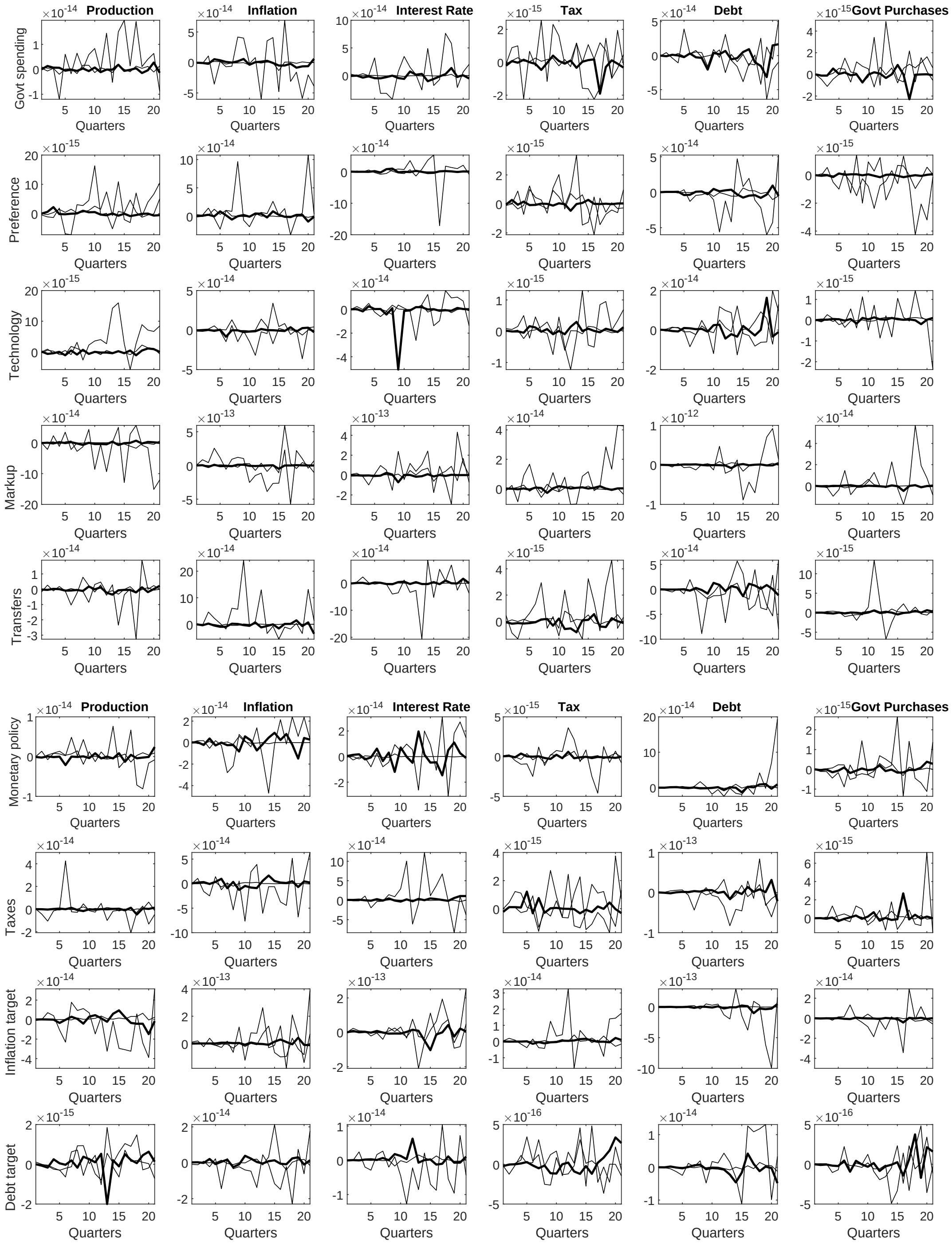


Figure 4.8: Difference of IRFs computed in the determinacy and the indeterminacy region around the fiscal boundary. The bold line shows posterior means and the solid line 90 % credible sets.

4.B Prior

In this appendix, we summarize the details of our prior distribution and show results of a prior predictive analysis.

4.B.1 Prior distribution

Table 4.4: Prior distributions

Parameter	Range	Distribution	Prior Mean	SD	90 percent int.
Monetary policy					
ϕ_π, interest rate response to inflation	$\mathbb{R}^+$	N	0.8	0.6	$[0.14, 1.84]$
ϕ_Y, interest rate response to output	$\mathbb{R}^+$	G	0.3	0.1	$[0.16, 0.5]$
ρ_R, response to lagged interest rate	$[0, 1)$	B	0.6	0.2	$[0.24, 0.9]$
Fiscal policy					
ψ_b, tax response to lagged debt	$\mathbb{R}$	N	0	0.1	$[-0.16, 0.16]$
ψ_Y, tax response to output	$\mathbb{R}$	N	0.4	0.3	$[-0.1, 0.9]$
χ_Y, govt spending response to lagged output	$\mathbb{R}$	N	0.4	0.3	$[-0.1, 0.9]$
ρ_g, response to lagged govt spending	$[0, 1)$	B	0.6	0.2	$[0.24, 0.9]$
ρ_τ, response to lagged taxes	$[0, 1)$	B	0.6	0.2	$[0.24, 0.9]$
Preference and HHs					
η, habit formation	$[0, 1)$	B	0.5	0.2	$[0.17, 0.83]$
$\mu \coloneqq 100(\beta^{-1} - 1)$, discount factor	$\mathbb{R}^+$	G	0.25	0.1	$[0.11, 0.44]$
Frictions					
α, price stickiness	$[0, 1)$	B	0.5	0.2	$[0.17, 0.83]$
γ, price indexation	$[0, 1)$	B	0.6	0.2	$[0.24, 0.9]$
Shocks					
ρ_d, preference	$[0, 1)$	B	0.6	0.2	$[0.24, 0.9]$
ρ_a, technology	$[0, 1)$	B	0.4	0.2	$[0.1, 0.76]$
ρ_u, cost-push	$[0, 1)$	B	0.6	0.2	$[0.24, 0.9]$
ρ_s, transfers	$[0, 1)$	B	0.6	0.2	$[0.24, 0.9]$
σ_g, govt spending	$\mathbb{R}^+$	Inv. Gamma	0.1	4	$[0.07, 0.24]$
σ_d, preference	$\mathbb{R}^+$	Inv. Gamma	0.3	4	$[0.19, 0.72]$
σ_a, technology	$\mathbb{R}^+$	Inv. Gamma	0.5	4	$[0.32, 1.17]$
σ_u, cost-push	$\mathbb{R}^+$	Inv. Gamma	0.04	4	$[0.026, 0.094]$
σ_s, transfers	$\mathbb{R}^+$	Inv. Gamma	0.08	4	$[0.052, 0.188]$
σ_R, monetary policy	$\mathbb{R}^+$	Inv. Gamma	0.15	4	$[0.098, 0.353]$
σ_τ, tax	$\mathbb{R}^+$	Inv. Gamma	0.2	4	$[0.13, 0.48]$
σ_π, inflation target	$\mathbb{R}^+$	Inv. Gamma	0.003	4	$[0.002, 0.007]]$
σ_b, debt/output target	$\mathbb{R}^+$	Inv. Gamma	0.05	4	$[0.033, 0.118]$

Table 4.4: Prior distributions - continued

Parameter	Prior Range	Distribution	Mean	SD	90 percent int.
Steady state					
$a := 100(\bar{a}-1)$, technology	$\mathbb{R}$	N	0.55	0.1	$[0.38, 0.71]$
$\pi := 100(\bar{\pi}-1)$, inflation	$\mathbb{R}$	N	0.8	0.1	$[0.63, 0.96]$
$b := 100\bar{b}$, debt/output	$\mathbb{R}$	N	35	2	$[31.71, 38.3]$
$\tau := 100\bar{\tau}$, tax/output	$\mathbb{R}$	N	25	2	$[21.73, 28.27]$
$g := 100\bar{g}$, govt spending/output	$\mathbb{R}$	N	22	2	$[18.81, 25.31]$
Indeterminacy					
σ_ζ, sunspot shock	$\mathbb{R}^+$	Inv. Gamma	0.2	4	$[0.13, 0.48]$
$M_{g\zeta}$	$\mathbb{R}$	N	0	1	$[-1.64, 1.64]$
$M_{d\zeta}$	$\mathbb{R}$	N	0	1	$[-1.64, 1.64]$
$M_{a\zeta}$	$\mathbb{R}$	N	0	1	$[-1.64, 1.64]$
$M_{u\zeta}$	$\mathbb{R}$	N	0	1	$[-1.64, 1.64]$
$M_{s\zeta}$	$\mathbb{R}$	N	0	1	$[-1.64, 1.64]$
$M_{R\zeta}$	$\mathbb{R}$	N	0	1	$[-1.64, 1.64]$
$M_{\tau\zeta}$	$\mathbb{R}$	N	0	1	$[-1.64, 1.64]$
$M_{\pi\zeta}$	$\mathbb{R}$	N	0	1	$[-1.64, 1.64]$
$M_{b\zeta}$	$\mathbb{R}$	N	0	1	$[-1.64, 1.64]$

Note: The Inverse Gamma prior distributions have the form $p(x|\nu, s) \propto x^{-\nu-1}e^{-\nu s^2/2x^2}$, where $\nu = 4$ and s is given by the value in the column denoted as "Mean".

4.B.2 Prior implications

Here we show results of a prior predictive analysis for the prior specification outlined in Section 4.3. Specifically, we take 20,000 draws from the prior and simulate with these draws 20,000 times the model's observables.

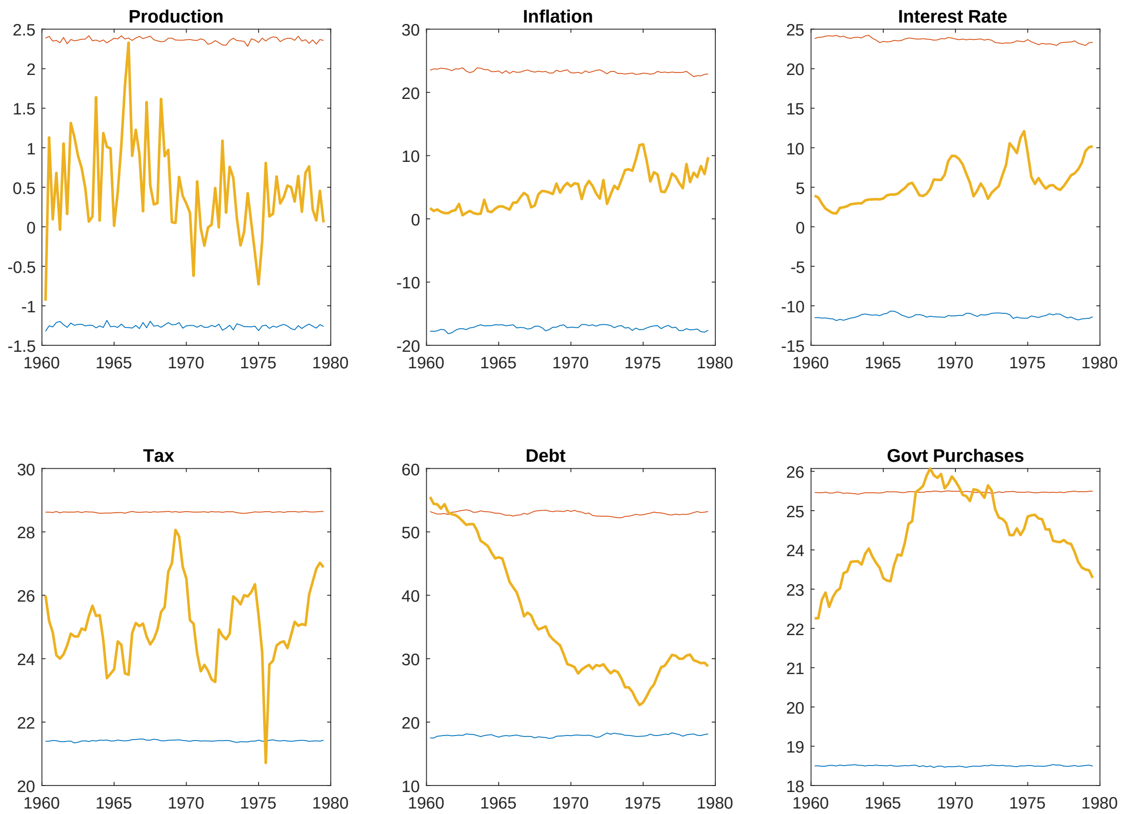


Figure 4.9: Simulated model observables vs. real data for 1960:Q1 to 1979:Q2. The bold yellow line shows the actual time series we use for estimating the model. The blue and the red line show the 90 % interval of the simulated time series.

4.C Data description

We use the dataset of Bhattarai et al. (2016). Unless otherwise noted, the data is retrieved from the National Income and Product Accounts Tables published by the Bureau of Economic Analysis. All time series in nominal values are converted to real values by dividing them by the GDP deflator.

Per capita output: Per capita output is the sum of personal consumption of non-durables and services, and government consumption divided by civilian noninstitutional population. Civilian noninstitutional population is taken from the FRED database of the Federal Reserve Bank of St. Louis.

Inflation: The gross inflation rate is the annualized GDP deflator.

Interest rate: The annualized nominal interest rate is the effective federal funds rate from the FRED database of the Federal Reserve Bank of St. Louis.

Tax revenues: The tax-revenues-to-output ratio is defined as the sum of current tax receipts and contributions for government social insurance divided by output.

Government debt: Government debt corresponds to the market value of privately held gross federal debt, retrieved from the Federal Reserve Bank of Dallas. The government debt-to-output ratio is obtained by dividing the series by output.

Government spending: The government spending-to-output ratio is defined as government consumption divided by output.

The relationship between observables and model variables is given by

$$\begin{bmatrix} 100 \times \Delta \ln \text{Production}_t \\ \text{Inflation}_t \ (\%) \\ \text{Interest}_t \ (\%) \\ \text{TaxRev}_t \ (\%) \\ \text{GovtDebt}_t \ (\%) \\ \text{GovtPurch}_t \ (\%) \end{bmatrix} = \begin{bmatrix} a \\ 4\pi \\ 4(a + \pi + \mu) \\ \tau \\ b \\ g \end{bmatrix} + \begin{bmatrix} \hat{Y}_t - \hat{Y}_{t-1} + \hat{a}_t \\ 4\hat{\pi}_t \\ 4\hat{R}_t \\ \hat{\tau}_t \\ \hat{b}_t \\ \hat{g}_t \end{bmatrix}. \tag{4.27}$$

4.D SMC algorithm

This appendix gives a technical description of the implemented SMC algorithm. In terms of exposition and notation it draws heavily on Herbst and Schorfheide (2014, 2015), and Bognanni and Herbst (2018).

4.D.1 SMC with likelihood tempering - intuition

The basic concept of the SMC relies on importance sampling, which means that the posterior $p(\vartheta, M|Y)$ is approximated by an easy-to-sample proposal, or source density. However, in the high-dimensional parameter space of DSGE models, good proposal densities are difficult to obtain. This is why the SMC constructs proposal densities sequentially. More precisely, the algorithm draws from a sequence of bridge densities that link a known starting distribution with the targeted posterior density. A meaningful starting distribution constitutes the prior $p(\vartheta, M)$. The bridge distributions, in contrast, differ in the amount of information from the likelihood they contain. At each stage of the algorithm, an increment of the likelihood is added to the proposal density. At the moment the full information from the likelihood has been released, an approximation of the posterior is obtained. In particular, the sequence of n distributions is given by

$$p_n(\vartheta, M|Y) = \frac{[p(Y|\vartheta, M)]^{\delta_n} p(\vartheta, M)}{\int [p(Y|\vartheta, M)]^{\delta_n} p(\vartheta, M) d\vartheta dM}, \quad n = 1, ..., N_\delta. \tag{4.28}$$

We follow Herbst and Schorfheide (2014) and choose the tuning parameter δ_n as an increasing sequence of values such that $\delta_1 = 0$ and $\delta_{N_\delta} = 1$. The length of this sequence coincides with the number of importance samplers. At the first stage of the algorithm, $p_1(\vartheta, M|Y)$ is the prior density $p(\vartheta, M)$. At the last stage, the final proposal density $p_{N_\delta}(\vartheta, M|Y)$ constitutes the posterior $p(\vartheta, M|Y)$. In particular, our tempering schedule $\{\delta_n\}_{n=1}^{N_\delta}$ is given by $\delta_n = (n - 1/N_\delta - 1)^\lambda$. The tuning parameter λ determines how much information from the likelihood is incorporated in each proposal density.

In a nutshell, the SMC draws in N_δ stages sequentially N parameter vectors $\vartheta^i, i = 1, ..., N$ from the proposal densities and assigns them with importance weights $\tilde{W}^i$. Each of the i pairs $(\vartheta^i, \tilde{W}^i)$ is known as a particle and the set of particles $\{(\vartheta^i, \tilde{W}^i)\}_{i=1}^N$ approximates the density in iteration. Each stage of the SMC consists of three steps. First, in the *correction* step of stage n, the particles of the previous stage $\{(\vartheta^i_{n-1}, \tilde{W}^i_{n-1})\}_{i=1}^N$ are reweighted to correct for the difference between $p_{n-1}(\vartheta, M|Y)$ and $p_n(\vartheta, M|Y)$. The second step, the *selection* step, controls the accuracy of the particle approximation. Whenever the distribution of weights becomes too uneven, systematic resampling restores a well-balanced set of particles. In the last step, the *mutation* step, the particle values are propagated around in the parameter space by M_{MH} iterations of a RWMH algorithm with N_{blocks} random blocks. The particles' new location determines the updated density $p_n(\vartheta, M|Y)$.

To estimate the model, we choose the following tuning parameters for the SMC. We use $N = 20,000$ particles, $N_\delta = 600$ stages, $\lambda = 2.4$, $N_{blocks} = 10$, $M_{MH} = 2$. As suggested by Herbst and Schorfheide (2014), λ is determined by examining the particle degeneracy after the first piece of information of the likelihood was added to the prior density in $n = 1$. We increased λ until at least 80% of the total number of particles (16,000) was retained. To choose N_{blocks} and M_{MH}, we monitored the acceptance rate in the mutation step in preliminary runs. $N_{blocks} = 10$ and $M_{MH} = 2$ insured a stable acceptance rate of 25 % without down-scaling the proposal variance too much.

4.D.2 SMC with likelihood tempering - the algorithm

1. The SMC is **initialized** by drawing the particles of the first stage ($n = 1$; $\delta_1 = 0$) from the prior density.[22]

$$\vartheta_1^i \overset{i.i.d.}{\sim} p(\vartheta) \quad i = 1, ..., N.$$

In the first stage, each particle receives equal weight such that $W_1^i = 1$.

2. **Recursions:**
`for n=2:`N_δ

    1. *Correction:* Reweight the particles from stage $n-1$ by defining the incremental and normalized weights as

$$\tilde{w}_n^i = \left[p(Y|\vartheta_{n-1}^i)\right]^{\delta_n - \delta_{n-1}}, \quad \tilde{W}_n^i = \frac{\tilde{w}_n^i W_{n-1}^i}{\frac{1}{N}\sum_{i=1}^N \tilde{w}_n^i W_{n-1}^i}, \; i = 1, ..., N.$$

    2. *Selection:* Check particle degeneracy by computing the effective sample size

$$ESS_n = \frac{N}{\frac{1}{N}\sum_{i=1}^N (\tilde{W}_n^i)^2}.$$

The ESS monitors the variance of the particle weights. The larger this variance, the more inefficient runs the sampler. If the distribution of particle weights becomes too uneven, resampling the particles helps to improve accuracy.
`if` $ESS_n < N/2$
Resample the particles via systematic resampling and set the weights to uniform

$$W_n^i = 1, \quad \hat{\vartheta}_n^i \sim \{\vartheta_{n-1}^j, \tilde{W}_n^j\}_{j=1,...,N} \quad i = 1, ..., N.$$

`else`

$$W_n^i = \tilde{W}_n^i, \quad \hat{\vartheta}_n^i = \vartheta_{n-1}^i, \quad i = 1, ..., N$$

`end if`

    3. *Mutation:* Propagate each particle $\{\tilde{\vartheta}_N^i, W_n^i\}$ via M_{MH} steps of a RWMH with N_{blocks} random blocks. See Appendix 4.D.3 for further details.

[22] To ease notation in Appendix 4.D, we assume that the parameters in M are part of ϑ.

```
end for
```

3. Process **posterior draws**.

4.D.3 Mutation step

In this section, we specify the RWMH sampler we use for particle mutation. In accordance with Herbst and Schorfheide (2014) and Bognanni and Herbst (2018), the RWMH steps in our application are characterized by two features. First, we reduce the dimensionality of the parameter vector ϑ by splitting it into N_{blocks} blocks, thus making it easier to approximate the target density in each of the RWMH's M_{MH} steps.[23] Second, we scale the variance of the proposal density adaptively. Let $\hat{\Sigma}_n$ be the estimate of the covariance of $p_n(\vartheta|Y)$ after the selection step and c_n be a scaling factor. We set c_n as a function of the previous stage's scaling factor c_{n-1} and the average empirical acceptance rate of the previous stage's mutation step $\hat{A}_{n-1}$. We target an acceptance rate of 25 % and, hence, increase c_n if the acceptance rate in stage $n-1$ was too high or decrease c_n if it was too low. In particular, the functional form is given by $\hat{c}_n = \hat{c}_{n-1} f(\hat{A}_{n-1})$, where $f(x) = 0.95 + 0.1\frac{e^{16(x-0.25)}}{1+e^{16(x-0.25)}}$.

1. In every n stage after the *selection* step, create a **random partitioning** of the parameter vector ϑ into N_{blocks}. b denotes the block of the parameter vector such that $\vartheta^i_{b,n}$ refers to the b elements of the ith particle, and $\vartheta^i_{<b,n}$ denotes the remaining partitions.

2. **Compute** an estimate of the **covariance** of the parameters as

$$\hat{\Sigma}_n = \sum_{i=1}^{N} W_n^i (\hat{\vartheta}_n^i - \hat{\mu}_n)(\hat{\vartheta}_n^i - \hat{\mu}_n)' \quad \text{with} \quad \hat{\mu}_n = \sum_{i=1}^{N} W_n^i \hat{\vartheta}_n^i.$$

The covariance for the bth block is given by

$$\hat{\Sigma}_{b,n} = [\hat{\Sigma}_n]_{b,b} - [\hat{\Sigma}_n]_{b,-b}[\hat{\Sigma}_n]^{-1}_{-b,-b}[\hat{\Sigma}_n]_{-b,b},$$

where $[\hat{\Sigma}_n]_{b,b}$ refers to the bth block of $\hat{\Sigma}_n$.

3. **MH steps:**
`for m=1:`M_{MH}

`for b=1:`N_{blocks}

1. Draw a proposal density $\vartheta_b^* \sim N(\vartheta^i_{m-1,b,n}, c_n^2 \hat{\Sigma}_{b,n})$.
$\vartheta^* = [\vartheta^i_{m,<b,n}, \vartheta^*_b, \vartheta^i_{m-1,>b,n}]$ and $\vartheta^i_{m,n} = [\vartheta^i_{m,<b,n}, \vartheta^i_{m-1,\geq b,n}]$.

2. With probability

$$\alpha = \min\left\{ \frac{[p(Y|\vartheta^*)]^{\delta_n} p(\vartheta^*)}{[p(Y|\vartheta^i_{m,n})]^{\delta_n} p(\vartheta^i_{m,n})}, 1 \right\},$$

[23] Chib and Ramamurthy (2010) and Herbst (2012) provide evidence that parameter blocking is beneficial for estimating DSGE models.

set $\vartheta^i_{m,b,n} = \vartheta^*_b$. Otherwise, set $\vartheta^i_{m,b,n} = \vartheta^i_{m-1,b,n}$.

`end for`

`end for`

4.E Posterior estimates

4.E.1 Restricted estimation

In this appendix, we show results of estimations in which we restrict the parameter space and apply SMC sampling to estimate each policy regime sequentially. The purpose of this exercise is to show (i) that the SMC sampler is able to replicate the RWMH estimation results of Bhattarai et al. (2016), our reference study, and (ii) that our prior specification does not affect the probability of policy regimes in the posterior. Hence, potential differences in findings are driven neither by the prior specification nor the sampling technique, but rather induced by restricting or not restricting the parameter space.

Restricted estimation - prior as in Bhattarai et al. (2016)

To understand how changing the posterior sampler influences the estimation results, we apply the SMC algorithm and replicate, in a first step, the study of Bhattarai et al. (2016). For this exercise, we follow strictly the approach of Bhattarai et al. (2016). We use the same dataset, and the same prior distributions.[24] It is only in terms of posterior sampling that we do not rely on RWMH sampling; rather we apply the SMC algorithm instead. We restrict the parameter space and estimate each policy regime 50 times with the SMC sampler.

Looking at the estimated marginal data densities of each regime, presented in Table 4.5, we come to the same conclusion as Bhattarai et al. (2016): the US-economy in the pre-Volcker period was in the PMPF regime. In this estimation, regime F and regime M receive no support from the data.

Table 4.5: Log marginal data densities for each policy regime from restricted estimation

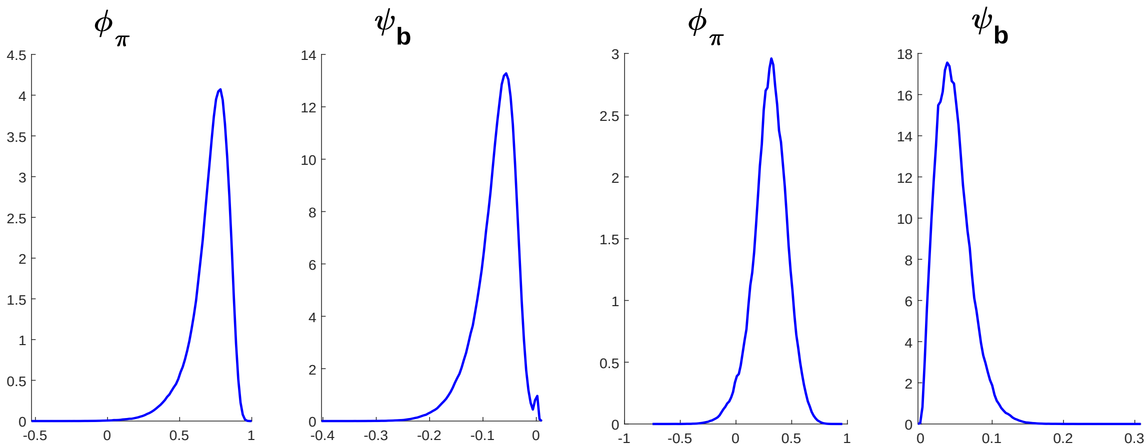
	AMPF	PMAF	PMPF
Log MDD	-541.85	-537.54	-521.41

Note: The log marginal data density is obtained as a by-product during the correction step of the SMC algorithm, see Herbst and Schorfheide (2014) for further details. For each regime, its mean is computed over 50 independent runs of the SMC algorithm.

Figure 4.10 shows plots of the posterior densities of the policy parameters for regime F and the PMPF regime. The mean estimates for the Taylor-coefficient ϕ_π (regime F: 0.71; PMPF: 0.31) and ψ_b (regime F: -0.08; PMPF: 0.05) are in line with the findings

[24] For details on this prior specification, we refer the reader to the Online Appendix of the original study.

of Bhattarai et al. (2016). Hence, using the SMC instead of the RWMH algorithm for posterior sampling does not influence the estimation results.

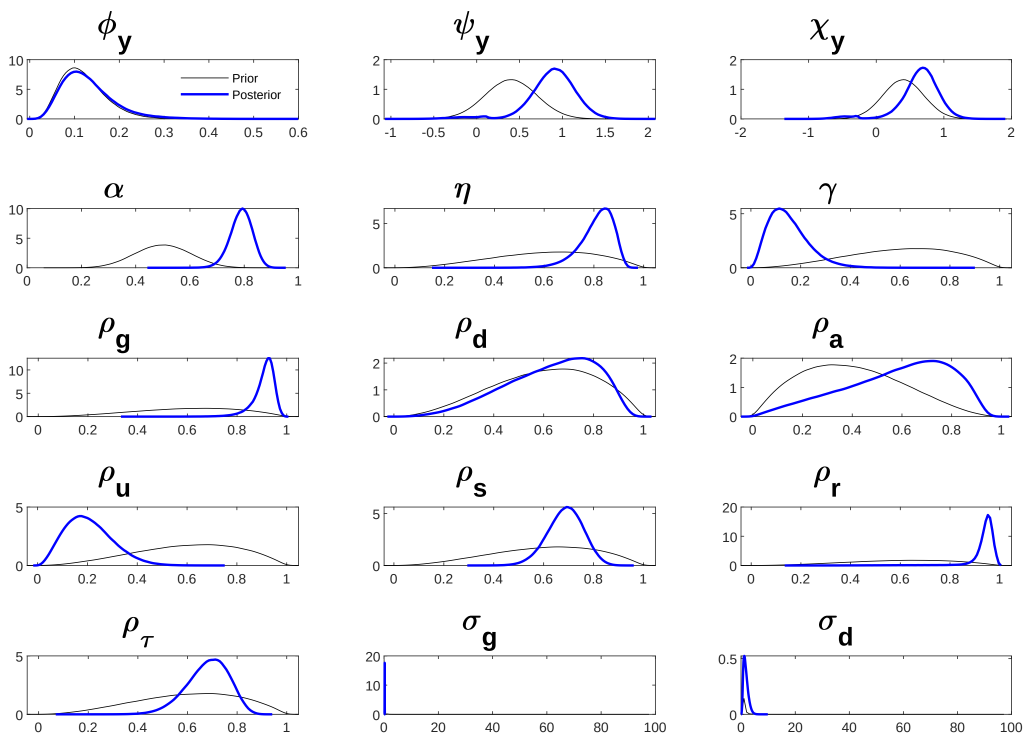


(a) Regime F (b) PMPF regime

Figure 4.10: Posterior densities of the policy parameters ϕ_π and ψ_b for regime F and the PMPF regime.

In the following, we show plots of the prior and posterior densities for the remaining parameters.

Regime F



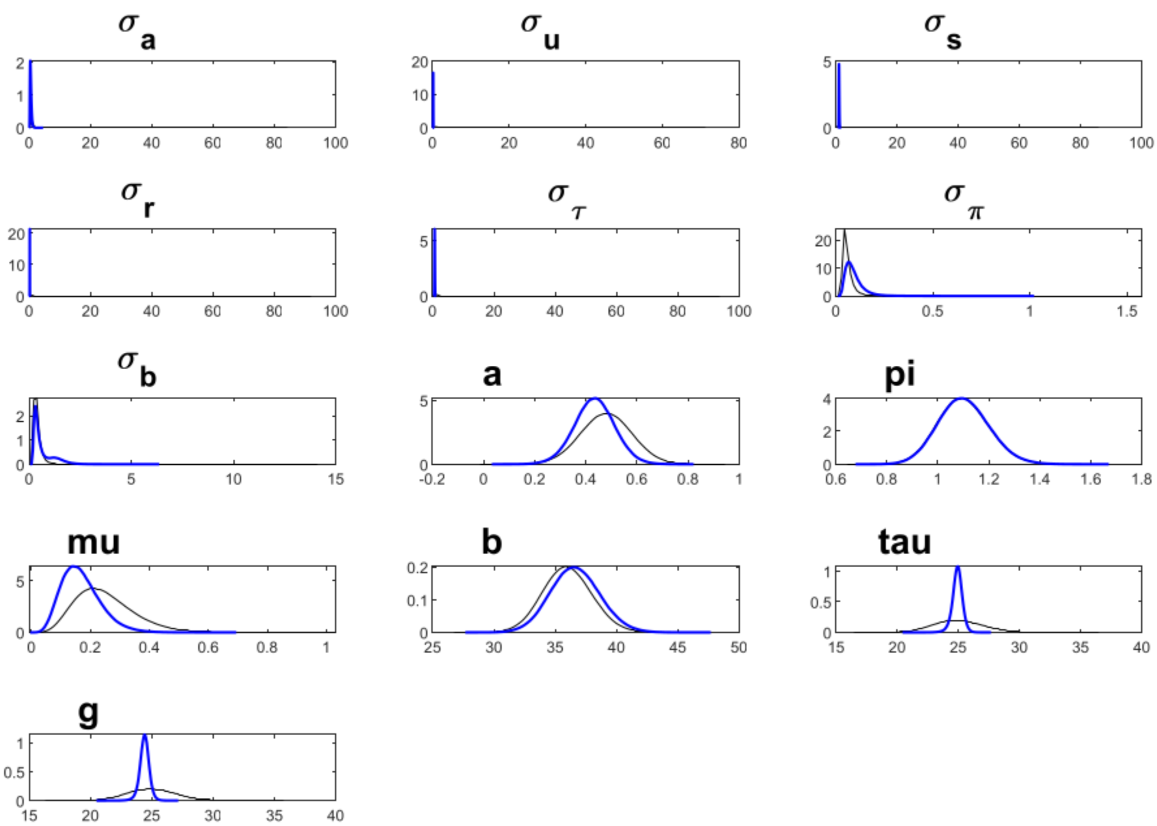


Figure 4.11: Prior and posterior densities of the estimated model parameters for regime F. The blue bold line depicts the posterior density, the black line the prior density. The prior densities are specified as in Bhattarai et al. (2016).

Table 4.6: Posterior distributions for estimated parameters (Regime F)

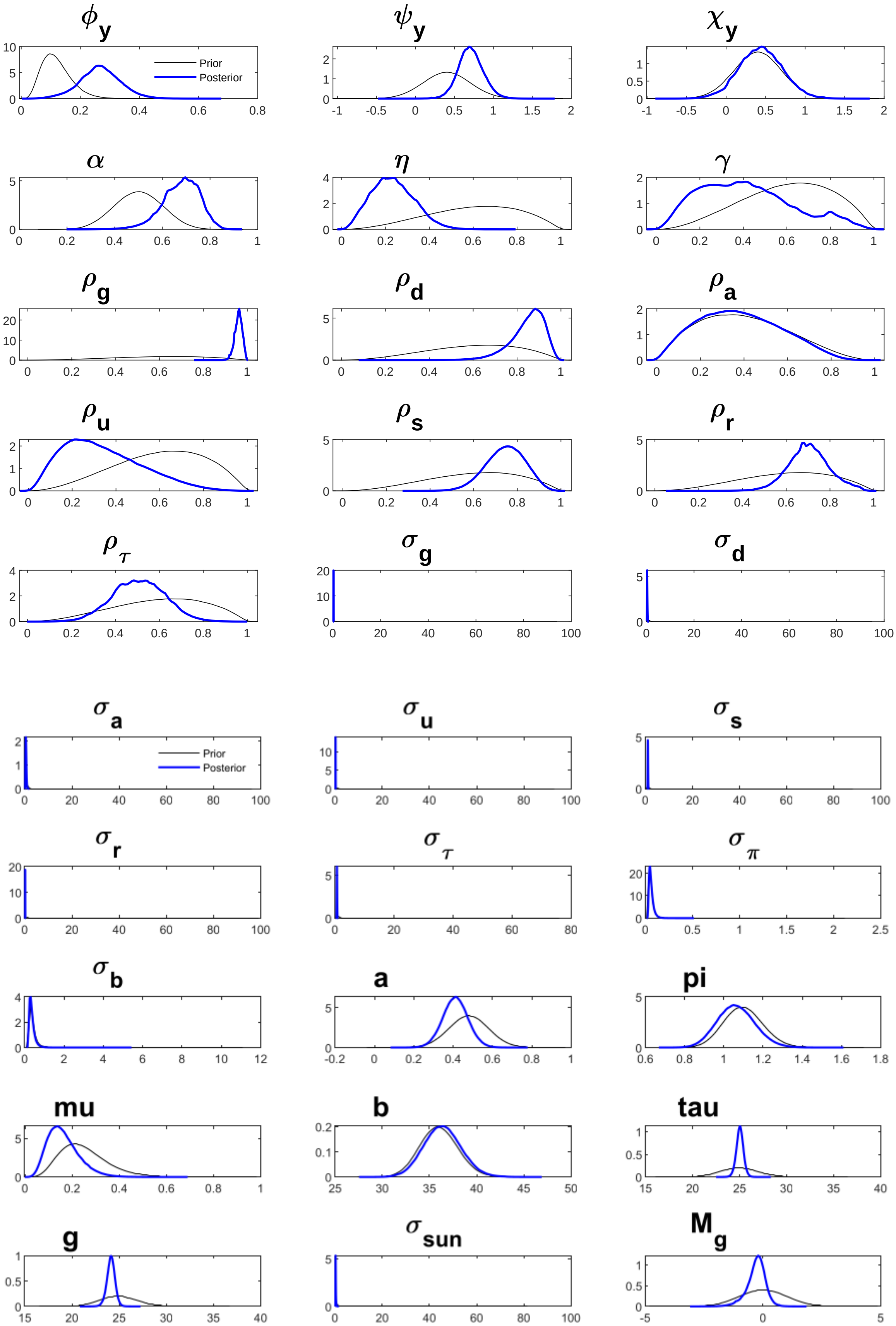
	Posterior		
Parameter	Mean	SD	90 percent credible set
Monetary policy			
ϕ_π, interest rate response to inflation	0.71	0.13	[0.53, 0.9]
ϕ_π^*, distance to monetary boundary	0.27	0.13	[0.09, 0.46]
ϕ_Y, interest rate response to output	0.13	0.06	[0.04, 0.21]
ρ_R, response to lagged interest rate	0.93	0.07	[0.9, 0.99]
Fiscal policy			
ψ_b, tax response to lagged debt	-0.08	0.04	[-0.14, -0.02]
ψ_b^*, distance to fiscal boundary	0.08	0.04	[0.02, 0.14]
ψ_Y, tax response to output	0.87	0.3	[0.49, 1.33]
χ_Y, govt spending response to lagged output	0.63	0.31	[0.24, 1.11]
ρ_g, response to lagged govt spending	0.91	0.04	[0.85, 0.97]
ρ_τ, response to lagged taxes	0.68	0.08	[0.55, 0.82]
Preference and HHs			
η, habit formation	0.81	0.07	[0.71, 0.91]
$\mu := 100(\beta^{-1} - 1)$, discount factor	0.17	0.07	[0.06, 0.27]
Frictions			
α, price stickiness	0.79	0.04	[0.72, 0.86]
γ, price indexation	0.15	0.08	[0.03, 0.27]
Shocks			
ρ_d, preference	0.63	0.18	[0.35, 0.91]
ρ_a, technology	0.58	0.21	[0.24, 0.9]
ρ_u, cost-push	0.21	0.09	[0.05, 0.35]
ρ_s, transfers	0.69	0.07	[0.57, 0.8]
σ_g, govt spending	0.21	0.02	[0.18, 0.25]
σ_d, preference	1.71	0.89	[0.41, 3.03]
σ_a, technology	0.54	0.25	[0.19, 0.89]
σ_u, cost-push	0.18	0.02	[0.14, 0.22]
σ_s, transfers	1.01	0.09	[0.87, 1.15]
σ_R, monetary policy	0.22	0.02	[0.19, 0.25]
σ_τ, tax	0.7	0.07	[0.59, 0.81]
σ_π, inflation target	0.09	0.05	[0.3, 0.15]
σ_b, debt/output target	0.65	0.49	[0.17, 1.44]
Steady state			
$a := 100(\bar{a} - 1)$, technology	0.43	0.08	[0.31, 0.56]
$\pi := 100(\bar{\pi} - 1)$, inflation	1.1	0.1	[0.94, 1.26]
$b := 100\bar{b}$, debt/output	36.63	2.01	[33.33, 39.93]

Table 4.6: Posterior distributions for estimated parameters (Regime F) - continued

	Posterior		
Parameter	Mean	SD	90 percent credible set
$\tau := 100\bar{\tau}$, tax/output	24.92	0.42	[24.26, 25.6]
$g := 100\bar{g}$, govt spending/output	24.4	0.4	[23.78, 25.05]

Note: Means and standard deviations are over 50 independent runs of the SMC algorithm with $N = 14,000$, $N_\delta = 500$, $\lambda = 2.5$, $N_{blocks} = 6$, and $M_{MH} = 1$. We compute 90 % highest posterior density intervals.

PMPF regime



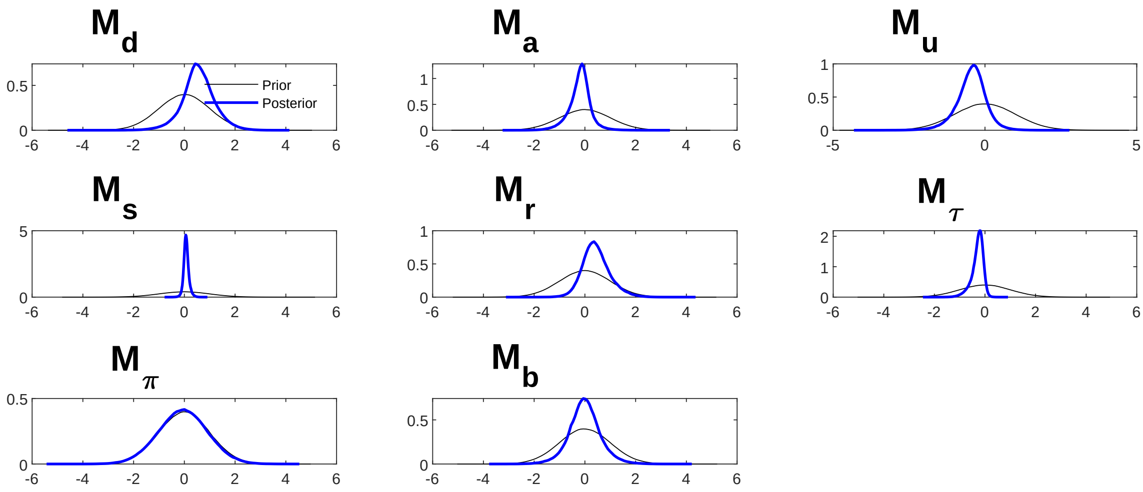


Figure 4.12: Prior and posterior densities of the estimated model parameters for the PMPF regime. The blue bold line depicts the posterior density, the black line the prior density. The prior densities are specified as in Bhattarai et al. (2016).

Table 4.7: Posterior distributions for estimated parameters (PMPF regime)

Parameter	Posterior		
	Mean	SD	90 percent credible set
Monetary policy			
ϕ_π, interest rate response to inflation	0.31	0.15	[0.06, 0.56]
ϕ_π^*, distance to monetary boundary	0.71	0.05	[0.66, 0.79]
ϕ_Y, interest rate response to output	0.28	0.02	[0.25, 0.31]
ρ_R, response to lagged interest rate	0.7	0.03	[0.66, 0.74]
Fiscal policy			
ψ_b, tax response to lagged debt	0.05	0.02	[0.008, 0.08]
ψ_b^*, distance to fiscal boundary	0.05	0.01	[0.039, 0.055]
ψ_Y, tax response to output	0.71	0.03	[0.66, 0.77]
χ_Y, govt spending response to lagged output	0.44	0.07	[0.33, 0.54]
ρ_g, response to lagged govt spending	0.96	0.004	[0.957, 0.967]
ρ_τ, response to lagged taxes	0.5	0.03	[0.44, 0.54]
Preference and HHs			
η, habit formation	0.23	0.02	[0.21, 0.28]
$\mu := 100(\beta^{-1} - 1)$, discount factor	0.16	0.01	[0.14, 0.18]
Frictions			
α, price stickiness	0.68	0.02	[0.65, 0.72]
γ, price indexation	0.4	0.08	[0.3, 0.49]

Table 4.7: Posterior distributions for estimated parameters (PMPF regime) - continued

Parameter	Posterior		
	Mean	SD	90 percent credible set
Shocks			
ρ_d, preference	0.85	0.02	[0.82, 0.88]
ρ_a, technology	0.37	0.06	[0.27, 0.44]
ρ_u, cost-push	0.33	0.05	[0.27, 0.41]
ρ_s, transfers	0.75	0.02	[0.73, 0.77]
σ_g, govt spending	0.23	0.002	[0.226, 0.23]
σ_d, preference	0.29	0.02	[0.26, 0.32]
σ_a, technology	0.52	0.07	[0.42, 0.61]
σ_u, cost-push	0.21	0.006	[0.2, 0.21]
σ_s, transfers	1.02	0.008	[1, 1.03]
σ_R, monetary policy	0.18	0.006	[0.17, 0.19]
σ_τ, tax	0.62	0.01	[0.6, 0.64]
σ_π, inflation target	0.06	0.004	[0.05, 0.06]
σ_b, debt/output target	0.36	0.02	[0.32, 0.39]
Steady state			
$a \coloneqq 100(\bar{a}-1)$, technology	0.41	0.01	[0.39, 0.42]
$\pi \coloneqq 100(\bar{\pi}-1)$, inflation	1.06	0.02	[1.03, 1.07]
$b \coloneqq 100\bar{b}$, debt/output	36.4	0.31	[35.97, 36.77]
$\tau \coloneqq 100\bar{\tau}$, tax/output	25.06	0.09	[24.94, 25.17]
$g \coloneqq 100\bar{g}$, govt spending/output	24.13	0.08	[24.04, 24.28]
Indeterminacy			
σ_ζ, sunspot shock	0.26	0.05	[0.22, 0.3]
$M_{g\zeta}$	-0.29	0.11	[-0.43, -0.13]
$M_{d\zeta}$	0.6	0.2	[0.42, 0.92]
$M_{a\zeta}$	-0.2	0.08	[-0.34, -0.1]
$M_{u\zeta}$	-0.44	0.15	[-0.59, -0.25]
$M_{s\zeta}$	0.08	0.03	[0.03, 0.12]
$M_{R\zeta}$	0.43	0.18	[0.22, 0.68]
$M_{\tau\zeta}$	-0.3	0.1	[-0.46, -0.2]
$M_{\pi\zeta}$	-0.05	0.16	[-0.28, 0.26]
$M_{b\zeta}$	-0.006	0.13	[-0.18, 0.12]

Note: Means and standard deviations are over 50 independent runs of the SMC algorithm with $N = 14,000$, $N_\delta = 500$, $\lambda = 2.5$, $N_{blocks} = 6$, and $M_{MH} = 1$. We compute 90 % highest posterior density intervals.

Restricted estimation - prior as in Section 4.3 with renormalized policy parameters

In a next step, we conduct the restricted SMC estimation with the prior specification as outlined in Section 4.3. One exception is the prior specifications for the policy parameters ϕ_π and ψ_b. To ensure that we completely impose a particular policy regime during estimation, we again follow Bhattarai et al. (2016) and estimate the model with the reparameterized policy parameters ϕ_π^* and ψ_b^*. ϕ_π^* follows a Gamma distribution with a mean of 0.5 and a standard deviation of 0.2. ψ_b^* is also Gamma-distributed and has a mean of 0.05 and a standard deviation of 0.04. The prior densities of the remaining parameters are specified as in Section 4.3.

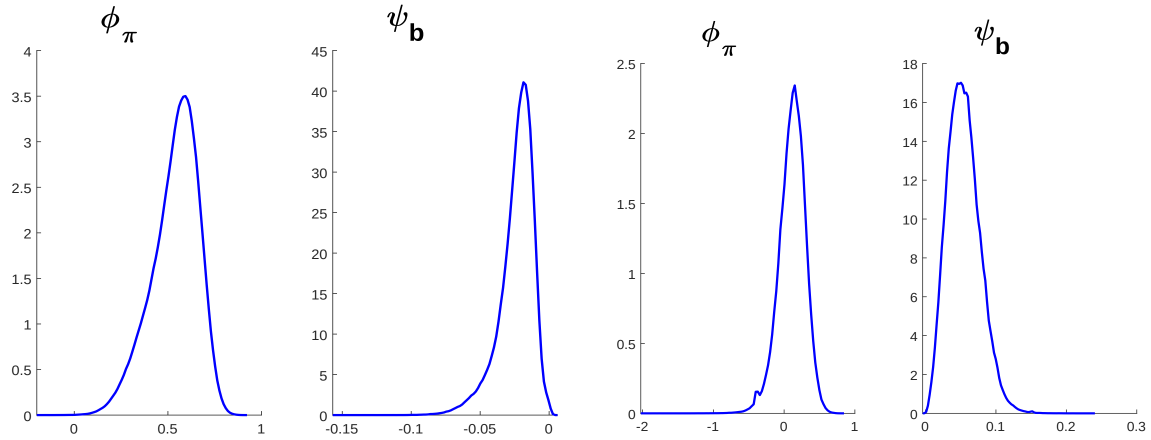
Table 4.8 shows the estimated marginal data densities of each regime. Also, with the prior specification of Section 4.3, we come to the conclusion, that in the US, in the pre-Volcker period, the PMPF regime receives the best support from the data.

Table 4.8: Log marginal data densities for each policy regime from restricted estimation

	AMPF	PMAF	PMPF
Log MDD	-548.72	-542.72	-523.17

Note: The log marginal data density is obtained as a by-product during the correction step of the SMC algorithm, see Herbst and Schorfheide (2014) for further details. For each regime, its mean is computed over 50 independent runs of the SMC algorithm.

Figure 4.13 shows plots of the posterior densities of the policy parameters for regime F and the PMPF regime. The shapes of the posterior densities are comparable to the findings in the previous subsection. The mean estimates for the Taylor-coefficient ϕ_π (regime F: 0.54; PMPF: 0.11) and ψ_b (regime F: -0.02; PMPF: 0.05) change only slightly. Hence, using, a for our exercise more suitable, prior specification together with SMC posterior sampling does not influence the estimation results.



(a) Regime F

(b) PMPF regime

Figure 4.13: Posterior densities of the policy parameters ϕ_π and ψ_b for regime F and the PMPF regime.

To make the results of the restricted estimation more comparable to the unrestricted estimation, we renormalized the policy parameters ϕ_π^* and ψ_b^* to ϕ_π and ψ_b in the density plots.

Regime F

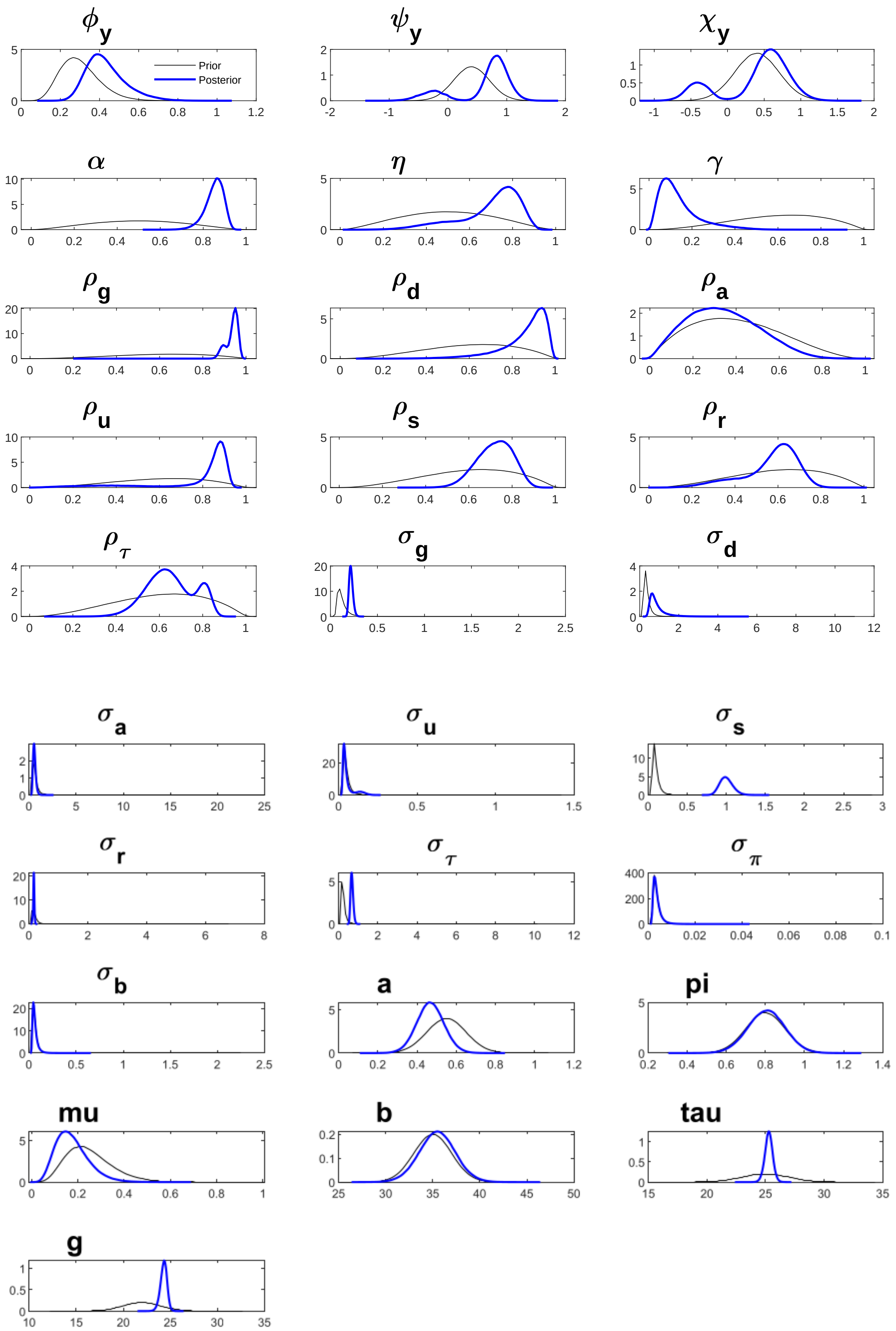


Figure 4.14: Prior and posterior densities of the estimated model parameters for regime F. The blue bold line depicts the posterior density, the black line the prior density. The densities of ϕ_{π}^{*} and ψ_{b}^{*} are specified as in Bhattarai et al. (2016), the remaining parameters as in Section 4.3.

Table 4.9: Posterior distributions for estimated parameters (Regime F)

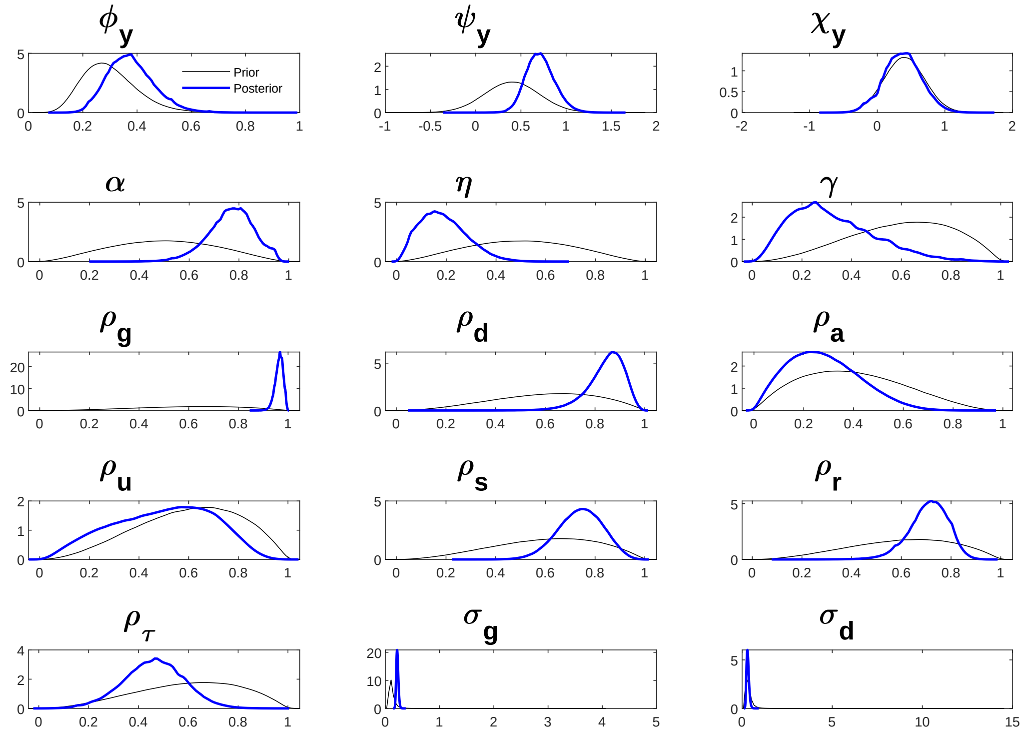
	Posterior		
Parameter	Mean	SD	90 percent credible set
Monetary policy			
ϕ_π, interest rate response to inflation	0.54	0.12	[0.33, 0.73]
ϕ_π^*, distance to monetary boundary	0.35	0.05	[0.31, 0.43]
ϕ_Y, interest rate response to output	0.44	0.06	[0.4, 0.54]
ρ_R, response to lagged interest rate	0.56	0.09	[0.38, 0.63]
Fiscal policy			
ψ_b, tax response to lagged debt	-0.02	0.01	[-0.04, -0.005]
ψ_b^*, distance to fiscal boundary	0.027	0.007	[0.02, 0.04]
ψ_Y, tax response to output	0.58	0.39	[-0.25, 0.86]
χ_Y, govt spending response to lagged output	0.38	0.36	[-0.38, 0.63]
ρ_g, response to lagged govt spending	0.93	0.02	[0.9, 0.95]
ρ_τ, response to lagged taxes	0.66	0.07	[0.61, 0.79]
Preference and HHs			
η, habit formation	0.69	0.1	[0.49, 0.78]
$\mu := 100(\beta^{-1} - 1)$, discount factor	0.17	0.01	[0.16, 0.19]
Frictions			
α, price stickiness	0.85	0.02	[0.83, 0.86]
γ, price indexation	0.13	0.06	[0.09, 0.22]
Shocks			
ρ_d, preference	0.86	0.03	[0.82, 0.9]
ρ_a, technology	0.33	0.04	[0.26, 0.37]
ρ_u, cost-push	0.77	0.17	[0.45, 0.88]
ρ_s, transfers	0.72	0.03	[0.65, 0.74]
σ_g, govt spending	0.22	0.006	[0.21, 0.23]
σ_d, preference	0.87	0.14	[0.58, 1.03]
σ_a, technology	0.56	0.01	[0.55, 0.58]
σ_u, cost-push	0.06	0.03	[0.04, 0.12]
σ_s, transfers	1	0.003	[0.997, 1.01]
σ_R, monetary policy	0.15	0.01	[0.13, 0.16]
σ_τ, tax	0.68	0.03	[0.66, 0.72]
σ_π, inflation target	0.004	0	[0.0036, 0.0039]
σ_b, debt/output target	0.06	0.001	[0.059, 0.064]
Steady state			
$a := 100(\bar{a} - 1)$, technology	0.47	0.007	[0.46, 0.48]
$\pi := 100(\bar{\pi} - 1)$, inflation	0.81	0.02	[0.79, 0.83]
$b := 100\bar{b}$, debt/output	35.5	0.16	[35.28, 35.62]

Table 4.9: Posterior distributions for estimated parameters (Regime F) - continued

	Posterior		
Parameter	Mean	SD	90 percent credible set
$\tau \coloneqq 100\bar{\tau}$, tax/output	25.26	0.12	[25.05, 25.36]
$g \coloneqq 100\bar{g}$, govt spending/output	24.31	0.09	[24.24, 24.45]

Note: Means and standard deviations are over 50 independent runs of the SMC algorithm with $N = 14,000$, $N_{\delta} = 500$, $\lambda = 2.5$, $N_{blocks} = 6$, and $M_{MH} = 1$. We compute 90 % highest posterior density intervals.

PMPF regime


ϕ_y
Prior
Posterior
ψ_y
χ_y
α
η
γ
ρ_g
ρ_d
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ρ_s
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ρ_τ
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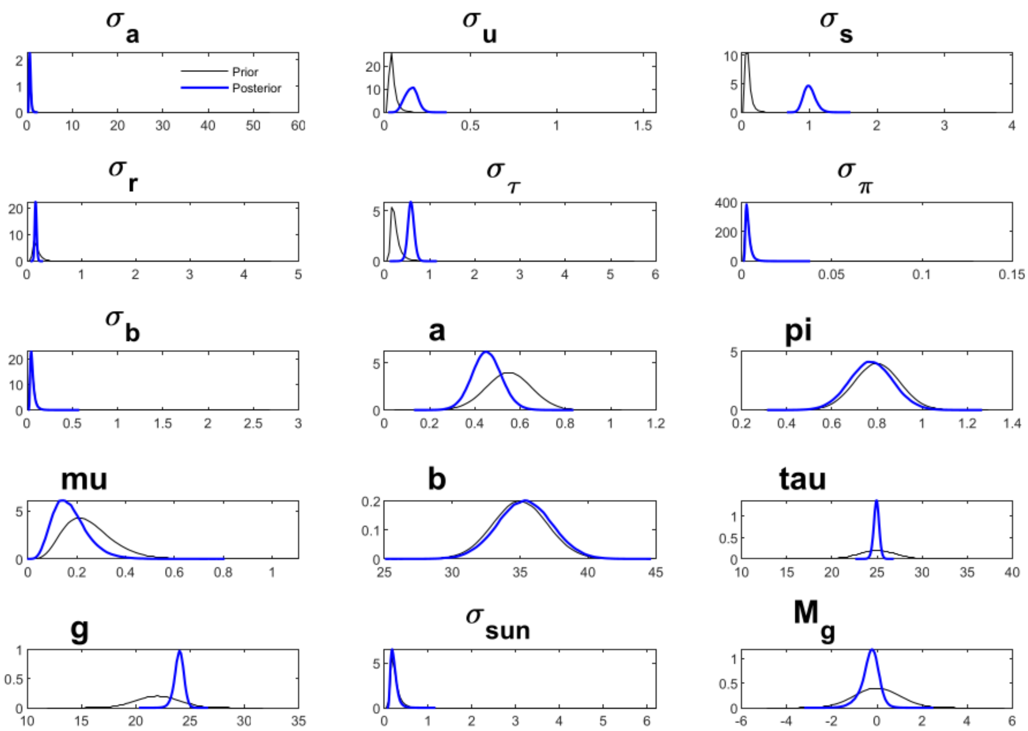

σ_a
Prior
Posterior
σ_u
σ_s
σ_r
σ_τ
σ_π
σ_b
a
pi
mu
b
tau
g
σ_{sun}
M_g

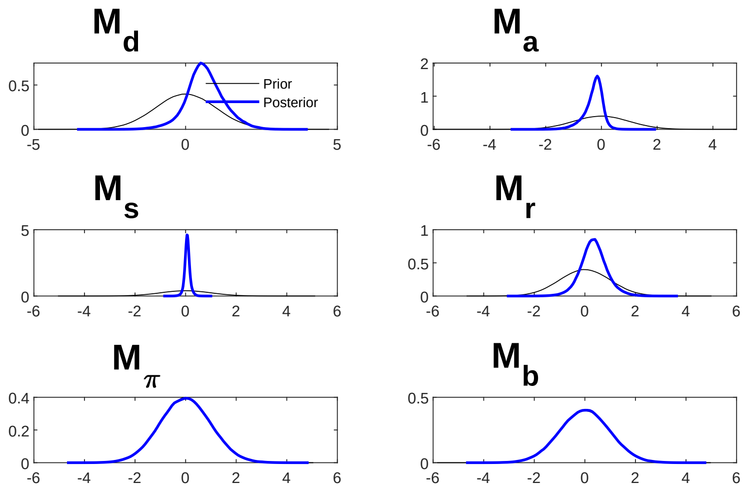


Figure 4.15: Prior and posterior densities of the estimated model parameters for the PMPF regime. The blue bold line depicts the posterior density, the black line the prior density. The densities of ϕ_π^* and ψ_b^* are specified as in Bhattarai et al. (2016), the remaining parameters as in Section 4.3.

Table 4.10: Posterior distributions for estimated parameters (PMPF regime)

	Posterior		
Parameter	Mean	SD	90 percent credible set
Monetary policy			
ϕ_π, interest rate response to inflation	0.11	0.19	[-0.18, 0.42]
ϕ_π^*, interest rate response to inflation	0.87	0.05	[0.83, 0.95]
ϕ_Y, interest rate response to output	0.39	0.02	[0.36, 0.41]
ρ_R, response to lagged interest rate	0.71	0.02	[0.69, 0.73]
Fiscal policy			
ψ_b, tax response to lagged debt	0.05	0.02	[0.02, 0.09]
ψ_b^*, distance to fiscal boundary	0.06	0.004	[0.05, 0.06]
ψ_Y, tax response to output	0.73	0.03	[0.7, 0.78]
χ_Y, govt spending response to lagged output	0.37	0.05	[0.29, 0.45]
ρ_g, response to lagged govt spending	0.97	0.002	[0.962, 0.969]
ρ_τ, response to lagged taxes	0.45	0.03	[0.4, 0.49]
Preference and HHs			
η, habit formation	0.19	0.02	[0.16, 0.21]
$\mu := 100(\beta^{-1} - 1)$, discount factor	0.17	0.01	[0.16, 0.19]
Frictions			
α, price stickiness	0.77	0.02	[0.74, 0.79]
γ, price indexation	0.31	0.04	[0.22, 0.35]

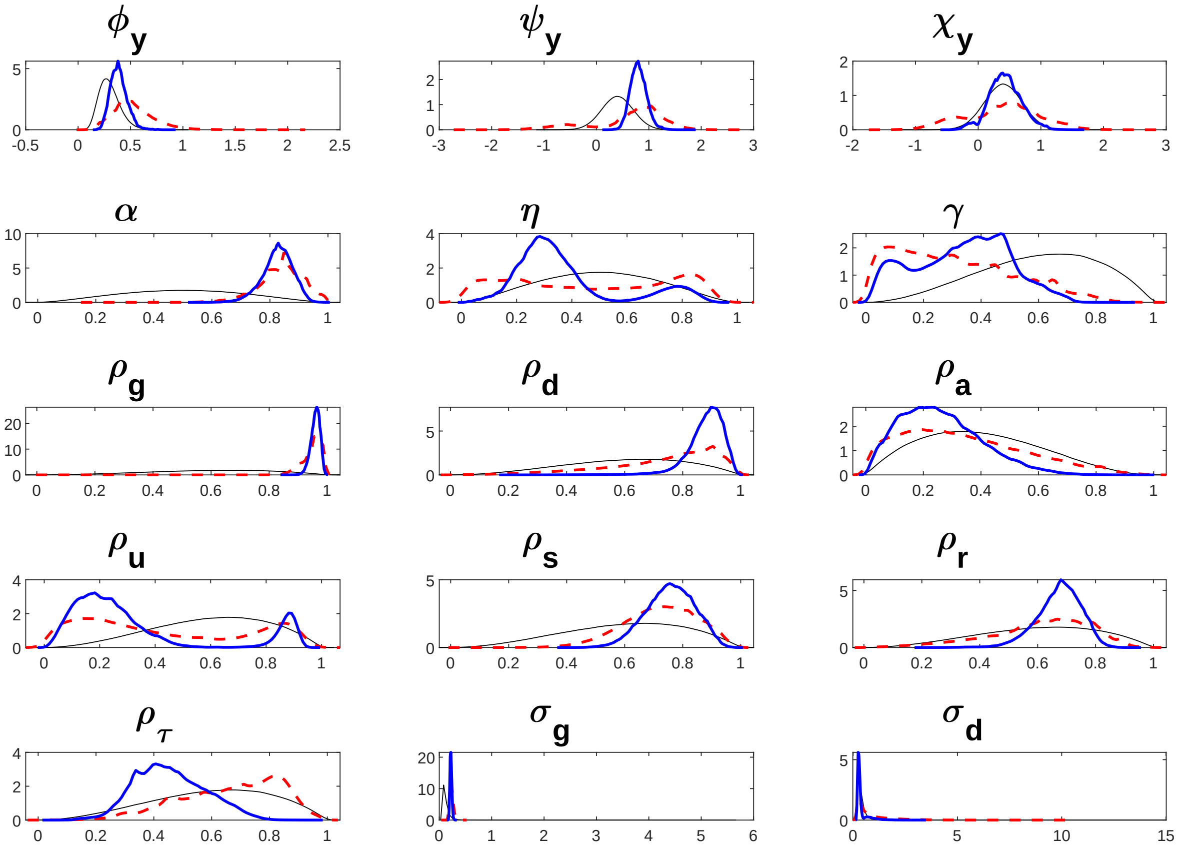
Table 4.10: Posterior distributions for estimated parameters (PMPF regime) - continued

Parameter	Posterior Mean	SD	90 percent credible set
Shocks			
ρ_d, preference	0.85	0.01	[0.83, 0.87]
ρ_a, technology	0.26	0.02	[0.22, 0.29]
ρ_u, cost-push	0.48	0.07	[0.38, 0.59]
ρ_s, transfers	0.74	0.01	[0.73, 0.76]
σ_g, govt spending	0.22	0.001	[0.219, 0.222]
σ_d, preference	0.31	0.01	[0.29, 0.33]
σ_a, technology	0.69	0.05	[0.63, 0.73]
σ_u, cost-push	0.16	0.01	[0.15, 0.18]
σ_s, transfers	1.01	0.006	[0.99, 1.01]
σ_R, monetary policy	0.16	0.003	[0.155, 0.163]
σ_τ, tax	0.59	0.01	[0.57, 0.6]
σ_π, inflation target	0.004	0	[0.003, 0.004]
σ_b, debt/output target	0.06	0.004	[0.056, 0.068]
Steady state			
$a := 100(\bar{a} - 1)$, technology	0.45	0.008	[0.44, 0.46]
$\pi := 100(\bar{\pi} - 1)$, inflation	0.77	0.01	[0.75, 0.79]
$b := 100\bar{b}$, debt/output	35.4	0.26	[35.02, 35.75]
$\tau := 100\bar{\tau}$, tax/output	24.01	0.06	[24.82, 24.99]
$g := 100\bar{g}$, govt spending/output	23.99	0.05	[23.93, 24.08]
Indeterminacy			
σ_ζ, sunspot shock	0.22	0.01	[0.21, 0.23]
$M_{g\zeta}$	-0.28	0.06	[-0.37, -0.2]
$M_{d\zeta}$	0.67	0.13	[0.48, 0.85]
$M_{a\zeta}$	-0.26	0.07	[-0.35, -0.19]
$M_{u\zeta}$	-0.41	0.09	[-0.54, -0.4]
$M_{s\zeta}$	0.07	0.02	[0.04, 0.09]
$M_{R\zeta}$	0.34	0.08	[0.24, 0.47]
$M_{\tau\zeta}$	-0.35	0.08	[-0.46, -0.25]
$M_{\pi\zeta}$	-0.02	0.1	[-0.18, 0.15]
$M_{b\zeta}$	0	0.03	[-0.11, 0.14]

Note: Means and standard deviations are over 50 independent runs of the SMC algorithm with $N = 14,000$, $N_\delta = 500$, $\lambda = 2.5$, $N_{blocks} = 6$, and $M_{MH} = 1$. We compute 90 % highest posterior density intervals.

4.E.2 Unrestricted estimation

Here we show plots of the prior and posterior densities for the remaining parameters from the unrestricted estimation with the SMC and RWMH sampler and tables that summarize the estimation results. Here, the prior specification and the estimation approach corresponds to the description in Section 4.3.



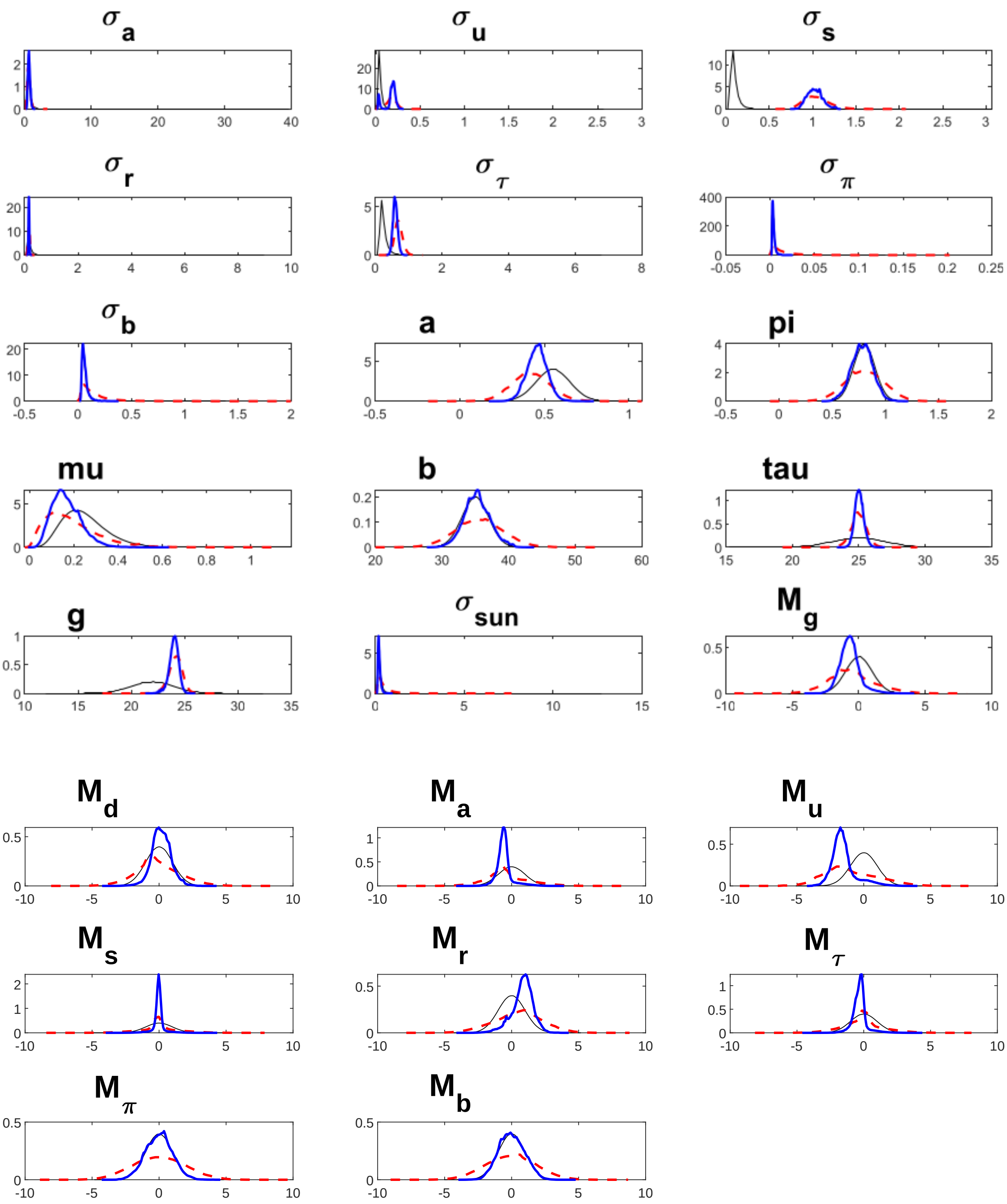


Figure 4.16: Prior and posterior densities of the estimated model parameters from the unrestricted estimation with SMC and RWMH. The red dashed line depicts the SMC posterior density, the blue solid line depicts the posterior density from RWMH sampling, and the black line the prior density.

Table 4.11: Posterior distributions, SMC estimation (Unrestricted)

	Posterior		
Parameter	Mean	SD	90 percent credible set
Monetary policy			
ϕ_π, interest rate response to inflation	0.4	0.22	[0.13, 0.73]
ϕ_Y, interest rate response to output	0.53	0.1	[0.4, 0.67]
ρ_R, response to lagged interest rate	0.61	0.11	[0.38, 0.74]
Fiscal policy			
ψ_b, tax response to lagged debt	0.026	0.04	[-0.05, 0.08]
ψ_Y, tax response to output	0.62	0.5	[-0.51, 1.05]
χ_Y, govt spending response to lagged output	0.38	0.35	[-0.25, 0.86]
ρ_g, response to lagged govt spending	0.95	0.02	[0.91, 0.97]
ρ_τ, response to lagged taxes	0.66	0.11	[0.5, 0.81]
Preference and HHs			
η, habit formation	0.45	0.23	[0.20, 0.81]
$\mu := 100(\beta^{-1} - 1)$, discount factor	0.19	0.04	[0.14, 0.22]
Frictions			
α, price stickiness	0.84	0.04	[0.8, 0.92]
γ, price indexation	0.31	0.12	[0.12, 0.44]
Shocks			
ρ_d, preference	0.73	0.11	[0.52, 0.87]
ρ_a, technology	0.33	0.08	[0.22, 0.41]
ρ_u, cost-push	0.41	0.2	[0.15, 0.71]
ρ_s, transfers	0.72	0.04	[0.64, 0.77]
σ_g, govt spending	0.23	0.01	[0.22, 0.24]
σ_d, preference	0.88	0.61	[0.31, 1.78]
σ_a, technology	0.62	0.09	[0.52, 0.72]
σ_u, cost-push	0.15	0.05	[0.09, 0.22]
σ_s, transfers	1.04	0.02	[1, 1.06]
σ_R, monetary policy	0.16	0.02	[0.13, 0.18]
σ_τ, tax	0.7	0.05	[0.64, 0.77]
σ_π, inflation target	0.006	0.006	[0.008, 0.02]
σ_b, debt/output target	0.15	0.05	[0.11, 0.2]
Steady state			
$a := 100(\bar{a} - 1)$, technology	0.42	0.03	[0.39, 0.45]
$\pi := 100(\bar{\pi} - 1)$, inflation	0.8	0.05	[0.74, 0.87]
$b := 100\bar{b}$, debt/output	35.62	0.79	[34.74, 36.44]
$\tau := 100\bar{\tau}$, tax/output	24.97	0.18	[24.68, 25.2]
$g := 100\bar{g}$, govt spending/output	24.12	0.21	[23.82, 24.48]

Table 4.11: Posterior distributions, SMC estimation (Unrestricted) - continued

Parameter	Posterior Mean	SD	90 percent credible set
Indeterminacy			
σ_ζ, sunspot shock	0.49	0.14	[0.27, 0.68]
$M_{g\zeta}$	-0.58	0.58	[-1.43, 0.03]
$M_{d\zeta}$	-0.11	0.35	[-0.69, 0.33]
$M_{a\zeta}$	-0.41	0.43	[-0.94, 0.17]
$M_{u\zeta}$	-1.09	0.98	[-2.37, 0.03]
$M_{s\zeta}$	-0.04	0.14	[-0.28, 0.16]
$M_{R\zeta}$	0.5	0.64	[-0.21, 1.22]
$M_{\tau\zeta}$	-0.13	0.38	[-0.7, 0.22]
$M_{\pi\zeta}$	0	0.45	[-0.54, 0.46]
$M_{b\zeta}$	-0.07	0.29	[-0.34, 0.45]

Note: Means, standard deviations, and 90 % highest posterior density intervals are over 50 independent runs of the SMC algorithm with $N = 20,000$, $N_\delta = 600$, $\lambda = 2.4$, $N_{blocks} = 10$, and $M_{MH} = 2$.

Table 4.12: Posterior distributions, RWMH estimation (Unrestricted)

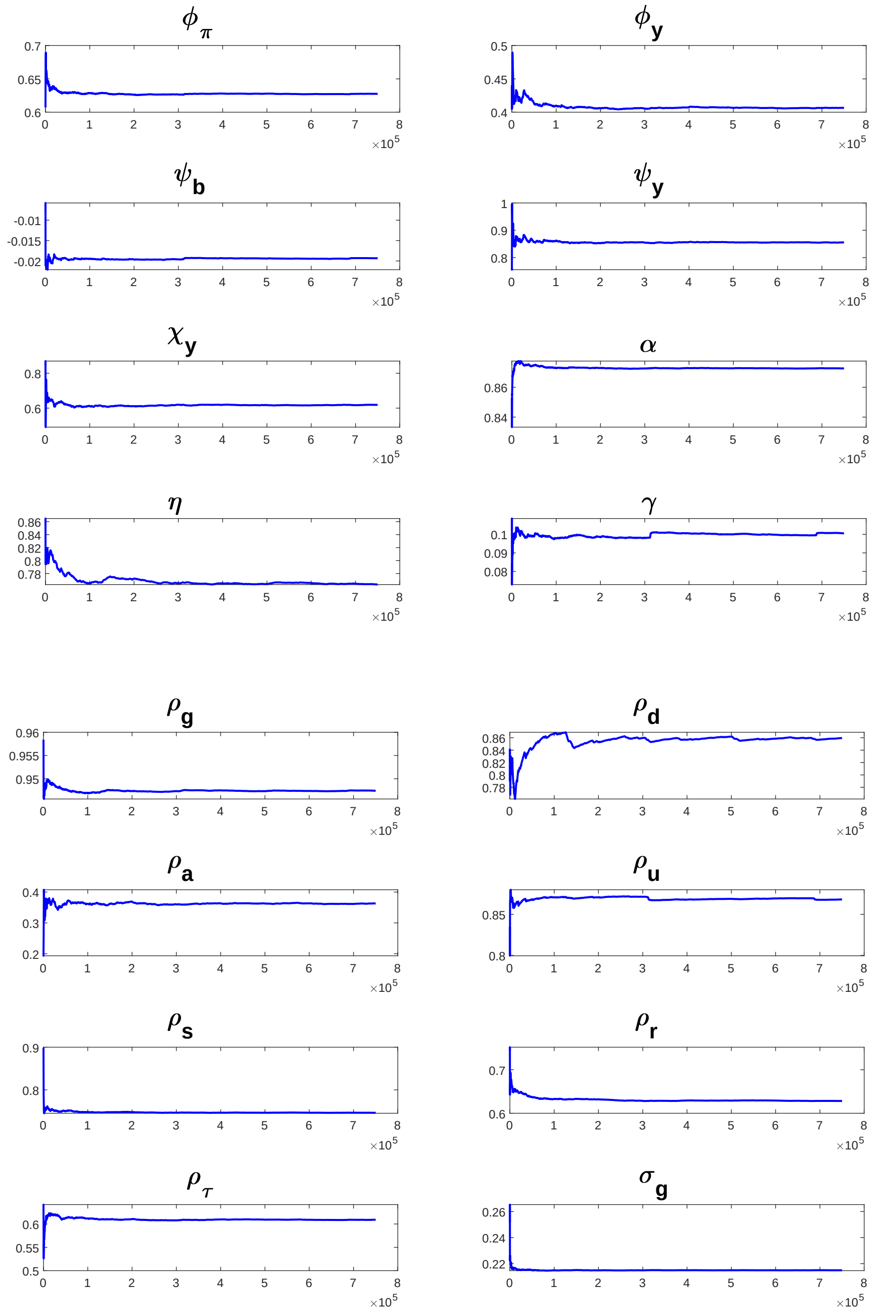
Parameter	Posterior Mean	SD	90 percent credible set
Monetary policy			
ϕ_π, interest rate response to inflation	0.22	0.21	[0.00, 0.61]
ϕ_Y, interest rate response to output	0.39	0.08	[0.26, 0.52]
ρ_R, response to lagged interest rate	0.67	0.076	[0.56, 0.8]
Fiscal policy			
ψ_b, tax response to lagged debt	0.051	0.037	[-0.026, 0.096]
ψ_Y, tax response to output	0.8	0.15	[0.55, 1.051]
χ_Y, govt spending response to lagged output	0.43	0.26	[0.036, 0.88]
ρ_g, response to lagged govt spending	0.96	0.016	[0.93, 0.99]
ρ_τ, response to lagged taxes	0.46	0.12	[0.26, 0.66]
Preference and HHs			
η, habit formation	0.38	0.19	[0.16, 0.8]
$\mu := 100(\beta^{-1} - 1)$, discount factor	0.17	0.065	[0.062, 0.26]
Frictions			
α, price stickiness	0.83	0.052	[0.74, 0.91]
γ, price indexation	0.34	0.16	[0.034, 0.55]

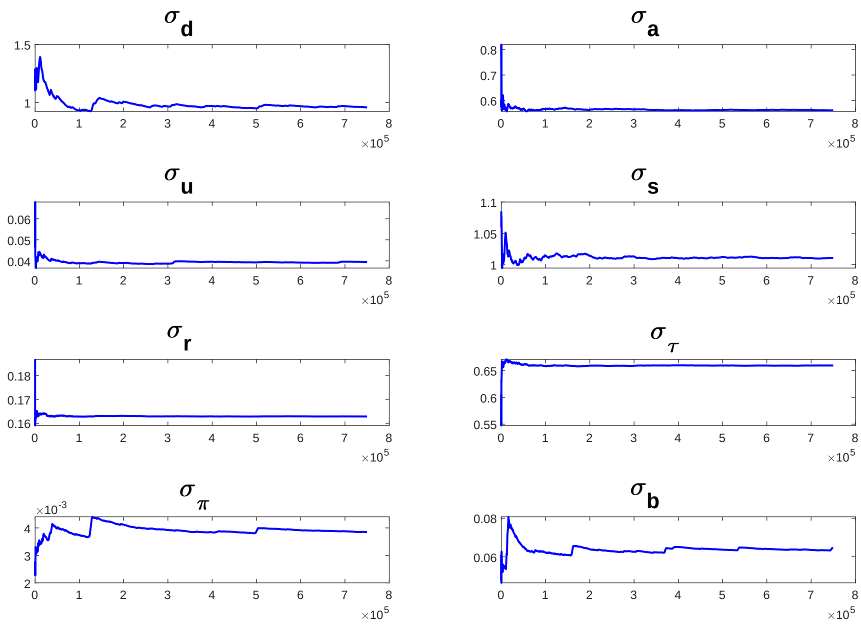
Table 4.12: Posterior distributions, RWMH estimation (Unrestricted) - continued

Parameter	Posterior		
	Mean	SD	90 percent credible set
Shocks			
ρ_d, preference	0.88	0.067	[0.79, 0.97]
ρ_a, technology	0.26	0.14	[0.031, 0.47]
ρ_u, cost-push	0.32	0.26	[0.077, 0.9]
ρ_s, transfers	0.76	0.083	[0.62, 0.9]
σ_g, govt spending	0.22	0.019	[0.19, 0.25]
σ_d, preference	0.39	0.31	[0.16, 0.78]
σ_a, technology	0.65	0.17	[0.39, 0.92]
σ_u, cost-push	0.17	0.063	[0.027, 0.23]
σ_s, transfers	1.03	0.087	[0.87, 1.15]
σ_R, monetary policy	0.16	0.02	[0.13, 0.19]
σ_τ, tax	0.6	0.07	[0.48, 0.71]
σ_π, inflation target	0.0037	0.0019	[0.0016, 0.0058]
σ_b, debt/output target	0.064	0.033	[0.027, 0.1]
Steady state			
$a := 100(\bar{a} - 1)$, technology	0.46	0.059	[0.36, 0.55]
$\pi := 100(\bar{\pi} - 1)$, inflation	0.78	0.1	[0.62, 0.95]
$b := 100\bar{b}$, debt/output	35.27	1.96	[31.98, 38.46]
$\tau := 100\bar{\tau}$, tax/output	25.03	0.33	[24.49, 25.58]
$g := 100\bar{g}$, govt spending/output	23.99	0.44	[23.3, 24.7]
Indeterminacy			
σ_ζ, sunspot shock	0.22	0.08	[0.11, 0.32]
$M_{g\zeta}$	-0.69	0.74	[-1.95, 0.37]
$M_{d\zeta}$	0.16	0.71	[-0.96, 1.33]
$M_{a\zeta}$	-0.57	0.57	[-1.56, 0.14]
$M_{u\zeta}$	-1.53	0.91	[-2.96, 0.0072]
$M_{s\zeta}$	-0.034	0.42	[-0.59, 0.52]
$M_{R\zeta}$	0.8	0.79	[-0.57, 2]
$M_{\tau\zeta}$	-0.32	0.53	[-1.23, 0.34]
$M_{\pi\zeta}$	-0.0095	0.99	[-1.62, 1.63]
$M_{b\zeta}$	-0.0053	0.95	[-1.51, 1.6]

Note: Means, standard deviations, and 90 % highest posterior density intervals are over 12 independent RWMH runs à ten million draws from which we discard seven million respectively as burn-in.

RWMH convergence diagnostics - mode initialization in regime F

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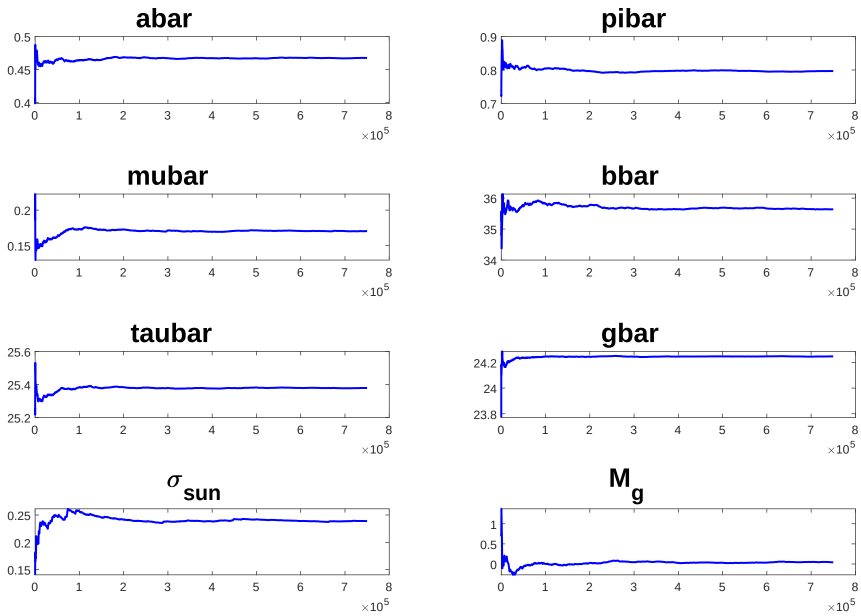
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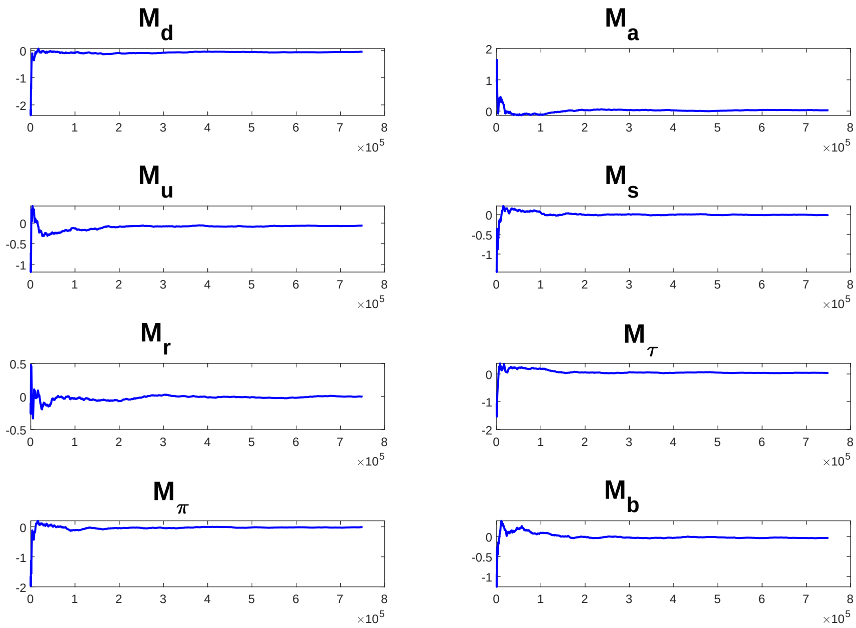
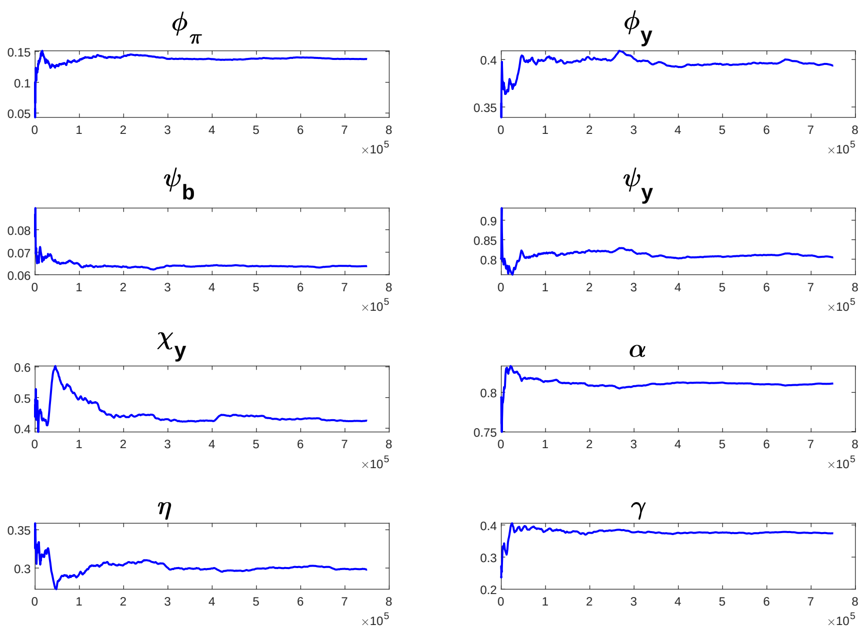
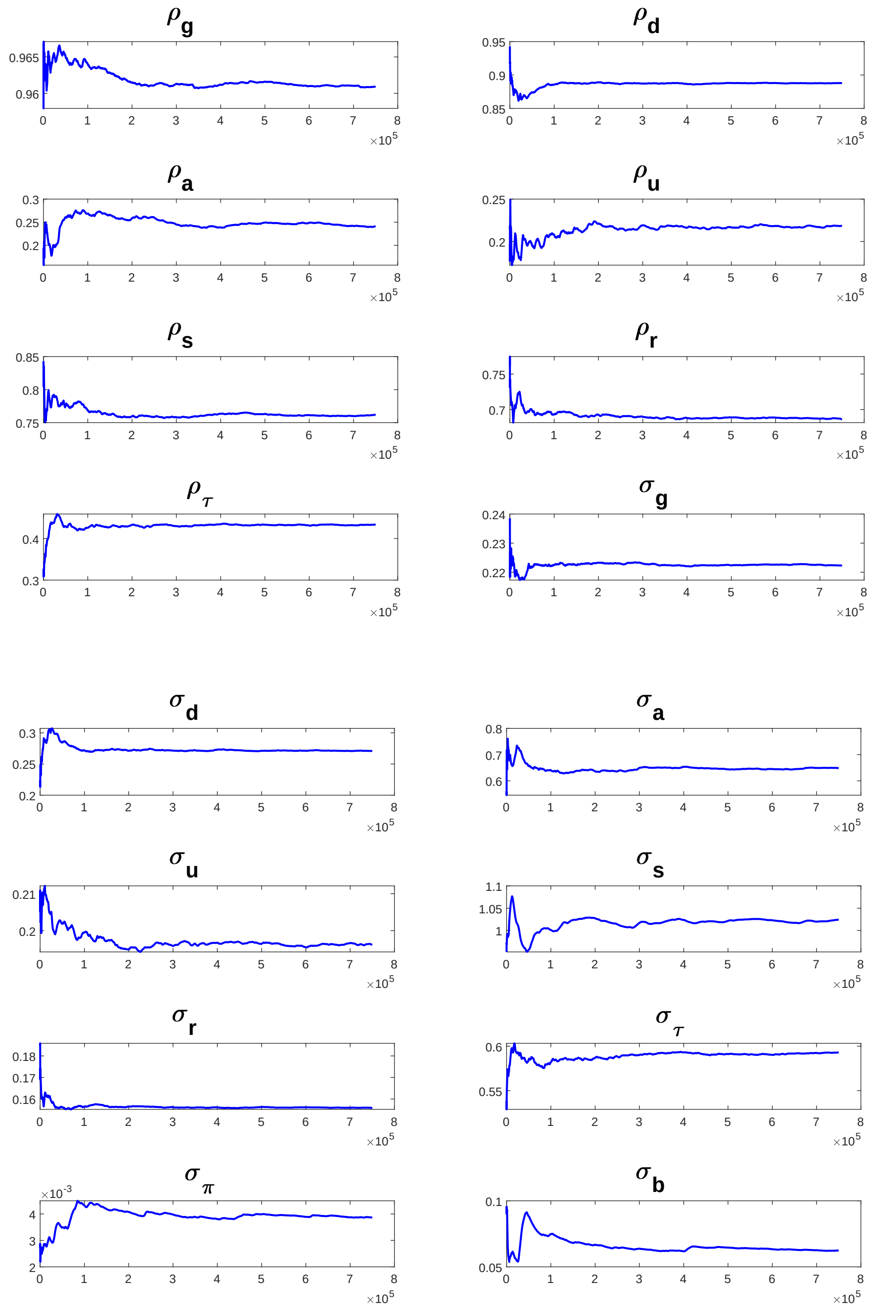


Figure 4.17: Recursive means - for RWMH runs initialized at the mode of regime F

RWMH convergence diagnostics - mode initialization in the indeterminacy regime




ρg
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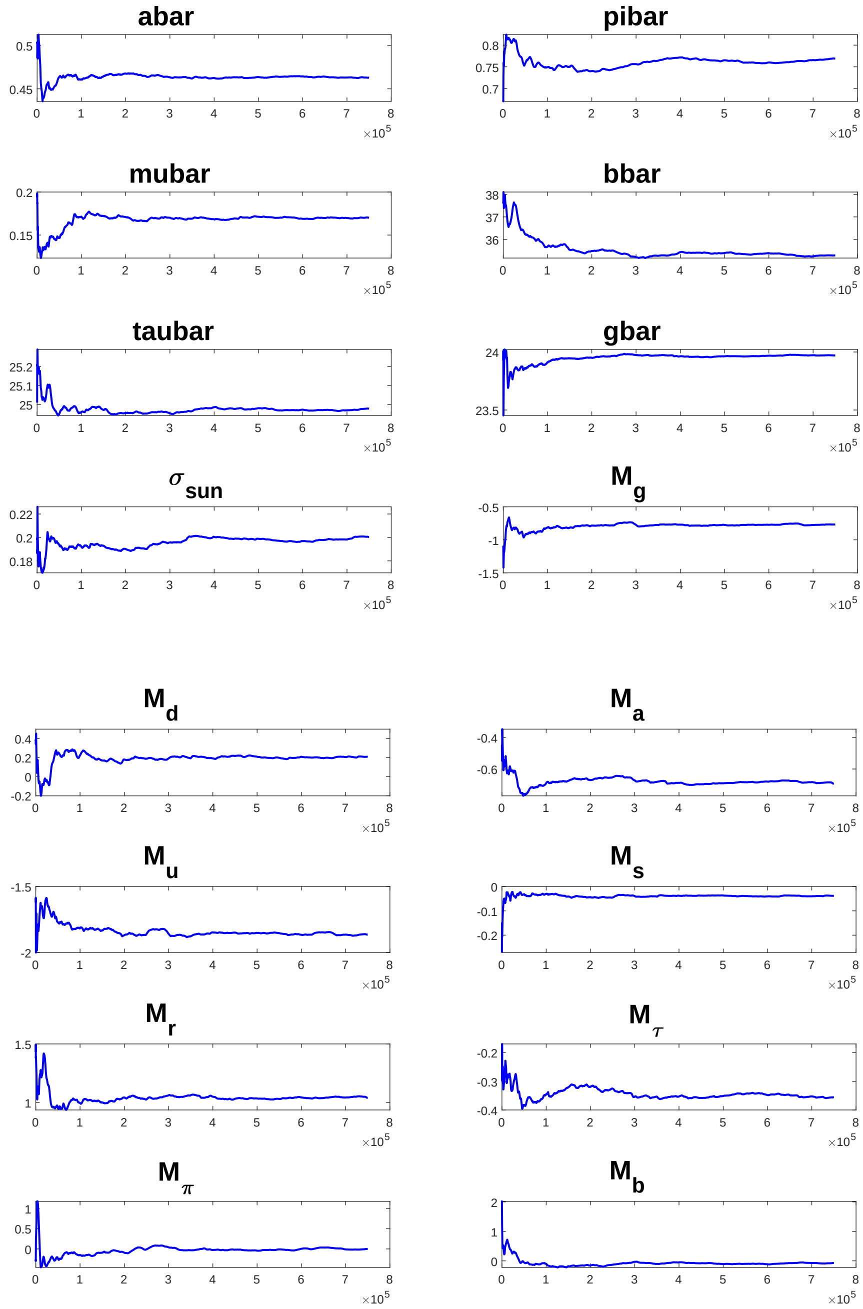
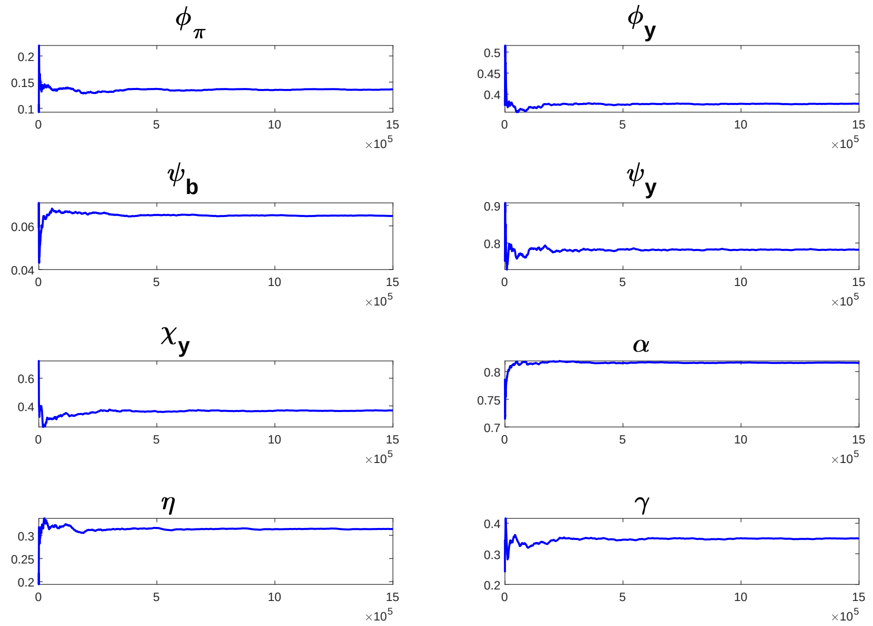
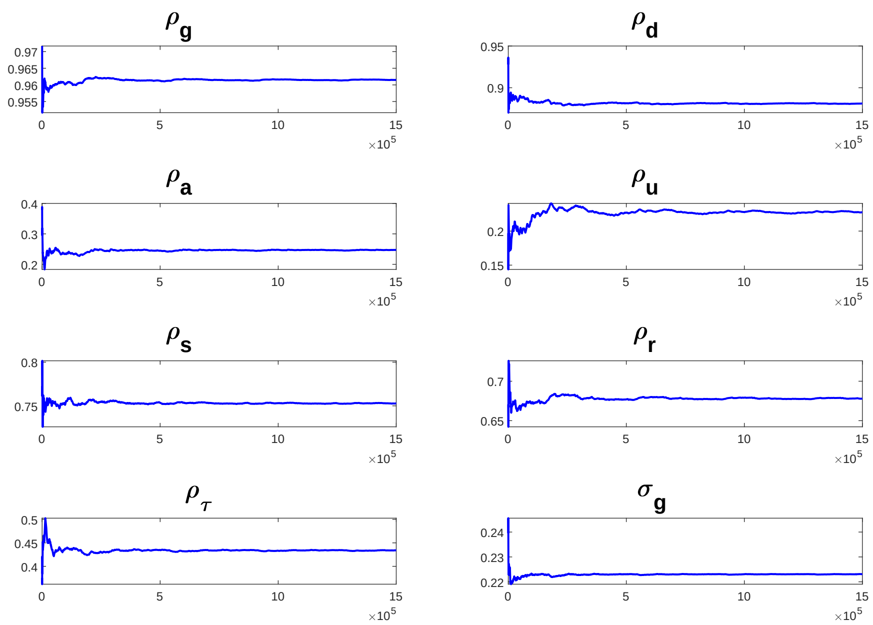
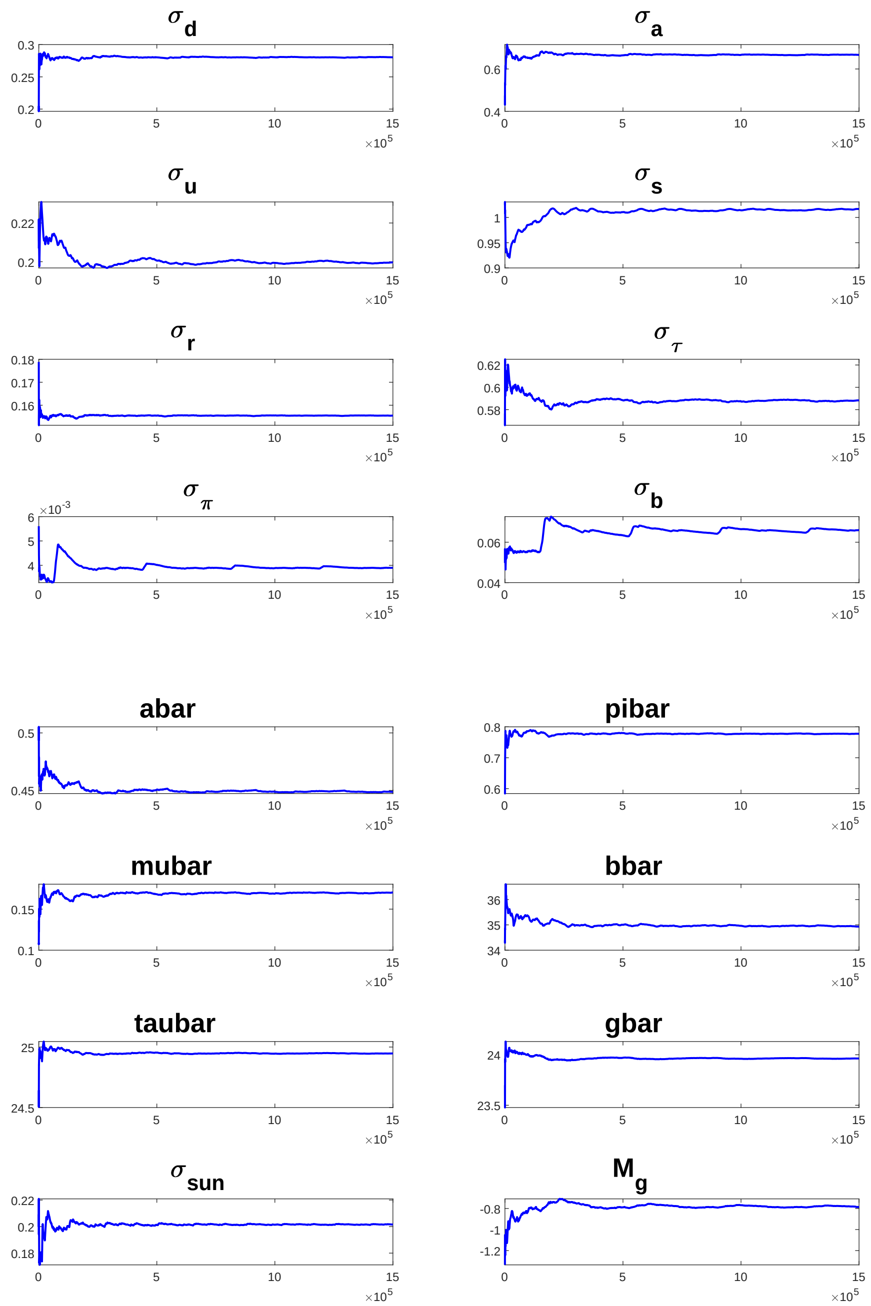


Figure 4.18: Recursive means - for RWMH runs initialized at the mode of regime PMPF

RWMH convergence diagnostics - random initialization in regime F






σ d
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abar
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×10^5

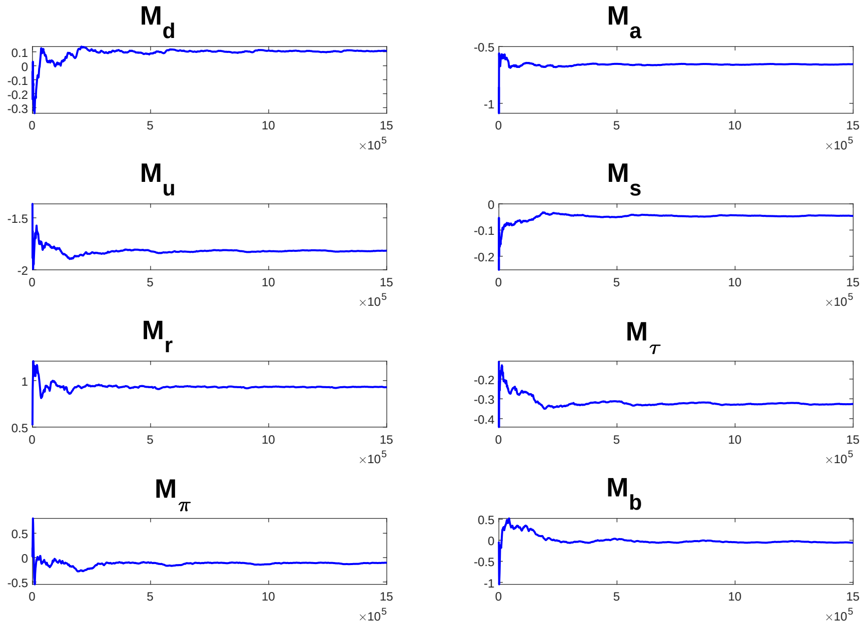
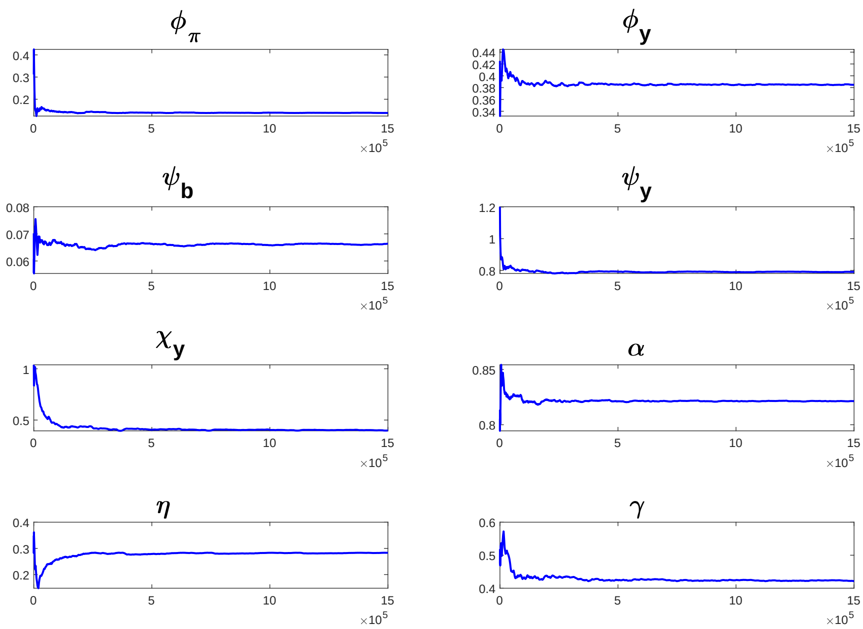
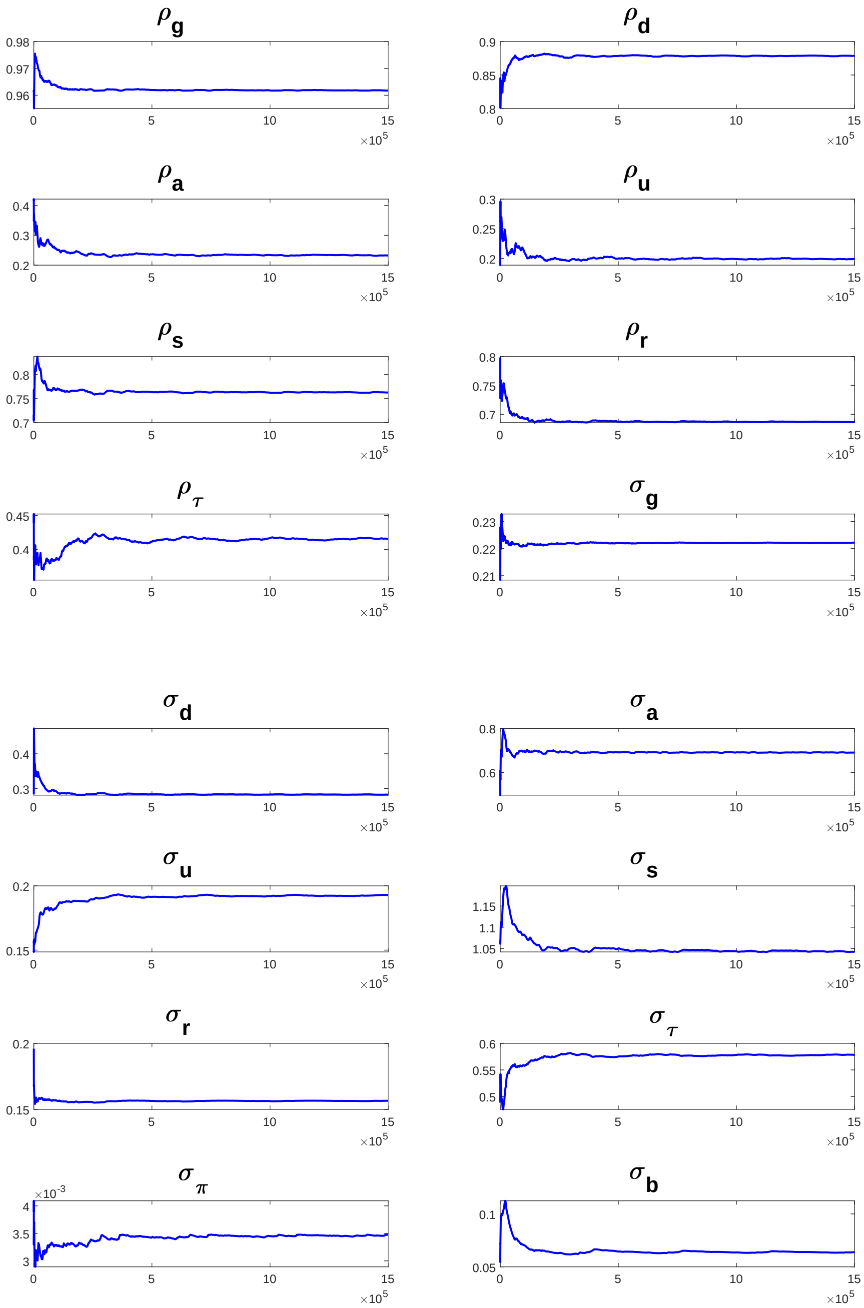


Figure 4.19: Recursive means - for RWMH runs initialized at a random value in regime F

RWMH convergence diagnostics - random initialization in the indeterminacy regime




ρg
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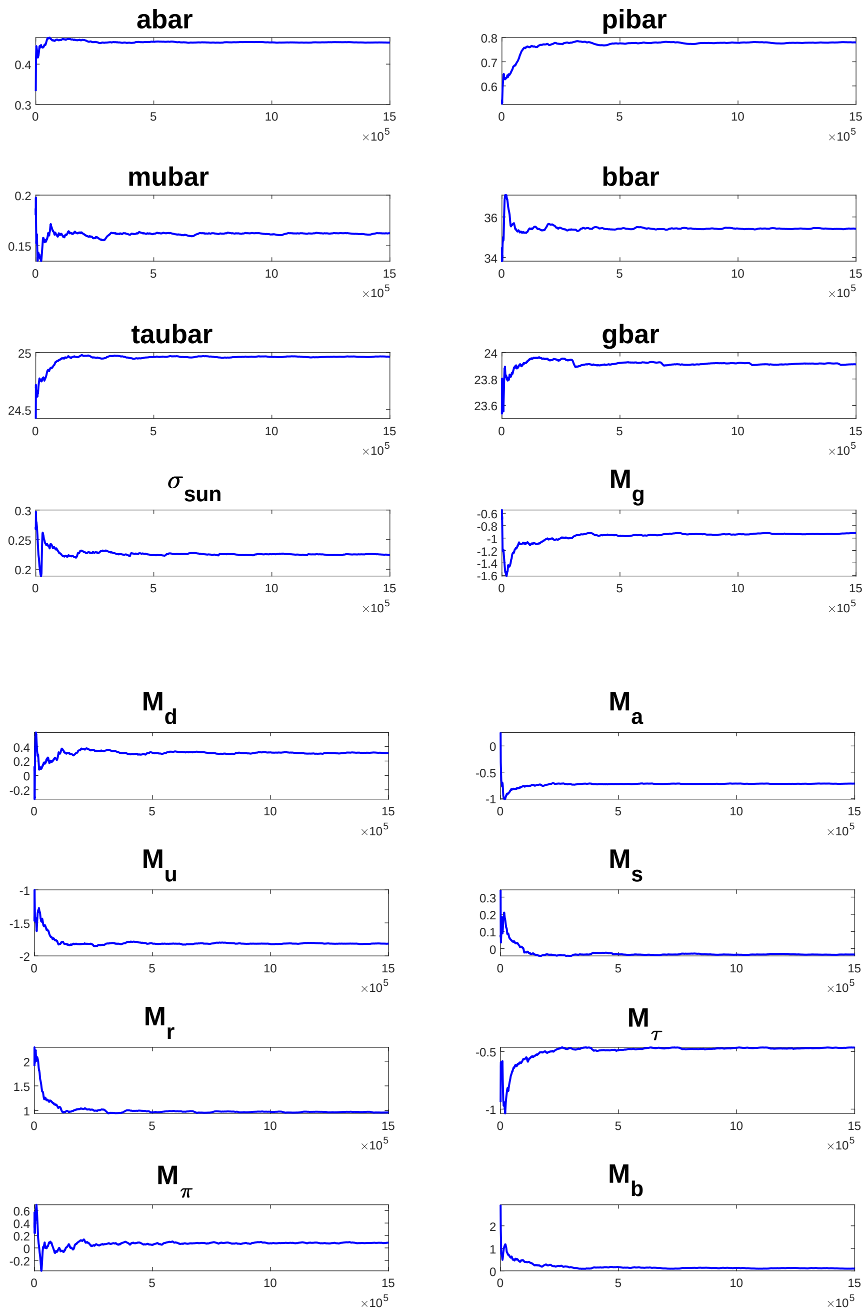
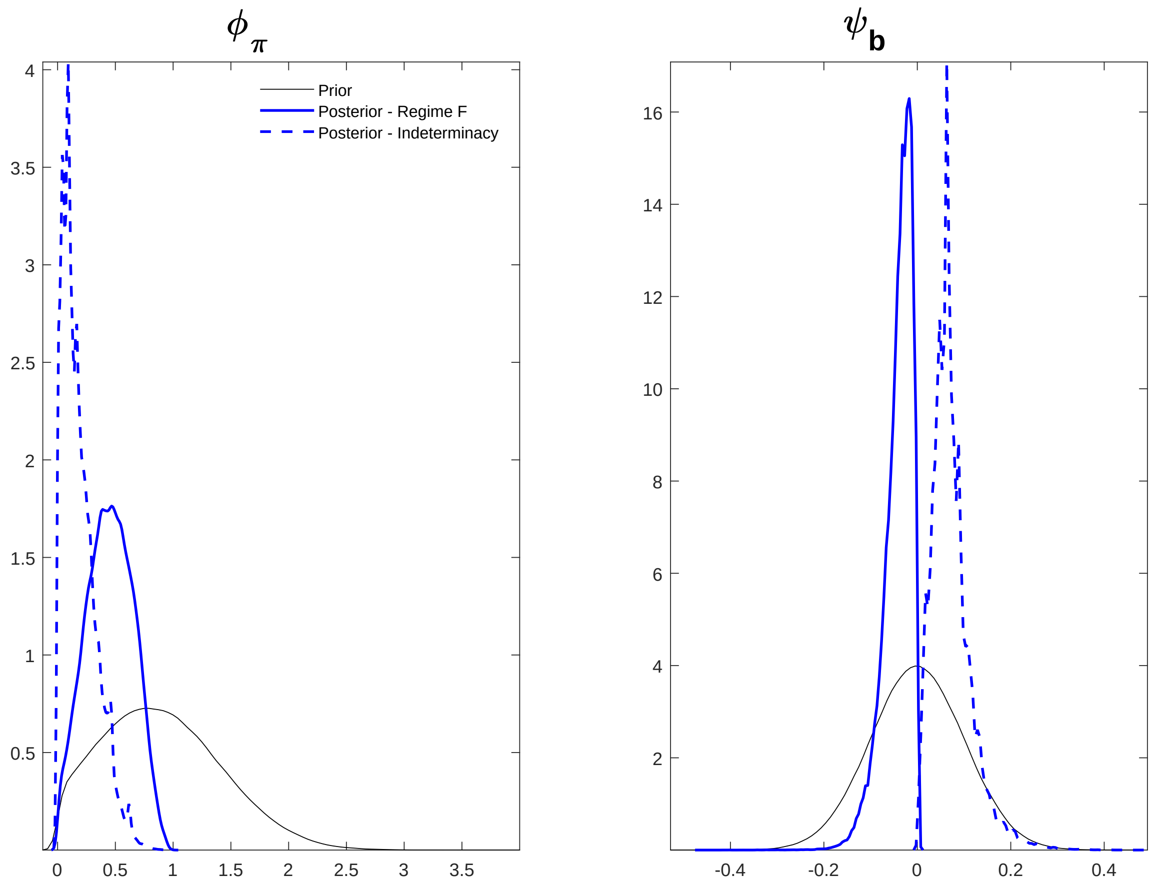
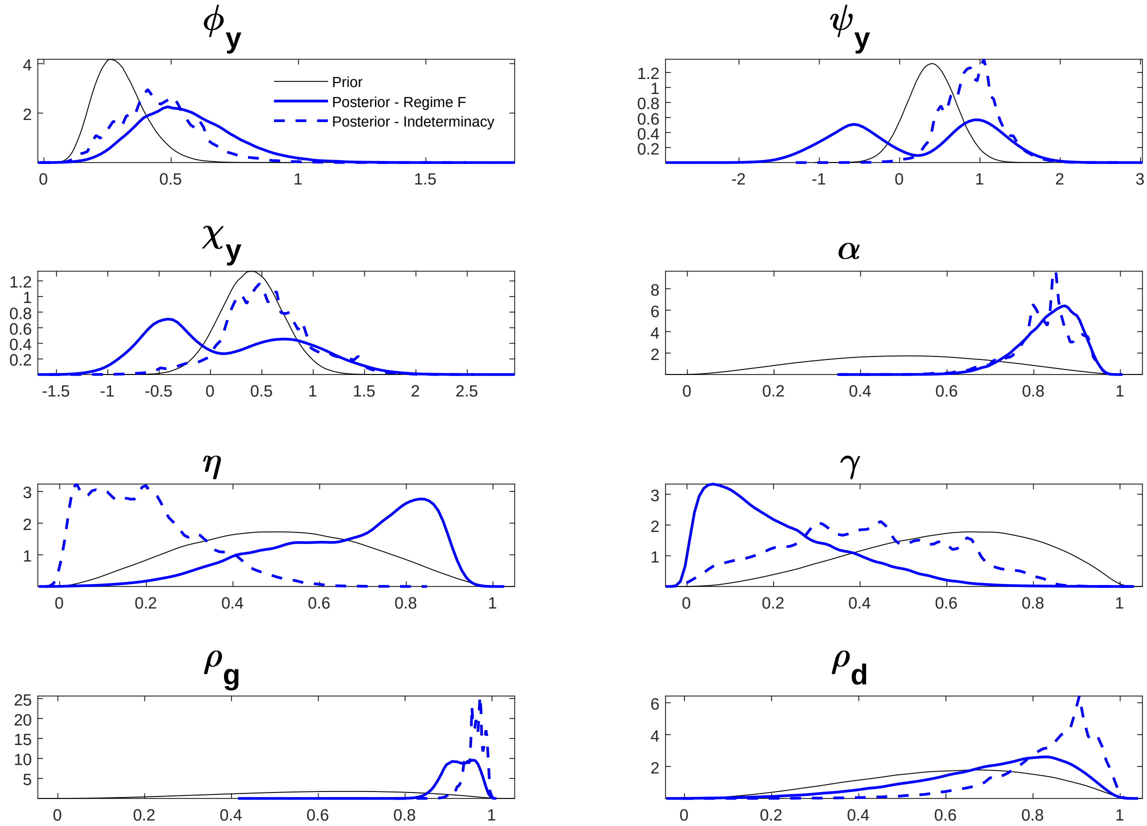


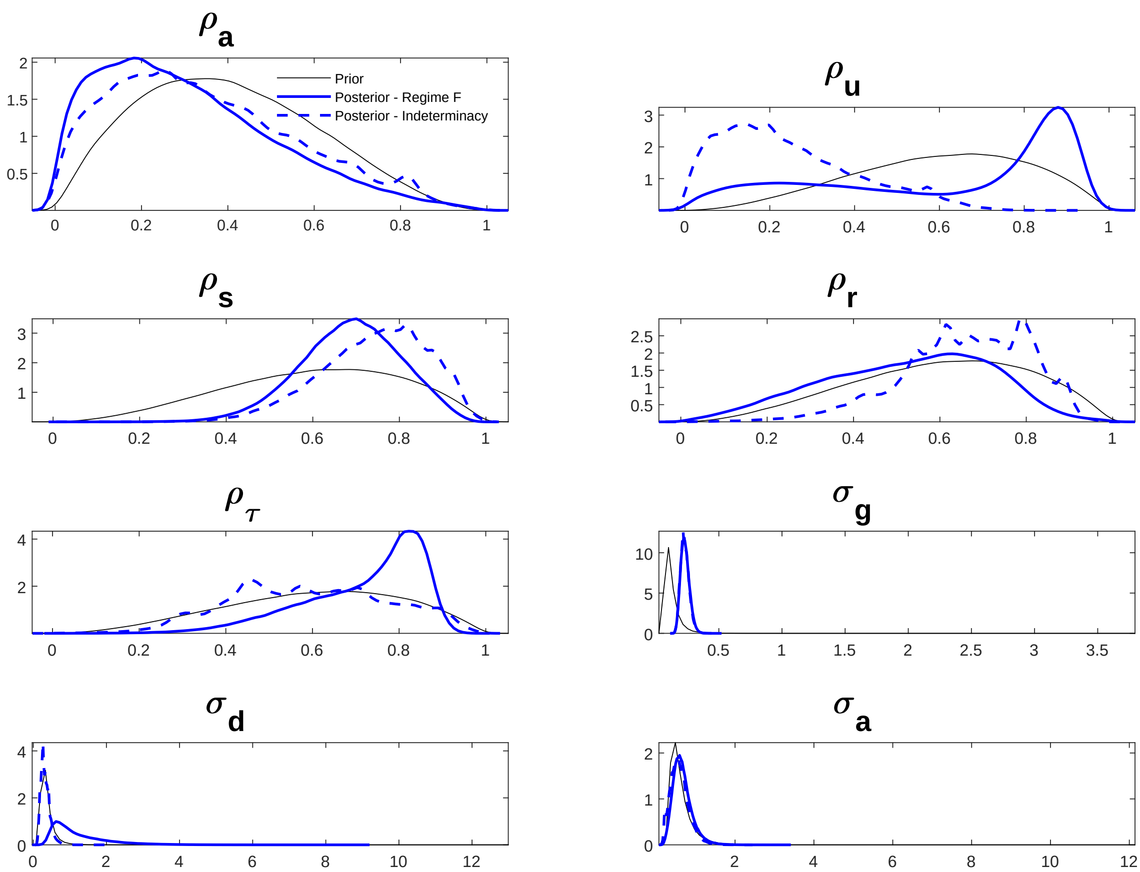
Figure 4.20: Recursive means - for RWMH runs initialized at a random value in regime PMPF

4.E.3 Unrestricted estimation - posterior densities conditional on regime F and the PMPF regime

Here we show plots of the prior and posterior densities conditional on regime F and indeterminacy from the unrestricted estimation with the SMC sampler for the policy parameters ϕ_π and ψ_b, and the remaining parameters.




ϕ_y
Prior
Posterior - Regime F
Posterior - Indeterminacy
ψ_y
χ_y
α
η
γ
ρ_g
ρ_d


ρ_a
Prior
Posterior - Regime F
Posterior - Indeterminacy
ρ_u
ρ_s
ρ_r
ρ_τ
σ_g
σ_d
σ_a

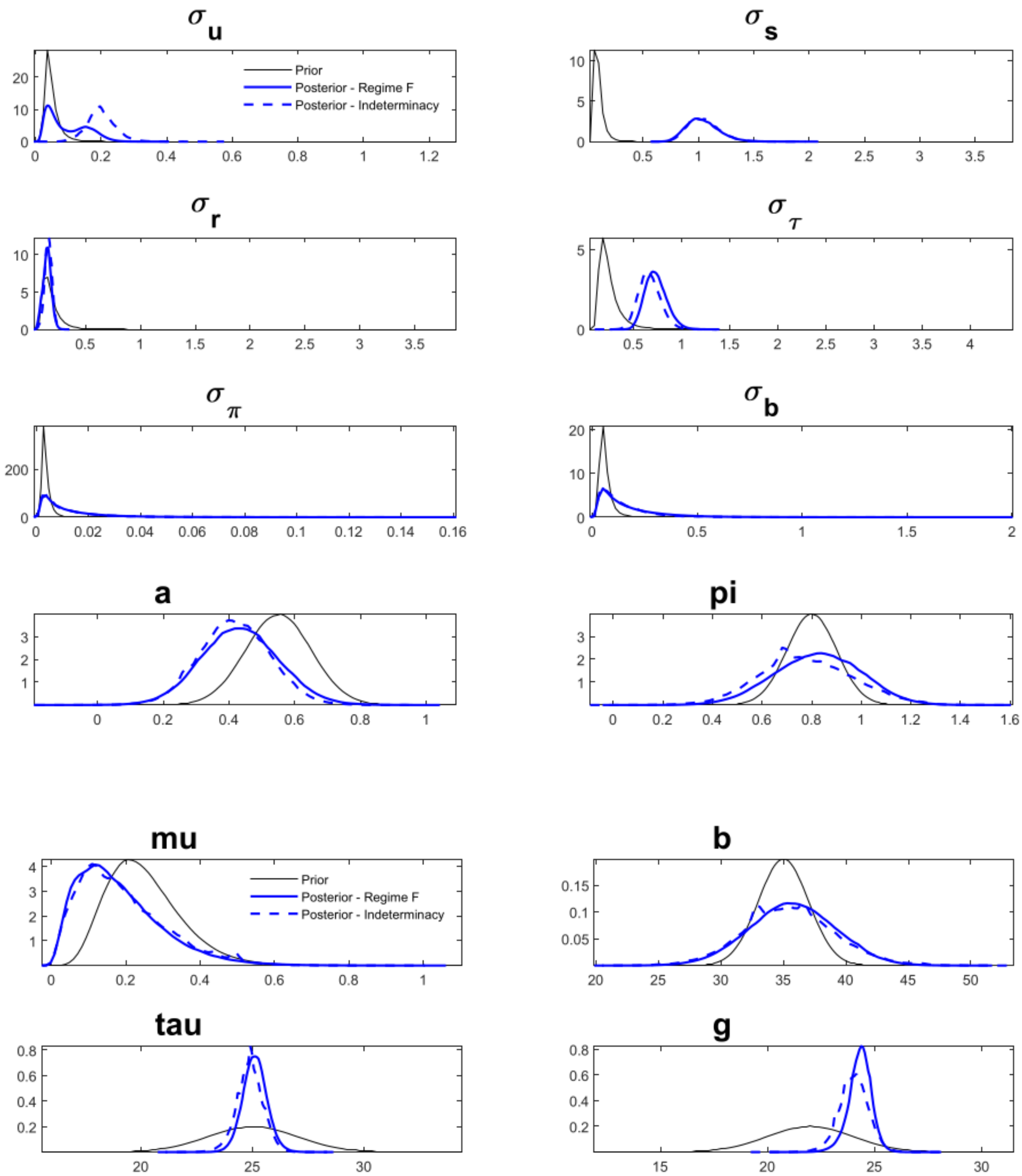


Figure 4.21: Prior and conditional posterior densities of the estimated model parameters from the unrestricted estimation. The blue bold line depicts the posterior density conditional on regime F, the dashed blue line the posterior density conditional on the PMPF regime, and the black line the prior density.

4.F Smoothed shocks

Here we show plots of the remaining smoothed shocks for regime F and the PMPF regime, respectively.

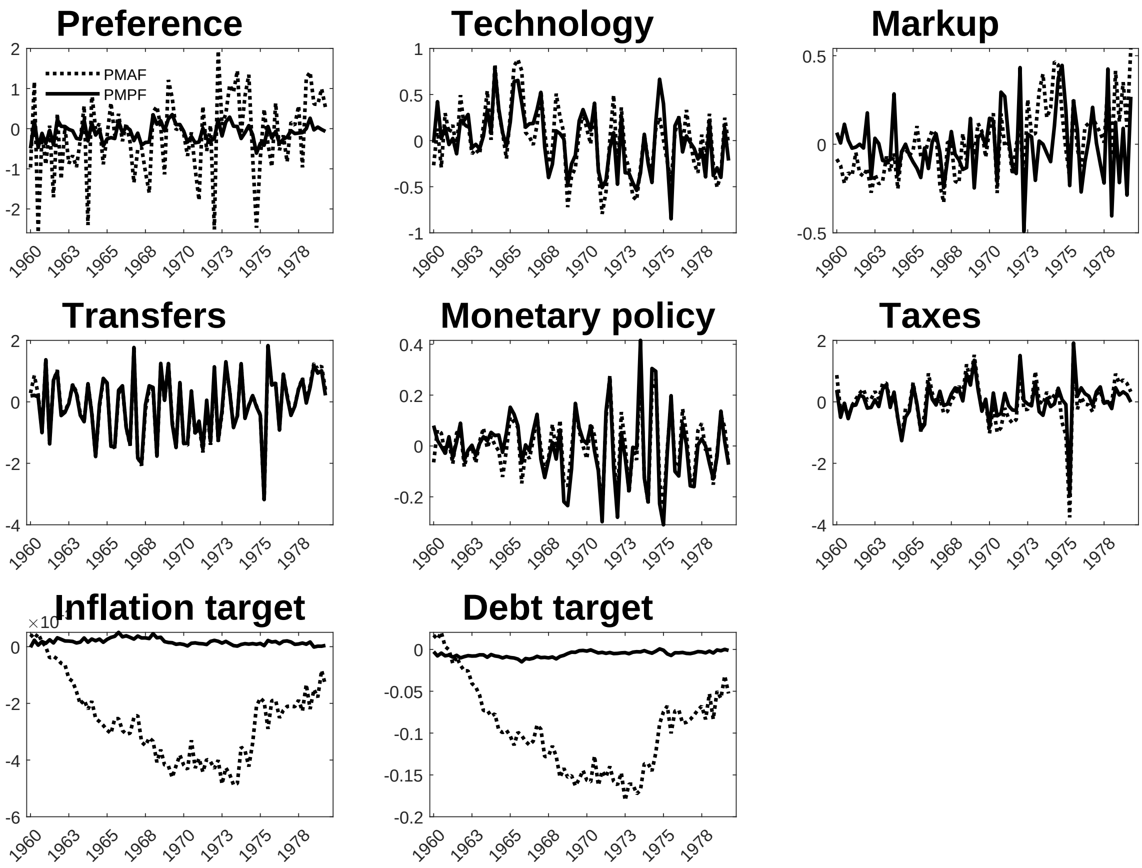


Figure 4.22: Smoothed shocks for 1960:Q1 to 1979:Q2 for regime F and the PMPF regime. The dashed line shows shocks computed at the mean of the posterior density from the unrestricted estimation conditional on regime F. The solid line shows shocks computed at the mean of the posterior density from the unrestricted estimation conditional on the PMPF regime.

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Summary

This dissertation collects empirical work in the field of fiscal and monetary policy, and their interaction. It comprises four chapters. In Chapter 1, I investigate the dynamic effects of tax changes on the cross-sectional distribution of disposable income in the US using a narrative identification approach. I distinguish between changes in personal and corporate income taxes and quantify the distributional effects on families and business owners. I document that tax changes affect incomes along the distribution differently and that the family status and the source of income matters. Tax reductions benefit high incomes and disadvantage lower incomes. Entrepreneurs and families benefit more from tax cuts than individuals without business income and non-families.

Chapter 2, also an application in fiscal policy, is a joint work with Alexander Kriwoluzky, Moritz Schularick, and Lucas ter Steege. It studies the most fateful austerity episode in history: Chancellor Brüning's budget cuts and tax increases in Germany between 1930 and 1932. We introduce a new monthly dataset on German government finances and macroeconomic variables and employ narrative records to identify the causal effects of austerity. We show that Brüning's belt-tightening aggravated the Great Depression. Without austerity, GDP would have been higher by 4.5 percent and unemployment down by 3.3 million people in 1932, a year with two crucial elections that eventually paved the way for Hitler.

Chapter 3, joint work with Alexander Kriwoluzky, contributes insights for empirically studying the causal effects of monetary policy. We determine the reliability and exogeneity of four popular monetary policy shock measures, namely the narrative series of Romer and Romer (2004), the high-frequency series of Barakchian and Crowe (2013), the high-frequency series of Gertler and Karadi (2015), and the hybrid series of Miranda-Agrippino and Ricco (2021). To this end, we employ the Proxy-SVAR model and different empirical diagnostic tools to determine the shock measures' information content. We find that the measure of Miranda-Agrippino and Ricco (2021), combining the insights from the narrative approach and high-frequency identification, outperforms the other three series.

Chapter 4, co-authored with Alexander Kriwoluzky, analyzes fiscal and monetary policy jointly by asking what role did US fiscal policy play during the Great Inflation. We estimate a DSGE model with three distinct monetary/fiscal policy regimes using a Sequential Monte Carlo (SMC) algorithm to evaluate the posterior distribution. In contrast to standard sampling algorithms, SMC enables us to determine the monetary/fiscal policy mix by sampling simultaneously from all regions of the parameter space, which makes comparing model fit across regimes unnecessary. A differentiated and novel perspective results: pre-Volcker macroeconomic dynamics were similarly driven by passive monetary/passive fiscal policy and fiscal dominance. Fiscal policy actions, especially government spending, were critical in the pre-Volcker inflation build-up.

Zusammenfassung

Die vorliegende Dissertation versammelt empirische Arbeiten im Bereich der Fiskal- und Geldpolitik und deren Wechselwirkungen. Sie umfasst vier Kapitel. In Kapitel 1 untersuche ich die dynamischen Auswirkungen von Steueränderungen auf die Verteilung des Einkommens nach Steuern in den Vereinigten Staaten unter Verwendung eines narrativen Identifikationsansatzes. Ich unterscheide Einkommensteuer- und Körperschaftsteueränderungen und quantifiziere die Verteilungseffekte für Familien und Unternehmer*innen. Ich dokumentiere, dass sich Steueränderungen entlang der Verteilung unterschiedlich auf Einkommen auswirken und dass der Familienstand sowie die Einkommensquelle eine Rolle spielen. Steuersenkungen begünstigen hohe Einkommen und benachteiligen niedrigere Einkommen. Unternehmer*innen und Familien profitieren stärker von Steuersenkungen als Personen ohne Geschäftseinkommen und Nichtfamilien.

Kapitel 2 fällt ebenfalls in den Bereich der Fiskalpolitik und ist in Kollaboration mit Alexander Kriwoluzky, Moritz Schularick und Lucas ter Steege entstanden. Es untersucht die verhängnisvollste Sparepisode der Geschichte, nämlich die Haushaltskürzungen und Steuererhöhungen durch Reichskanzler Brüning in Deutschland zwischen 1930 und 1932. Wir erstellen einen neuen monatlichen Datensatz, der eine detaillierte Aufgliederung der deutschen Staatsfinanzen sowie makroökonomische Variablen enthält und verwenden historische Quellen, um die kausalen Auswirkungen der Sparmaßnahmen narrativ zu identifizieren. Wir zeigen, dass Brünings Austeritätspolitik die Auswirkungen der Großen Depression verschlimmerte. Ohne Brünings Konsolidierungsmaßnahmen wäre 1932 die Wirtschaftsleistung um 4,5 Prozent höher ausgefallen und 3,3 Millionen Menschen weniger hätten ihre Arbeit verloren - ein Jahr mit zwei entscheidenden Wahlen, welche am Ende den Weg für Hitler ebneten.

Kapitel 3, gemeinsam mit Alexander Kriwoluzky entstanden, liefert Erkenntnisse zur empirischen Untersuchung der kausalen Wirkung von Geldpolitik. Wir bestimmen die Zuverlässigkeit und Exogenität von vier weitverbreiteten geldpolitischen Schockmaßen: der narrativen Reihe von Romer und Romer (2004), der aus hochfrequenten Finanzmarktdaten identifizierten Reihen von Barakchian und Crowe (2013) und Gertler und Karadi (2015) und der Schockreihe von Miranda-Agrippino und Ricco (2021), die den narrativen Ansatz mit der Hochfrequenzidentifikation kombiniert. Um den Informationsgehalt der Schockmaße zu bestimmen, verwenden wir das Proxy-SVAR-Modell und verschiedene empirische Diagnosewerkzeuge. Unsere Ergebnisse zeigen, dass das Schockmaß von Miranda-Agrippino und Ricco (2021), das Erkenntnisse aus dem narrativen Ansatz und der Hochfrequenzidentifikation vereinbart, besser abschneidet als die anderen drei Serien.

Kapitel 4, verfasst mit Alexander Kriwoluzky, untersucht Fiskal- und Geldpolitik gemeinsam, indem es sich der Frage widmet, welche Rolle US-Fiskalpolitik während der Großen Inflation gespielt hat. Wir schätzen ein DSGE-Modell mit drei unterschiedlichen geld-/fiskalpolitischen Regimen und verwenden einen sequentiellen Monte-Carlo-Algorithmus (SMC), um die A-posteriori-Verteilung zu evaluieren. Im Gegensatz zu herkömmlichen Sampling-Algorithmen ermöglicht uns SMC, den geld-/fiskalpolitischen Mix in einem Schritt durch gleichzeitiges Samplen aus allen Regionen des Parameterraums direkt zu bestimmen. Ein nachträglicher Vergleich der Anpassungsgüte von für jedes Regime separat geschätzten Modellen kann dadurch vermieden werden. Diese unbeschränkte Schätzung resultiert in einer differenzierten und neuartigen Perspektive: Die makroökonomische Dynamik in den Jahren vor Paul Volcker wurde in nahezu gleicher Weise von passiver Geld-/passiver Fiskalpolitik und fiskalischer Dominanz bestimmt. Fiskalpolitische Maßnahmen, insbesondere Staatsausgaben, waren für den Anstieg der Inflation in der Vor-Volcker-Periode von entscheidender Bedeutung.

Eidesstattliche Erklärung

Hiermit erkläre ich, dass ich die vorgelegte Dissertation auf Grundlage der angegebenen Quellen und Hilfsmittel selbstständig verfasst habe. Alle Textstellen, die wörtlich oder sinngemäß aus veröffentlichten oder nicht veröffentlichten Schriften entnommen sind, sind als solche kenntlich gemacht. Die vorgelegte Dissertation hat weder in der gleichen noch einer anderen Fassung bzw. Überarbeitung einer anderen Fakultät, einem Prüfungsausschuss oder einem Fachvertreter an einer anderen Hochschule zum Promotionsverfahren vorgelegen.

Stephanie Ettmeier
Berlin, October 2022

Liste verwendeter Hilfsmittel

- Statistische Programme

  Excel, Julia, Matlab, R, Stata

- Texteditoren

  Latex

- Siehe auch Literatur- und Quellenangaben