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Abstract

Greece experienced a boom until 2007, followed by a collapse of unprecedented magnitude and persistence. We assess the sources of the boom and the bust, using a rich estimated dynamic general equilibrium model. External demand and government consumption fueled the boom in production, whereas transfers fueled the boom in consumption. Different from the standard narrative, wages and prices declined substantially during the bust. Tax policy accounts for the largest fraction of the bust in production, whereas uninsurable risk accounts for the bust in consumption and wages. We assess how the composition of fiscal adjustment and bailouts affected the crisis.

JEL-Codes: E20, E32, E44, E62, F41.

*The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

1 Introduction

The Greek economy experienced a significant boom between 1998 and 2007, with real GDP per capita growing by more than 30 percent, followed by a sustained depression, with real GDP per capita contracting by roughly 20 percent between 2007 and 2017. Figure 1 documents that the magnitude and length of the Greek depression have no precedent among modern middle- and high-income economies. The severity is atypical even among economies experiencing sudden stops, sovereign defaults, or leverage cycles (Gourinchas, Philippon, and Vayanos, 2016).[1]

A standard narrative (for example, Schmitt-Grohé and Uribe, 2016) of a boom-bust cycle in a small open economy with a currency peg unfolds as follows. Output grows during the boom because of increased productivity or demand, and capital flows into the country. The boom ends with a reversal of the favorable economic conditions and capital outflows. Downward nominal wage rigidity and commitment to the currency peg prevent real wages from adjusting downward, which generates a large fall in income and employment. While the Greek experience shares some elements with this narrative, the key mechanism that amplifies the depression is at odds with the observation that nominal wages and prices fell sharply during the Greek bust. This opens up the possibility that the mechanisms amplifying shocks into great depressions and the policies mitigating them differ profoundly from those during relatively smaller contractions.

We focus our analysis on three questions. First, what are the driving forces of the Greek boom and bust? Second, how important are frictions in product, labor, and financial markets for amplifying the macroeconomic effects of shocks? Third, by how much did fiscal and financial policies amplify or mitigate the depression? Answering these questions is important for reasons that extend beyond the Greek case. The macroeconomics of great depressions (Kehoe and Prescott, 2002; Gorodnichenko, Mendoza, and Tesar, 2012) have received less scholarly attention than analyses of typical international business cycles, which attribute a role to price or wage rigidities (Schmitt-Grohé and Uribe, 2016) and financial frictions (Neumeyer and Perri, 2005; Mendoza, 2010) for understanding economic fluctuations when shocks are relatively small. Likewise, the literatures evaluating fiscal consolidations (Alesina and Ardagna, 2010) and external adjustments (Aguiar and

[1]Figure B.1 analyzes the magnitude and persistence of output drops during the sudden stop episodes identified in Gourinchas, Philippon, and Vayanos (2016) based on the methodology of Calvo, Izquierdo, and Talvi (2006) and Korinek and Mendoza (2014).

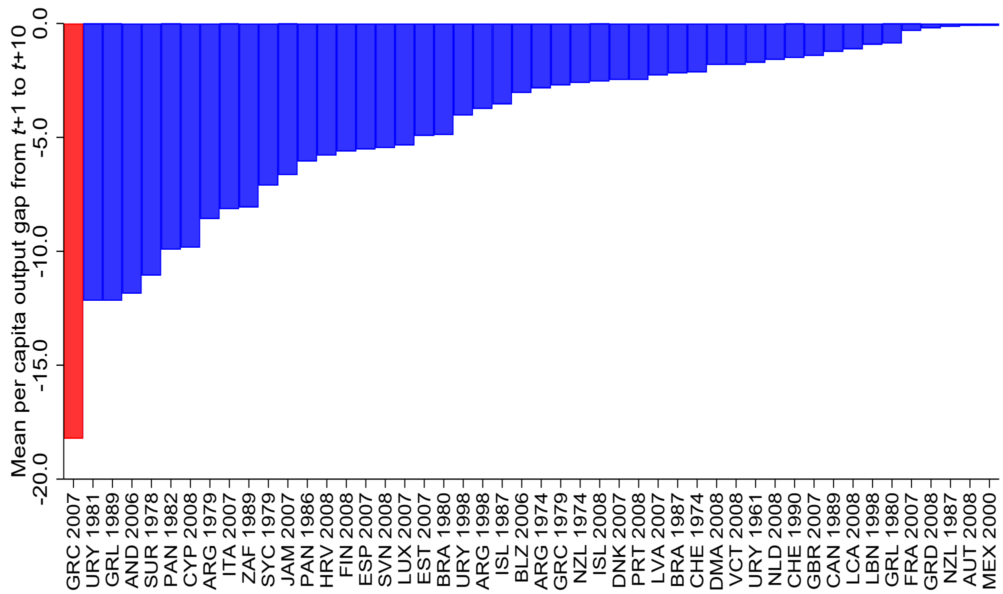


Figure 1: The Greek Depression Relative to Other Depressions

Figure 1 displays episodes in which mean real output per capita (World Development Indicators code NY.GDP.PCAP.KN) declined between a peak and ten years following the peak. We define a peak as when real GDP per capita exceeds the maximum of the preceding three and succeeding two years. Each bar shows mean real GDP per capita gap relative to the peak. For example, Greece, represented by the red bar, experienced a 18 percent gap between 2008 and 2017, relative to 2007. Our sample covers all upper-middle- and high-income countries, according to the World Bank definition, between 1960 and 2019, excluding oil producers and tax havens.

Gopinath, 2007; Garca-Cicco, Pancrazi, and Uribe, 2010) typically focus on smaller contractions.

We answer these questions by developing and estimating a rich dynamic general equilibrium model of a small open economy. The model features heterogeneous households, firms that produce tradeable and non-tradeable products, and banking, government, and external sectors. We inform the model environment with a detailed analysis of macroeconomic patterns in Greece during both the boom and the bust periods.

On the production side, increases in labor and capital drive output in the boom, whereas declines in both factors of production and total factor productivity (TFP) contribute to the bust in economic activity. Using firm surveys, we document a decline in factor utilization coincident with the decline in TFP. This observation informs our model economy in which endogenous TFP movements arise from firms' choice of how intensively to utilize factors.

Financial conditions are favorable in the boom and deteriorate in the crisis. We build on the frameworks of Gertler and Kiyotaki (2011) and Bocola (2016) to analyze the passthrough of sovereign risk to the rest of the economy. Financial developments such as bank losses from holdings of sovereign debt and equity injections to the banking sector affect real outcomes through changes in the equilibrium borrowing cost because firms face a working capital constraint that requires them to borrow in order to finance input purchases.

Measures of risk increase substantially during the crisis, impacting precautionary saving and intertemporal substitution. We model heterogeneous workers facing time-varying uninsurable idiosyncratic income risk. We discipline the evolution of idiosyncratic risk with changes in the long-term unemployment rate, which increased from below 5 percent before the crisis to almost 20 percent during the crisis. We model changes in the probability of an aggregate disaster and discipline this time-varying probability using option prices from the Greek stock market. Aggregate risk spikes around major political events such as the 2015 bailout referendum.

We model fiscal policies in detail, motivated by the significant fluctuations in both spending and taxes in the data. The government spends on consumption and investment goods, provides transfers to workers, and issues debt. Government purchases and transfers to workers rise during the boom and fall precipitously during the bust. Capturing the misreporting of government statistics before the crisis, we model workers as perceiving changes in their wealth when the government lies about its current deficit and debt. On the revenue side, the government receives transfers from European Union structural funds and raises taxes from consumption, investment, labor, and capital. Following the methodology of Mendoza, Razin, and Tesar (1994), we demonstrate that all tax rates rise sharply during the bust and remain elevated through 2017. As part of its tax policy, the government also sets the fraction of taxes that firms have to prepay before their revenues are realized. This fraction increases from 50 percent to 100 percent during the crisis.

While measures of production comove strongly between the traded and non-traded sectors, the dynamics of terms of trade and the real exchange rate lead us to consider a multi-sector environment as well as changes in the external demand for Greek traded goods. The considerable terms of trade appreciation during the boom motivates our modeling of Greek traded output as imperfectly substitutable with traded goods produced by the rest of the world. Using observed changes in exports and relative prices, we infer a significant increase in external demand for Greek traded goods during the boom, a period coinciding with the Greece's adoption of the euro and hosting of the Olympic Games, and a significant decline during the bust, a period coinciding with a slump in the global shipping industry, in which Greece plays a substantial role.

We estimate the parameters of the model using standard Bayesian techniques. Our approach differs from estimated models in the tradition of Smets and Wouters (2007), which infer latent shocks that best fit macroeconomic outcomes. Instead, our observables include counterparts of all exogenous processes, and we force these structural shocks into the model without adding to them any measurement error. Despite this discipline on the shocks, the model generates a boom and bust in output, labor, TFP, consumption, and investment that are in line with the data.

What factors account for the boom and bust in economic activity? Two demand shifters, the increase in demand for traded goods by the rest of the world and for non-traded goods by the government, account for the largest fraction of the boom in production. The consumption boom, facilitated by increased external borrowing, is driven by realized and perceived transfers to workers and by transfers from structural funds to the government. Contractionary tax policy plays the most important role for the bust in production, contributing an 18 percentage points decline in output.[2] For the bust in consumption, prices, and wages, the model attributes the most important role to the increase in uninsurable idiosyncratic risk, which increases precautionary saving.

We provide an account of the structural elements of the model responsible for these conclusions. Without variable utilization, by the end of the sample the model would generate declines in output and TFP that are more than 10 percentage points smaller. By contrast, we find a moderate role for price or wage rigidity in accounting for the persistence of the bust, reflecting the significant increase in nominal prices (14 percent relative to euro trend inflation) and wages (24 percent relative to trend) in the boom and their decline in the bust (7 percent and 34 percent relative to trend). The working capital constraint on firms amplifies the bust in production by 16 percentage points. Incomplete asset markets play an important role for the bust in consumption, prices, and wages because they generate a role for precautionary saving in response to idiosyncratic risk.

Why do these shocks and elements matter the most? The Greek experience is characterized by a persistent increase and then decline in production, prices, and wages. The boom and bust in prices and wages and the persistence of the output decline argue against the importance of

[2]As in Martin and Philippon (2017), we take the fiscal consolidation as given and quantify its macroeconomic effects. The fiscal consolidation itself was triggered by a combination of the 2008-2009 recession and the budget deficit revisions announced in October 2009. It became necessary because of the high pre-existing level of public debt. Considered through this lens, 18 percentage points should be interpreted as an upper bound of the gain in output if pre-existing conditions such as the high debt level had not made the fiscal adjustment through taxes necessary, or alternatively if Greece had received substantial additional debt relief.

nominal rigidities. Tax increases, variable utilization, and financial frictions play an important role because they amplify the output decline and generate persistence. The increase in the fraction of taxes that firms have to prepay tightens their working capital constraint and decreases their factor demand. However, these forces do not generate comovement between prices and quantities. To achieve such a comovement, the estimated model gives a prominent role to demand shifters such as changes in external demand from foreigners and changes in idiosyncratic risk.

We use the estimated model to evaluate alternative fiscal policies. The model generates tax multipliers that are larger than its spending multipliers. As a result, we find that the bust in output would have been 7 percentage points smaller by 2017 if the burden of fiscal consolidation had shifted toward further spending cuts instead of tax increases. We also highlight the benefits of running less expansionary fiscal policies during the boom. Removing the debt-financed rise of household transfers during the boom and reallocating the freed-up resources to reduce capital taxes during the bust would generate output gains of more than 15 percentage points by 2017.[3]

Finally, we assess the role of bailouts. The external bailout of Greece provided additional debt, implicit transfers because of the lower borrowing cost (Gourinchas, Martin, and Messer, 2020), and resources to bail out domestic banks. Without this assistance, Greece would have either further reduced spending or further increased taxes, resulting in an additional shortfall of output of roughly 20 percentage points at the beginning of the crisis and 5 percentage points by the end. The model attributes an important role to the bank bailout component of the assistance, which increased output by roughly 4 percentage points in 2017, relative to a counterfactual in which Greece had used these resources to cut taxes.

The seminal paper by Gourinchas, Philippon, and Vayanos (2016) provides the first systematic analysis of macroeconomic aspects of the Greek depression. We quantitatively confirm a broad message of their analysis, by attributing roughly half of the boom in output to increased government spending and of the bust to fiscal consolidation. Whereas they use total revenues to infer the time series properties of a single income tax rate, our modeling and measurement of different tax rates leads to the more nuanced conclusion that the tax side is more important than the spending

[3]Our analysis of the effects of capital income taxes confirms the conclusions of Mendoza, Tesar, and Zhang (2014) regarding dynamic Laffer curve effects with respect to capital income tax rates in open economy models with variable utilization.

side of the consolidation, especially in the later years of the depression.[4] Our model departs from their work in several other dimensions, the most quantitatively important of which are the role of external demand in the boom and bust, endogenous movements in TFP due to utilization and in precautionary saving due to idiosyncratic risk, the endogenous passthrough from bank net worth to the borrowing cost, and the treatment of nominal rigidities.[5]

The Greek experience contrasts with earlier narratives of the boom and bust in the euro area. For the boom, Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez (2017) emphasize the decline in TFP due to a deterioration of resource allocation in Spain and Italy. However, Greek traded industries did not experience declines in trend TFP during the boom. For the bust, Schmitt-Grohé and Uribe (2016) emphasize the problem of downward nominal wage rigidity in preventing internal devaluation for several countries between 2008 and 2011, including Greece. While it is true that Greek nominal wages kept increasing until 2010, they then fell by 17 percent. This timing suggests that downward nominal rigidity may be more important for countries that face relatively small contractions or that they are more important in the early stage of a crisis and become less important as shocks become larger and the crisis persists (Schmitt-Grohé and Uribe, 2017). Martin and Philippon (2017) provide a joint analysis of the boom and the bust in European countries between 2000 and 2012. Like us, they conclude that more conservative fiscal policies during the boom could have allowed a smaller fiscal consolidation in the bust. Our model differs from theirs in several important respects, including allowing for endogenous movements in TFP, capital accumulation, a banking sector, endogenous exports, time variation in taxes, and idiosyncratic risk. These elements result in better fit and lead to substantively different conclusions about the main driving forces and propagation mechanisms.[6]

[4] Economides, Philippopoulos, and Papageorgiou (2017) also attribute a substantial role to fiscal consolidation in the bust. Dellas, Malliaropulos, Papageorgiou, and Vourvachaki (2018) highlight the tax side of the consolidation and the role of the informal sector. Relative to these papers, ours examines the origins of both the boom and the bust and allows for a richer set of shocks and transmission channels. Fakos, Sakellaris, and Tavares (2022) present firm-level evidence that roughly half of the decline in manufacturing investment is accounted for by tighter credit constraints.

[5] Gourinchas, Philippon, and Vayanos (2016) externally set parameters implying a relatively high degree of price and wage rigidity and find that these rigidities help the model generate the boom and bust in quantities. They allow for markup shocks that help them match the boom and bust in prices and wages.

[6] For example, Martin and Philippon (2017) report that their model accounts for 82 percent of the observed variation in output, 65 percent in labor, 10 percent in the terms of trade, and 45 percent in net exports. Our model accounts for 97 percent, 92 percent, 41 percent, and 87 percent of the variation of these observables, respectively. The driving forces in their model exclude taxes or idiosyncratic risk, which we find to be important contributors to the bust.

The strong comovement between the traded and non-traded sector and the fact that Greek traded output did not recover despite a decline in wages challenge narratives of slow economic growth focused solely on non-traded sectors such as the government or housing. To generate this comovement, our model attributes an important role to supply-side influences such as higher tax rates and amplification mechanisms such as higher borrowing costs and lower utilization.[7] Similar to the study of Gorodnichenko, Mendoza, and Tesar (2012) on the Finnish depression in the early 1990s, we also attribute an important role to depressed external demand for the Greek bust. Our analysis differs from theirs in that, in our model, external shocks generate a decline in both employment and wages and we do not impose significant wage rigidity.

The open economy literature has debated the importance of permanent productivity shocks for consumption drops and sudden stops during crises (Aguiar and Gopinath, 2007; Garca-Cicco, Pancrazi, and Uribe, 2010). For Greece, which experienced a significantly larger consumption drop and sudden stop than those faced by a typical small open economy, we attribute the most important role to the rise of uninsurable idiosyncratic risk. The rise of idiosyncratic risk differs from productivity shocks, in that it generates declines in both prices and consumption, as observed in Greece. Empirical studies such as Storesletten, Telmer, and Yaron (2004) and Guvenen, Ozkan, and Song (2014) have documented the cyclicality of idiosyncratic risk. Quantitative studies show how elevated idiosyncratic risk depresses aggregate demand in models with heterogeneous households and nominal rigidities (Bayer, Luetticke, Pham-Dao, and Tjaden, 2019) and how monetary policy affects aggregate and household outcomes in the open economy (Guo, Ottonello, and Perez, 2021). A contribution of our paper to this emerging literature is to extend insights from Constantinides and Duffie (1996) to estimate a rich model with uninsurable idiosyncratic risk.

2 Model

We model Greece as a small open economy in a currency union. Trend productivity grows at constant rate $(1-\alpha)\mu > 1$, where $1-\alpha$ is labor's elasticity in production and μ is output's

[7] Our emphasis on utilization to reconcile movements in output and factor inputs echoes earlier work on the Mexican tequila crisis (Meza and Quintin, 2007) and on the East Asian financial crisis (Gertler, Gilchrist, and Natalucci, 2007). Unlike these articles, our paper directly measures utilization from firm surveys, which motivates our attention to this explanation for the TFP decline, rather than to other factors such as imperfect substitution of intermediate inputs (Mendoza and Yue, 2012).

growth rate in the balanced growth path. To facilitate the presentation of the model, we remove trend growth from variables and write the model directly in terms of the transformed stationary variables.[8]

2.1 Households

Heterogeneity. Workers $\iota \in [0,1]$ differ in two dimensions. First, a constant fraction ζ of workers discount with factor β^r and a fraction $1-\zeta$ of workers discount with factor $\beta^o > \beta^r$. The more impatient workers choose to borrow as much as possible and do not hold firm shares, whereas the more patient workers choose bonds and share holdings in an interior solution. Anticipating this result, we say that the former workers belong to the rule-of-thumb household r and the latter workers belong to the optimizing household o. Second, workers in the optimizing household are heterogeneous in their income, whereas all workers in the rule-of-thumb household have the same income.

Preferences. Worker ι in household $h = \{r, o\}$ values flows of consumption and labor with

$$V_{\iota t}^h = \left[\left(c_{\iota t}^h\right)^{1-\frac{1}{\rho}} \left(1 + \left(\frac{1}{\rho} - 1\right) \frac{\chi \left(\ell_{\iota t}^h\right)^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}}\right)^{\frac{1}{\rho}} + \beta^h e^{(1-1/\rho)\mu} \left(\mathbb{E}_{\iota t} \left(V_{\iota t+1}^h\right)^{1-\sigma}\right)^{\frac{1-\frac{1}{\rho}}{1-\sigma}} \right]^{\frac{1}{1-\frac{1}{\rho}}}, \tag{1}$$

where $c_{\iota t}^h$ is consumption and $\ell_{\iota t}^h$ is differentiated labor services. This specification combines Epstein and Zin (1989) preferences, which allow us to disentangle risk aversion from intertemporal substitution, with a constant Frisch elasticity of labor supply. The latter is used by Shimer (2010) and Trabandt and Uhlig (2011), among others, and is consistent with a balanced growth with constant labor. Parameter $\chi > 0$ governs the disutility of labor, $\sigma > 0$ governs risk aversion, and $\epsilon > 0$ is the Frisch elasticity of labor supply. Parameter $\rho > 0$ governs both the intertemporal elasticity of substitution in consumption and the complementarity between consumption and labor. When $\rho \to 1$, preferences are separable between consumption and labor.

Consumption c is a CES aggregator of traded c_T and non-traded c_N goods, and traded goods

[8] The model features an aggregate disaster shock that permanently moves state variables to a lower level. For that reason, we treat state variables, x^*, differently than control variables, y^*, when detrending. If x_t^* is a state variable growing at rate μ along the balanced growth path, we define the detrended variable x_t by dividing with the trend factor at the end of the previous period, $x_t = x_t^*/e^{\mu(t-1)}$. If y_t^* is a control variable growing at rate μ, we define the detrended variable y_t by dividing with the trend factor at the beginning of the period, $y_t = y_t^*/e^{\mu t}$.

are a CES aggregator of home-produced c_H and foreign-produced c_F goods:

$$c_t = \left(\omega_c^{\frac{1}{\phi}} (c_{T,t})^{\frac{\phi-1}{\phi}} + (1-\omega_c)^{\frac{1}{\phi}} (c_{N,t})^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}}, \quad c_{T,t} = \left(\gamma^{\frac{1}{\eta}} (c_{H,t})^{\frac{\eta-1}{\eta}} + (1-\gamma)^{\frac{1}{\eta}} (c_{F,t})^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}}. \quad (2)$$

Parameters $\omega_c > 0$ and $\gamma > 0$ are preference weights for goods, and parameters $\phi > 0$ and $\eta > 0$ are elasticities of substitution between goods. Home traded and non-traded goods are CES bundles of differentiated varieties indexed by j:

$$c_{H,t} = \left(\int_0^1 (c_{H,t}(j))^{\frac{\varepsilon_p-1}{\varepsilon_p}} \mathrm{d}j\right)^{\frac{\varepsilon_p}{\varepsilon_p-1}}, \quad c_{N,t} = \left(\int_0^1 (c_{N,t}(j))^{\frac{\varepsilon_p-1}{\varepsilon_p}} \mathrm{d}j\right)^{\frac{\varepsilon_p}{\varepsilon_p-1}}. \quad (3)$$

In equation (3), $\varepsilon_p > 1$ is the elasticity of substitution across varieties. Varieties are monopolistically competitive, so ε_p governs the markup of price over marginal cost in both sectors.

Idiosyncratic income risk. Worker ι receives a share $\theta^h_{\iota t}$ of labor income and transfers net of wage adjustment costs accruing to household h. For workers in the optimizing household, the log share is random walk:

$$\log \theta^o_{\iota t+1} = \log \theta^o_{\iota t} + \nu^\theta_{\iota t+1}, \quad (4)$$

where ν^θ_ι is an innovation to worker ι's income. Innovations wash out at the household level: $\int \exp(\nu^\theta_{\iota t}) \mathrm{d}\iota = 1$. Workers in the rule-of-thumb household have the same income share, $\theta^r_{\iota t} = 1$.

The random walk process in equation (4) implies that consumption of worker ι is proportional to household consumption: $c^o_{\iota t} = \theta^o_{\iota t} c^o_t$. As a result, relative consumption among workers depends only on relative idiosyncratic shocks, which are uninsurable.[9] This convenient result allows us to solve for endogenous variables of the model using perturbation methods on a system of equilibrium conditions that includes only household consumption c^o_t and not individual consumption $c^o_{\iota t}$. The difference from a model with identical workers is that an increase in idiosyncratic risk, modeled as a mean preserving increase in the dispersion of $\nu^\theta_{\iota t}$, strengthens precautionary motives and reduces desired consumption for all members of the optimizing household.

We motivate changes in idiosyncratic risk over time with the observation that long-term unemployment in Greece increased substantially during the crisis. To link changes in idiosyncratic

[9] Owing to the random walk process for income shares, all workers expect their consumption to grow at the same rate, and none of them choose to trade securities with workers in the same household. This logic traces back to Constantinides and Duffie (1996), who first derived a no-trade theorem in an endowment economy. In Appendix A.1 we show how their result extends in our richer framework that features Epstein-Zin preferences, trade of assets with the rest of the world, endogenous labor supply, wage markups, and wage adjustment costs.

income risk in the model to observed changes in unemployment risk, we assume that $\nu^{\theta}_{\iota t}$ takes two values. With probability π^{θ}_{t}, which we measure with the long-term unemployment rate, workers are in a disaster state and receive $\nu^{\theta}_{\iota t} = -\varphi^{\theta}$. With probability $1-\pi^{\theta}_{t}$, workers are in a good state and receive $\nu^{\theta}_{\iota t} = \log\left(\frac{1-\pi^{\theta}_{t}\exp(-\varphi^{\theta})}{1-\pi^{\theta}_{t}}\right)$, a value chosen to make idiosyncratic shocks wash out at the household level ($\int \exp(\nu^{\theta}_{\iota t})\mathrm{d}\iota = 1$).

Wage setting. A perfectly competitive employment agency rents bundles of labor to firms at price W_t. The agency chooses differentiated labor varieties $\ell^{h}_{\iota t}$ to maximize profits:

$$W_t(\ell^{r}_{t} + \ell^{o}_{t}) - \int W^{r}_{\iota t}\ell^{r}_{\iota t}\mathrm{d}\iota - \int W^{o}_{\iota t}\ell^{o}_{\iota t}\mathrm{d}\iota, \tag{5}$$

where $\ell^{h}_{t} = \left(\int \left(\ell^{h}_{\iota t}\right)^{\frac{\varepsilon_w - 1}{\varepsilon_w}} \mathrm{d}\iota\right)^{\frac{\varepsilon_w - 1}{\varepsilon_w}}$ is the bundle of labor for each type of household h with an elasticity of substitution across varieties $\varepsilon_w > 1$. In equation (5), $W^{h}_{\iota t}$ denotes the cost of hiring one unit of $\ell^{h}_{\iota t}$. The perfect substitutability between ℓ^{r}_{t} and ℓ^{o}_{t} implies a common wage W_t for both types of households. Workers in the rule-of-thumb household are symmetric, and thus in equilibrium we obtain $\ell^{r}_{\iota t} = \ell^{r}_{t}$ and $W^{r}_{\iota t} = W_t$. While workers in the optimizing household are heterogeneous, their consumption and labor income scale with the same factor $\theta^{o}_{\iota t}$, and thus in equilibrium we also obtain $\ell^{o}_{\iota t} = \ell^{o}_{t}$ and $W^{o}_{\iota t} = W_t$.

The first-order conditions from the optimization problem (5) yield a downward sloping demand function for labor varieties:

$$\ell^{h}_{\iota t} = \left(\frac{W^{h}_{\iota t}}{W_t}\right)^{-\varepsilon_w} \ell^{h}_{t}. \tag{6}$$

Workers internalize these labor demand functions in setting wages. Parameter ε_w governs the markup of real wages over the marginal rate of substitution between leisure and consumption. Workers face quadratic costs of changing after-tax wages, $\mathrm{AC}^{h}_{w,\iota t} = \frac{\psi_w}{2}\left(\frac{(1-\tau^{\ell}_{t})e^{-\mu}W^{h}_{\iota t}}{(1-\tau^{\ell}_{t-1})W^{h}_{\iota t-1}} - 1\right)^2 (1 - \tau^{\ell}_{t})W^{h}_{t}\ell^{h}_{t}$, where $\psi_w \geq 0$ controls for the strength of these costs.[10]

Asset markets. Workers can hold firm shares $\varsigma^{h}_{\iota t}$ and borrow in bonds $B^{h}_{\iota t}$. Choices of shares and bonds are subject to the financial constraints

$$\varsigma^{h}_{\iota t+1} \geq 0, \quad B^{h}_{\iota t+1} \leq \overline{B}^{h}_{t+1}. \tag{7}$$

[10]We model adjustment costs on after-tax wages because negotiated and posted salaries in Greece are commonly quoted in after-tax terms. We have confirmed the robustness of our results to modeling adjustment costs on a pre-tax basis.

The borrowing limit $\overline{B}^h_{t+1} > 0$ is exogenously set by the rest of the world. The assumption $\beta^o > \beta^r$ implies that in a neighborhood around the steady state, workers in the rule-of-thumb household choose $B^r_t = \overline{B}^r_t$ and $\varsigma^r_t = 0$.

Budget constraint. Workers face a sequence of budget constraints:

$$(1+\tau^c_t)P_{c,t}c^h_{\iota t} + (1+i(B^h_{\iota t}))e^{-\mu}B^h_{\iota t} - B^h_{\iota t+1} + Q^\varsigma_t \varsigma^h_{\iota t+1}$$
$$= \theta^h_{\iota t}\left[(1-\tau^\ell_t)\int W^h_{\iota t}\ell^h_{\iota t}\mathrm{d}\iota - \int \mathrm{AC}^h_{w,\iota t}\mathrm{d}\iota + T^h_t + \frac{\mathcal{I}(h=o)(\Pi^b_t + T^l_t)}{1-\zeta}\right] + \left(Q^\varsigma_t + \Pi^f_t\right)\varsigma^h_{\iota t}, \quad (8)$$

where $P_{c,t}$ is the price of consumption, τ^c_t and τ^ℓ_t are consumption and labor income tax rates, $i(.)$ is the interest schedule on bonds, Q^ς_t is the price of firm shares, T^h_t and T^l_t are lump sum transfers, and Π^b_t and Π^f_t are bank and firm profits.

There are three differences between workers in the rule-of-thumb household and workers in the optimizing household. First, workers in the optimizing household save in a neighborhood around the steady state, $B^o_{\iota t} \leq 0$, and receive an interest rate $i(B \leq 0) = \bar{i}_t$ taken as given from the rest of the world. Workers in the rule-of-thumb household borrow from domestic banks, $B^r_{\iota t} > 0$, and face an interest rate $i(B > 0) = i_t$, which is determined in equilibrium. Second, workers in the optimizing household own the banks and receive their profits Π^b_t. Finally, the transfer T^l_t (superscript l for "lie") appears only in the budget constraint of workers in the optimizing household. This variable captures perceptions of changes in wealth when the government lies about its current debt position and future tax revenue obligations. Misreporting of statistics does not generate an actual transfer of resources and thus we model the realized T^l_t as always equal to zero. To model the perception of changes in wealth, we assume that workers receive news of future transfers embedded in $\mathbb{E}_t T^l_{t+1}$ that never realize during the sample path.

Household optimization. Worker ι in household h chooses sequences of consumption $c^h_{H,\iota t}(j)$, $c^h_{F,\iota t}$, $c^h_{N,\iota t}(j)$, labor supply $\ell^h_{\iota t}$, wages $W^h_{\iota t}$, bonds $B^h_{\iota t+1}$, and shares $\varsigma^h_{\iota t+1}$ in order to maximize their value in equation (1), subject to the law of motion of their income (4), the downward sloping demand for labor (6), the financial constraints (7), and the budget constraint (8).

2.2 Firms

Intermediate goods firms use labor and capital to produce traded and non-traded goods, y_H and y_N. Retailers transform these into differentiated goods, $y_H(j)$ and $y_N(j)$, and set prices.

Production. Production is Cobb-Douglas:

$$y_{H,t} = z_{H,t} u_{H,t} (e^{-\mu} k_{H,t})^{\alpha} (\ell_{H,t})^{1-\alpha}, \qquad y_{N,t} = z_{N,t} u_{N,t} (e^{-\mu} k_{N,t})^{\alpha} (\ell_{N,t})^{1-\alpha}, \tag{9}$$

where $z_{H,t}$ and $z_{N,t}$ denote exogenous productivity in each sector and parameter $\alpha > 0$ governs the capital share of income.[11] Firms hire labor inputs, $\ell_{H,t}$ and $\ell_{N,t}$, at a wage W_t. Share s_t of aggregate capital k_t is allocated to the traded sector, so $k_{H,t} = s_t k_t$ and $k_{N,t} = (1 - s_t) k_t$.

Firms choose endogenously the utilization of factors $u_{H,t}$ and $u_{N,t}$, motivated by the observation that the significant drop in sectoral TFP in the bust coincides with declines in utilization as measured in firm surveys. The cost of utilizing factors more intensively is increased depreciation rates of capital:

$$\delta_{H,t} = \bar{\delta}_H + \frac{\bar{\xi}_H}{\xi_H}\left(u_{H,t}^{\xi_H} - 1\right), \qquad \delta_{N,t} = \bar{\delta}_N + \frac{\bar{\xi}_N}{\xi_N}\left(u_{N,t}^{\xi_N} - 1\right), \tag{10}$$

where $\bar{\delta}_H, \bar{\delta}_N > 0$ are the depreciation rates when utilization equals the steady state value of one, $\bar{\xi}_H, \bar{\xi}_N > 0$ are constants normalized to target steady state utilization, and $\xi_H, \xi_N > 1$ govern the responsiveness of depreciation rates to utilization.

Capital accumulates according to

$$k_{t+1} = \left(1 - (s_t \delta_{H,t} + (1 - s_t)\delta_{N,t})\right) e^{-\mu} k_t + x_t + g_t^x, \tag{11}$$

where private investment $x_t = \left(\omega_x^{\frac{1}{\phi}} (x_{T,t})^{\frac{\phi-1}{\phi}} + (1 - \omega_x)^{\frac{1}{\phi}} (x_{N,t})^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}}$ is a bundle of traded and non-traded goods with share parameter $\omega_x > 0$ and elasticity of substitution $\phi > 0$. In this bundle, $x_{T,t}$ is a CES aggregator between home $x_{H,t}$ and foreign $x_{F,t}$ traded goods similar to the $c_{T,t}$ aggregator in equation (2), and $x_{H,t}$ and $x_{N,t}$ are CES aggregators of varieties similar to the $c_{H,t}$ and $c_{N,t}$ aggregators in equation (3). We add to capital accumulation the government's spending on investment goods g_t^x, which is also a CES aggregator of traded and non-traded goods.

Asset markets. Firms require working capital to finance their operations because of a mismatch between the timing of revenues and expenses. Working capital generates a demand for bank loans and transmits changes in the borrowing cost i_t to intratemporal and intertemporal production

[11] We use the same α for both sectors because the sample average labor share is nearly identical for both sectors. We justify the representative firm setup by noting that declines in value added and employment occurred throughout the firm size distribution in the bust (Appendix Figure B.2). Additionally, for almost all industries, the decline in labor productivity is accounted for by declines in labor productivity within size class rather than by a reallocation of economic activity across firms of different sizes (Appendix Figure B.3).

decisions. Fractions $\kappa_x \in [0,1]$ of investment, $\kappa_\ell \in [0,1]$ of employee compensation, and $\kappa_{\tau,t} \in [0,1]$ of income taxes require financing at the beginning of the period, before all revenues realize. Firms have access to a fraction κ_y of income at the beginning of the period and finance the rest of their expenses by borrowing B^f_{t+1} from banks. Debt is repaid at the beginning of next period at the interest rate i_t. The working capital constraint is

$$B^f_{t+1} + \kappa_y \left(P_{H,t}y_{H,t} + P_{N,t}y_{N,t}\right) = \kappa_x(1+\tau^x_t)P_{x,t}x_t + \kappa_\ell W_t\ell_t + \kappa_{\tau,t}T^f_t + (1+i_t)e^{-\mu}B^f_t, \tag{12}$$

where $P_{H,t}$ and $P_{N,t}$ are the prices of traded and non-traded goods, $(1+\tau^x_t)P_{x,t}$ is the after-tax price of investment goods, and T^f_t is income tax payments. Motivated by tax reforms during the crisis that raised tax prepayments of firms, we allow $\kappa_{\tau,t}$ to vary over time.

Intermediate goods optimization. The objective of firms is to maximize their value $J^f_t = \Pi^f_t + \mathbb{E}_t\Lambda^o_{t,t+1}J^f_{t+1}$, where $\Lambda^o_{t,t+1}$ is the common stochastic discount factor of workers in the optimizing household. Firms choose sequences of labor demand $\ell_{H,t}$, $\ell_{N,t}$, capital k_t, s_t, utilization $u_{H,t}$, $u_{N,t}$, and bonds B^f_{t+1} in order to maximize their value subject to the production functions (9), depreciation rates (10), capital accumulation (11), and the working capital constraint (12). Flow profit Π^f_t is

$$\begin{aligned}\Pi^f_t &= \left(1-\tau^k_{H,t}\right)\left(P^f_{H,t}y_{H,t} - W_t\ell_{H,t} + \Pi_{H,t}\right) + \left(1-\tau^k_{N,t}\right)\left(P^f_{N,t}y_{N,t} - W_t\ell_{N,t} + \Pi_{N,t}\right) - \mathrm{AC}^f_t + B^f_{t+1} \\ &\quad - (1+\tau^x_t)P_{x,t}x_t - e^{-\mu}\left[(1+i_t)B^f_t - s_t\tau^k_{H,t}\left(\bar{\delta}_H Q^k_t k_t + i_t B^f_t\right) - (1-s_t)\tau^k_{N,t}\left(\bar{\delta}_N Q^k_t k_t + i_t B^f_t\right)\right], \end{aligned} \tag{13}$$

where $P^f_{H,t}$ and $P^f_{N,t}$ are the prices of intermediate goods supplied to retailers, τ^k_t and τ^x_t are capital income and investment taxes, and Q^k_t is the price of capital. Capital income taxes are sector specific, $\tau^k_{H,t}$ and $\tau^k_{N,t}$, motivated by the observation that property taxes increased significantly during the bust and fall disproportionally on the non-traded sector. To ensure that all non-labor income is taxed, we make it so that taxable income includes the monopoly profits of retailers, $\Pi_{H,t}$ and $\Pi_{N,t}$. With depreciation and interest expenses deducted, income tax payments are $T^f_t = \sum_{i=H,N}\tau^k_{i,t}\left(P^f_{i,t}y_{i,t} - W_t\ell_{i,t} + \Pi_{i,t} - e^{-\mu}s_{i,t}\left(\bar{\delta}_i Q^k_t k_t + i_t B^f_t\right)\right)$. Finally, costs of adjusting dividends, investment, and labor are included in AC^f_t and are all quadratic.[12]

Price setting. Retailers in the traded sector produce differentiated varieties $y_{H,t}(j)$ using the intermediate traded good $y_{H,t}$. They choose price $P_{H,t}(j)$ to maximize their value $J_{H,t}(j) =$

[12]The adjustment cost terms equals $\mathrm{AC}^f_t = \mathrm{AC}^f_{\pi,t} + \mathrm{AC}^f_{x,t} + \mathrm{AC}^f_{\ell,t} + q_\ell W_t(\ell_t - \ell) - T^q_t$. Dividend adjustment costs

$\Pi_{H,t}(j) + \mathbb{E}_t \Lambda^o_{t,t+1} J_{H,t+1}(j)$. Flow profits are $\Pi_{H,t}(j) = \left(P_{H,t}(j) - P^f_{H,t}\right) y_{H,t}(j) - \text{AC}_{H,t}(j)$, where $\text{AC}_{H,t}(j) = \frac{\psi_{H,p}}{2}\left(\frac{P_{H,t}(j)}{P_{H,t-1}(j)} - 1\right)^2 P_{H,t} y_{H,t}$ are quadratic costs of changing nominal prices, as in Rotemberg (1982), and $\psi_{H,p} \geq 0$ controls for the strength of these costs.

In setting prices, retailers internalize the residual demand for their variety j by households, intermediate goods firms, government, and the rest of the world:

$$y_{H,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\varepsilon_p}\left[\gamma\left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\eta}\left(c_{T,t} + x_{T,t} + g^c_{T,t} + g^x_{T,t}\right) \;\; + (1-\gamma)\left(\frac{P_{H,t}}{P_{F,t}}\right)^{-\eta} \bar{a}_{T,t}\right]. \tag{14}$$

The first term in the bracket of equation (14) is domestic demand for household consumption $c_{H,t}(j)$, firm investment $x_{H,t}(j)$, government consumption $g^c_{H,t}(j)$, and government investment $g^x_{H,t}(j)$. The second term is demand for Greek traded goods from the rest of the world, where the exogenous shifter $\bar{a}_{T,t}$ is a convolution of preferences for Greek goods and overall traded-goods demand by the rest of the world.[13]

Retailers in the non-traded sector produce differentiated varieties $y_{N,t}(j)$ using the intermediate non-traded good $y_{N,t}$. They choose price $P_{N,t}(j)$ to maximize their value $J_{N,t}(j) = \Pi_{N,t}(j) + \mathbb{E}_t \Lambda^o_{t,t+1} J_{N,t+1}(j)$, where flow profits are $\Pi_{N,t}(j) = \left(P_{N,t}(j) - P^f_{N,t}\right) y_{N,t}(j) - \text{AC}_{N,t}(j)$ and adjustment costs of changing nominal prices are $\text{AC}_{N,t}(j) = \frac{\psi_{N,p}}{2}\left(\frac{P_{N,t}(j)}{P_{N,t-1}(j)} - 1\right)^2 P_{N,t} y_{N,t}$. The residual demand for their variety j is

$$y_{N,t}(j) = \left(\frac{P_{N,t}(j)}{P_{N,t}}\right)^{-\varepsilon_p}\left[c_{N,t} + x_{N,t} + g^c_{N,t} + g^x_{N,t}\right]. \tag{15}$$

2.3 Banks

We model financial intermediation following Gertler and Kiyotaki (2011) and Bocola (2016). In this framework, financial developments such as sovereign default affect domestic production, in-

are $\text{AC}^f_{\pi,t} = \frac{\psi_\pi}{2}\left(\frac{\Pi^f_t}{P_{F,t}} - \frac{\Pi^f}{P_F}\right)^2 P_{F,t}$, where $\psi_\pi \geq 0$ controls for the strength of these costs and Π^f/P_F denotes steady state profits relative to the foreign price. Investment adjustment costs are $\text{AC}^f_{x,t} = \frac{e^\mu \psi_x}{2}\left(\frac{x_t}{x_{t-1}} - 1\right)^2 P_{F,t} x_{t-1}$, where $\psi_x \geq 0$ controls for the strength of these costs. Labor adjustment costs are $\text{AC}^f_{\ell,t} = \frac{\psi_\ell}{2}\left(\frac{\ell_t}{\ell_{t-1}} - 1\right)^2 W_t \ell_{t-1}$, where $\psi_\ell \geq 0$ controls for the strength of these costs. We add to adjustment costs a constant labor tax q_ℓ when labor exceeds its steady state level ℓ, which we conveniently calibrate to target the labor share of income in steady state. Finally, $T^q_t = q_\ell W_t(\ell_t - \ell)$ is a lump sum transfer that offsets the tax.

[13] Denoting rest of the world variables with an upper bar, under CES preferences the quantity of Greek traded goods demanded from the rest of the world is $\bar{c}_{H,t}(j) + \bar{x}_{H,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\varepsilon_p}(1-\bar{\gamma}_t)\left(\frac{P_{H,t}}{P_{F,t}}\right)^{-\eta}(\bar{c}_{T,t} + \bar{x}_t)$, where $P_{F,t} = \bar{P}_{T,t}$ because Greece is too small to affect the price of traded goods in the rest of the world. Therefore, external demand is $\bar{a}_{T,t} = \frac{1-\bar{\gamma}_t}{1-\gamma}(\bar{c}_{T,t} + \bar{x}_t)$.

vestment, and consumption through changes in the borrowing cost, i_t, which is determined endogenously from decisions of banks and the private sector. Collectively, the banking sector and the financial constraints (7) on workers and (12) on firms make up the financial mechanisms in our framework.

Bankers are members of the optimizing household. Each period, an incumbent banker exits with probability δ_b and is replaced by a new banker to keep the total measure of bankers constant. New bankers are endowed by the optimizing household with a fraction ω_b of aggregate output, $N^e_{t+1} = \omega_b(P_{H,t}y_{H,t} + P_{N,t}y_{N,t})$. Incumbent bankers hold a portfolio of firm debt B^f_{t+1} and rule-of-thumb debt ζB^r_{t+1}. They finance their portfolio with deposits B^b_{t+1} raised from the optimizing household and the rest of the world and with their net worth:

$$N_t = e^{\mu}\left(B^f_{t+1} + \zeta B^r_{t+1} - B^b_{t+1}\right). \tag{16}$$

The net worth of bankers who continue to the next period, N^c_{t+1}, equals the return on private sector loans, $(1 + i_{t+1})\left(B^f_{t+1} + \zeta B^r_{t+1}\right)$, minus the cost of financing, $(1 + \bar{i}_{t+1})B^b_{t+1}$. Applying the definition of incumbent bankers' net worth to equation (16), we obtain

$$N^c_{t+1} = (1 + \bar{i}_{t+1})e^{-\mu}N_t + (i_{t+1} - \bar{i}_{t+1})\left(B^f_{t+1} + \zeta B^r_{t+1}\right). \tag{17}$$

Continuing bankers' net worth is augmented by the cost of funds $\bar{i}_{t+1}$ earned on previous period net worth and by the spread $i_{t+1} - \bar{i}_{t+1}$ earned on private sector loans. Profits distributed to the optimizing household equal the net worth of exiting bankers minus the funds required to finance new entrants: $\Pi^b_t = e^{-\mu}(\delta_b N^c_t - N^e_t)$.

The spread $i_{t+1} - \bar{i}_{t+1}$ arises from the limited enforcement of contracts. Bankers can divert a fraction κ_b of their assets to the optimizing household before repaying their debt. The return on loans i_{t+1} has to rise sufficiently above the cost of funds $\bar{i}_{t+1}$ so that bankers satisfy the incentive compatibility constraint that induces them to repay in equilibrium:

$$\kappa_b\left(B^f_{t+1} + \zeta B^r_{t+1}\right) \leq J^b_t. \tag{18}$$

Bankers do not default in equilibrium when their value J^b_t exceeds the value of divertible assets.

Incumbent bankers choose sequences of investments B^f_{t+1} and B^r_{t+1}, financing B^b_{t+1}, and net worth N^c_{t+1} to maximize their value $J^b_t = \mathbb{E}\Lambda^o_{t,t+1}\left(\delta_b N^c_{t+1} + (1-\delta_b)J^b_{t+1}\right)$, subject to their net worth (16), the net worth evolution for continuing bankers (17), and the incentive compatibility constraint (18). As in Gertler and Kiyotaki (2011), the problem becomes tractable by conjecturing and then verifying that the value function J_t^b is proportional to net worth N_t for a factor of proportionality that we solve for in equilibrium.

Finally, the total net worth of the banking sector is

$$N_{t+1} = (1-\delta_b)N_{t+1}^c + N_{t+1}^e + T_{W,t}^b + e^{\mu}T_{G,t}^b. \tag{19}$$

Motivated by the global financial crisis and the Greek sovereign debt crisis, we introduce two exogenous processes in the evolution of bank net worth. The variable $T_{W,t}^b$ is net flows from the rest of the world to domestic banks and, in our quantitative results, equals changes in valuations of foreign assets held by domestic banks. The variable $T_{G,t}^b$ is net flows from the government to domestic banks and, in our quantitative results, equals changes in the value of sovereign debt held by domestic banks and equity injections from the government to domestic banks.[14]

2.4 Government

The government receives capital transfers from European Union structural funds T_t^g and raises revenues from taxes on consumption τ_t^c, investment τ_t^x, labor income τ_t^ℓ, and capital income $\tau_{H,t}^k$,$\tau_{N,t}^k$. Sovereign debt held by the rest of the world is $\bar{B}_t^g$ and pays an interest rate of $\bar{r}_t$. Debt held by domestic banks is subject to valuation effects that we quantify in the term $T_{G,t}^b$ in the banks' problem. The government spends its resources on consumption, $g_{T,t}^c$ and $g_{N,t}^c$, investment, $g_{T,t}^x$ and $g_{N,t}^x$, and transfers to households, T_t^r and T_t^o. The government budget constraint is

$$\begin{aligned}
&\bar{B}_{t+1}^g + T_t^g + \tau_t^c P_{c,t}\left(\zeta c_t^r + (1-\zeta)c_t^o\right) + \tau_t^x P_{x,t}x_t + \tau_t^\ell W_t\left(\zeta \ell_t^r + (1-\zeta)\ell_t^o\right)\\
&+ \sum_{i=H,N} \tau_{i,t}^k \left(P_{i,t}^f y_{i,t} - W_t\ell_{i,t} + \Pi_{i,t} - e^{-\mu}s_{i,t}\left(\bar{\delta}_i Q_t^k k_t + i_t B_t^f\right)\right)\\
&\qquad = (1+\bar{r}_t)e^{-\mu}\bar{B}_t^g + T_{G,t}^b + P_{T,t}(g_{T,t}^c + g_{T,t}^x) + P_{N,t}(g_{N,t}^c + g_{N,t}^x) + \zeta T_t^r + (1-\zeta)T_t^o.
\end{aligned} \tag{20}$$

2.5 Driving Forces

We organize the exogenous processes driving the model in six categories:

[14] Banks in our model do not choose how to allocate their portfolio between private and government securities, owing to financial repression. However, through the variable $T_{G,t}^b$, changes in the value of these assets and government equity injections affect bank net worth.

1. *Productivity.* Includes traded productivity $\log z_{H,t}$ and non-traded productivity $\log z_{N,t}$.

2. *External.* Includes demand from the rest of the world for Greek products $\bar{a}_{T,t}$, the price of imports $P_{F,t}$, capital transfers from structural funds T^g_t, and anticipation of transfers T^l_t.

3. *Financial.* Includes government debt held by the rest of the world $\log \bar{B}^g_t$, the borrowing limit of rule-of-thumb workers $\log \bar{B}^r_t$, the interest rate on government debt $\bar{r}_t$, the cost of funds $\bar{i}_t$, and the changes in banks' net worth related to foreign assets $T^b_{W,t}$ and holdings of sovereign debt $T^b_{G,t} = T^b_{Gd,t} + T^b_{Ge,t}$. We further split $T^b_{G,t}$ into two processes, valuation effects on banks' balance sheets from sovereign debt $T^b_{Gd,t}$ and equity injections from the government $T^b_{Ge,t}$.

4. *Government spending.* Includes spending on consumption of traded goods $\log g^c_{T,t}$, consumption of non-traded goods $\log g^c_{N,t}$, investment of traded goods $\log g^x_{T,t}$, investment of non-traded goods $\log g^c_{N,t}$, and transfers to the rule-of-thumb household $\log T^r_t$.

5. *Tax policy.* Includes taxes on consumption τ^c_t, investment τ^x_t, labor income τ^ℓ_t, capital income in the traded sector $\tau^k_{H,t}$, capital income in the non-traded sector $\tau^k_{N,t}$, and the fraction of taxes firms prepay $\kappa_{\tau,t}$.

6. *Disaster risk.* Includes the idiosyncratic disaster probability π^θ_t and the aggregate disaster probability π^a_t.

We add to the driving processes an aggregate disaster risk. We motivate aggregate disaster risk by the elevated aggregate uncertainty Greece experienced around 2012 and 2015, during the debt negotiations and the possibility of exit from the euro. The modeling of aggregate disaster risk follows Gourio (2012). A disaster event moves the economy permanently to a state in which variables such as productivity and external demand scale down by a factor $\exp(-\varphi^a) < 1$ (see Appendix A.3 for details). Disasters occur with time-varying probability π^a_t. To discipline our quantitative exercise, we fix φ^a to a constant, assume a disaster does not occur in sample, and consider only the impact of changes in the probability of a disaster π^a_t.

The exogenous processes are collected in vector $\mathbf{z}_t$ and follow an autoregressive process:

$$\mathbf{z}_{t+1} = \mathbf{z} + \mathbb{R}\mathbf{z}_t + \Sigma\nu_{t+1}, \tag{21}$$

where $\mathbf{z}$ is a constant that depends on steady state values and the size of the aggregate disaster φ^a, $\mathbb{R}$ is a diagonal matrix containing the persistence of each stochastic process, Σ is a diagonal matrix containing the standard deviations of the innovations, and $\nu_{t+1} \sim \mathbb{N}(0, \mathbb{I})$.[15]

2.6 Equilibrium

Given exogenous processes $\mathbf{z}_t$ and initial conditions on the state variables, an equilibrium is a sequence of quantities and prices such that workers, firms, and banks maximize their values, the labor market clears, $\ell_t \equiv \ell_{H,t} + \ell_{N,t} = \zeta \ell_t^r + (1-\zeta)\ell_t^o$, traded goods markets clear, $y_{H,t}(j) = c_{H,t}(j) + x_{H,t}(j) + g^c_{H,t}(j) + g^x_{H,t}(j) + \bar{c}_{H,t}(j) + \bar{x}_{H,t}(j)$, non-traded goods markets clear, $y_{N,t}(j) = c_{N,t}(j) + x_{N,t}(j) + g^c_{N,t}(j) + g^x_{N,t}(j)$, the equity market clears, $\zeta \varsigma_t^r + (1-\zeta)\varsigma_t^o = 1$, bond markets clear, meaning that banks hold assets B^r_{t+1} from the rule-of-thumb household and B^f_{t+1} from firms, and the government budget constraint (20) holds. As a baseline, we let transfers to the optimizing household T_t^o adjust endogenously to balance the government budget constraint, and present several alternative ways of balancing the budget below. The equilibrium is symmetric across varieties, so henceforth we omit the index j. Appendix A.2 collects all conditions in the symmetric equilibrium of the model. We solve the model using a first-order approximation of the equilibrium conditions around the steady state to facilitate the estimation of parameters.

3 Measurement

Our sample covers the period between 1998 and 2017. We summarize the definitions of variables and sources of data in Appendix Tables B.2 to B.4. We divide quantities by population. To account for trend growth, we deflate per capita quantities by 1.6 percent per year, which is the average growth of constant-price GDP per capita from the Penn World Tables in the 30 years before 1998. To account for trend inflation, we deflate prices and interest rates by 1 percent per year, which is the average euro inflation rate in our sample. Values and nominal wages are deflated by 2.6 percent, and productivity measures are deflated by $((1+0.016)^{0.44} - 1) \approx 0.7$ percent, where 0.44 is our estimated capital elasticity.

[15] The correlation between shocks would matter for the properties of endogenous variables if one simulated the model by drawing shocks ν_{t+1}. Our approach, however, is to feed the path of ν_{t+1} that we obtain after estimating $\mathbb{R}$. Thus, in a first-order approximation of the model, off-diagonal elements of Σ do not enter the policy functions and do not affect the model-generated paths of endogenous variables.

3.1 Outcome Variables

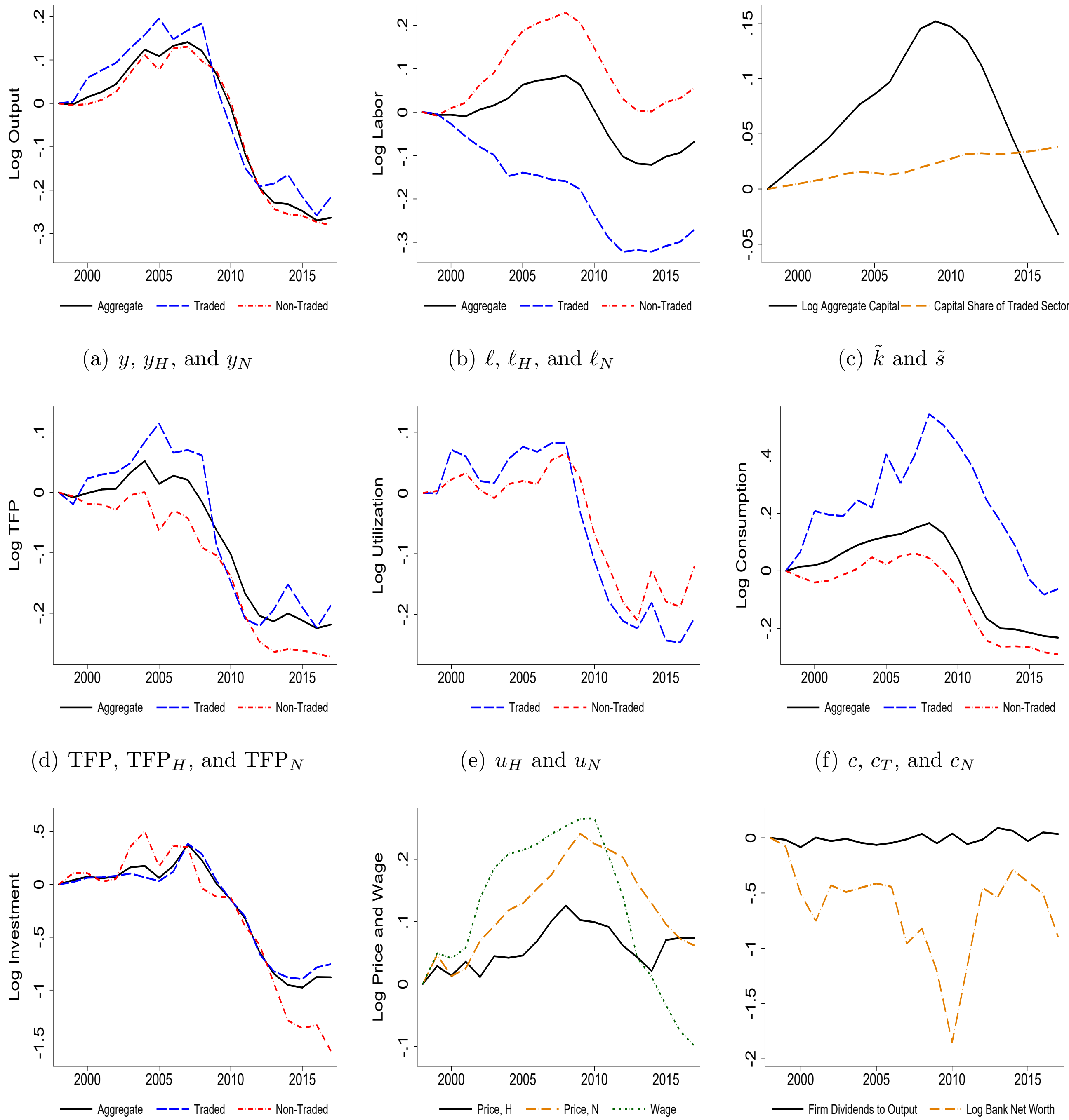
Figure 2 presents the outcome variables we use to estimate and evaluate the model, in deviations from their 1998 values. We obtain constant-price output y and its price P_y from Eurostat's European System of Accounts (ESA) database.[16] The traded sector consists of agriculture, mining, manufacturing, transportation, accommodation and food services, and travel agency and tour operators. The latter two categories belong to the traded sector because tourism composes a significant fraction of economic activity in these industries. Denoting the current-price value added of industry i by $P_i y_i$, we sum up value added for traded goods $P_H y_H = \sum_{i \in H} P_i y_i$, construct P_H as the Paasche price index of the underlying prices P_i, and obtain constant-price value added $y_H = \sum_{i \in H} P_i y_i / P_H$. We follow a similar procedure to measure P_N and y_N. Figure 2(a) shows a strong comovement between y_H and y_N over time. Output in both sectors increases until 2007, declines by roughly 30 log points between 2007 and 2012, and does not recover after 2012.

Labor inputs ℓ_H and ℓ_N are hours worked per capita in each sector from national surveys of households and establishments. These measures include both employee hours and hours worked by self-employed workers. Figure 2(b) shows that both labor inputs fell by roughly 15 log points after 2008, despite their divergence in the boom.

We use the perpetual inventory method with a fixed depreciation rate and private and public investment for four types of assets (structures, machinery and equipment, cultivated biological resources, and intellectual property assets) to measure capital. We denote this variable by $\tilde{k}$ and distinguish it from the variable k in the model, which accounts for variable depreciation. Figure 2(c) shows a roughly 15 log points increase in capital until 2010, followed by a 20 log points decline. We measure the share of capital allocated to the traded sector, $\tilde{s}$, using Eurostat industry-level fixed asset accounts. This share remains relatively stable over time.

We obtain sectoral TFP by using growth accounting (see Appendix B.3 for details). Within each sector, we use a constant returns to scale production function with time-varying income shares that maps labor and capital services into value added. To construct capital services, we aggregate the four types of assets, using user cost weights that depend on asset-specific depreciation rates and a common required net return. Our TFP measures capture both within-industry TFP and

[16] In the model, P_y is a Paasche price index of P_H and P_N and $y = \frac{P_H y_H + P_N y_N}{P_y}$.



(a) y, y_H, and y_N (b) ℓ, ℓ_H, and ℓ_N (c) $\tilde{k}$ and $\tilde{s}$

(d) TFP, TFP$_H$, and TFP$_N$ (e) u_H and u_N (f) c, c_T, and c_N

(g) x, x_T and x_N (h) P_H, P_N, and W (i) Π^f and N

Figure 2: Outcomes

Figure 2 plots the evolution of macroeconomic variables. H denotes the traded sector for production measures and T denotes the traded sector for consumption measures. N denotes the non-traded sector. y is output, ℓ is labor, $\tilde{k}$ is capital, $\tilde{s}$ is the share of capital allocated to the traded sector, TFP is total factor productivity, u is utilization, c is consumption, x is investment, P is price, W is wage, Π^f is firm profits, and N is net worth of banks. Quantities are detrended with 1.6 percent per year, TFP with 0.7 percent, prices with 1 percent, and wages with 2.6 percent.

the reallocation of inputs across industries within sectors.[17] Figure 2(d) shows that in the boom TFP in the traded sector increases and TFP in the non-traded sector decreases. Both, however, decrease substantially in the bust, and neither recovers.

Measures of utilization u_H and u_N come from two Joint Harmonised European Commission Surveys. We average the quarterly responses to the Industry Survey question "*At what capacity is your company currently operating (as a percentage of full capacity)?*" to obtain utilization in the manufacturing sector. For service industries, we use the question added in 2011 to the Services Survey: "*If the demand expanded, could you increase your volume of activity with your present resources? If so, by how much?*". We use the fraction of respondents reporting "None" to the question "*What main factors are currently limiting your business?*" to extend this measure back in time. We then aggregate within sectors to obtain u_H and u_N. Figure 2(e) shows that both utilization indices increase modestly in the boom, decline substantially between 2007 and 2012, and remain depressed after.[18]

Current-price private consumption of non-traded goods equals non-traded value added minus other absorption of non-traded goods, $P_N c_N = P_N \left(y_N - x_{N,t} - g^c_{N,t} - g^x_{N,t}\right)$. Consumption expenditure on traded goods is therefore $P_T c_T = P_c c - P_N c_N$, where $P_c c$ is current-price consumption of households and non-profits. We obtain c_N using the Paasche index P_N from the underlying industry prices that compose the non-traded sector, c_T using the Paasche price index P_T from the price of domestic traded goods P_H and the price of foreign traded goods P_F, and c from the consumption price index P_c.[19] Figure 2(f) displays a consumption boom until 2007 and then a significant decline and lack of recovery. Expenditure on non-traded goods composes roughly 70 percent of total expenditure, and thus total consumption comoves more closely with non-traded

[17] Applying the Basu (1996) decomposition of TFP to a within-industry and a between-industry component, we find a small role for reallocation across industries in accounting for the dynamics of TFP at the sectoral or aggregate level.

[18] The surveys do not cover agriculture or mining, for which we assume full utilization. We also depart from the survey measurement for the shipping industry, which is part of the traded sector. TFP in shipping fell by almost 70 percent between 2007 and 2017, reflecting the widespread idling of ships due to excess capacity following an investment boom (Kalouptsidi, 2014). We attribute all of the fluctuations in TFP in shipping to utilization. In Appendix B.3, we present an alternative series for utilization, based on Basu (1996), that relates unobserved utilization to the growth of material inputs. Our baseline survey measures correlate well with this alternative measure, with both measures showing a sharp decline in utilization in the bust.

[19] As in the model, these price indices are basic, meaning that they exclude indirect taxes. Expenditure series and price indices in national accounts are at market prices, meaning that they map into $(1 + \tau^c)\, P_c$. We use our series on the consumption tax rate τ^c described below to obtain P_c from the national accounts price index.

consumption than with traded consumption.

Figure 2(g) displays total private investment x, the part purchased from the traded sector x_T, and the part purchased from the non-traded sector x_N. We assign to non-traded investment the value-added component of structures, calculated as total investment in structures multiplied by the value-added share of gross output in the construction industry. We assign all other investment to the traded sector. Both categories of investment fall more than 100 log points in the crisis, and neither recovers in the last years of the sample.

Figure 2(h) displays the evolution of prices and wages. Until 2008, the relative price of non-traded goods increases and Greek terms of trade appreciate. These trends reverse after 2010. Relative to their trend, wages increase by more than 20 log points by 2010 and then decline by more than 30 log points. We measure wages as total employee compensation divided by total employee hours. In Appendix B.4, we document that this measure correlates highly with other wage series available for Greece, including the Eurostat Labor Cost Index and the quadrennial Structure of Earnings Survey, that both public and private sector employees experienced declines in nominal wages after 2010, and that significant nominal wage declines occur across all age groups and skill categories and throughout the wage distribution.

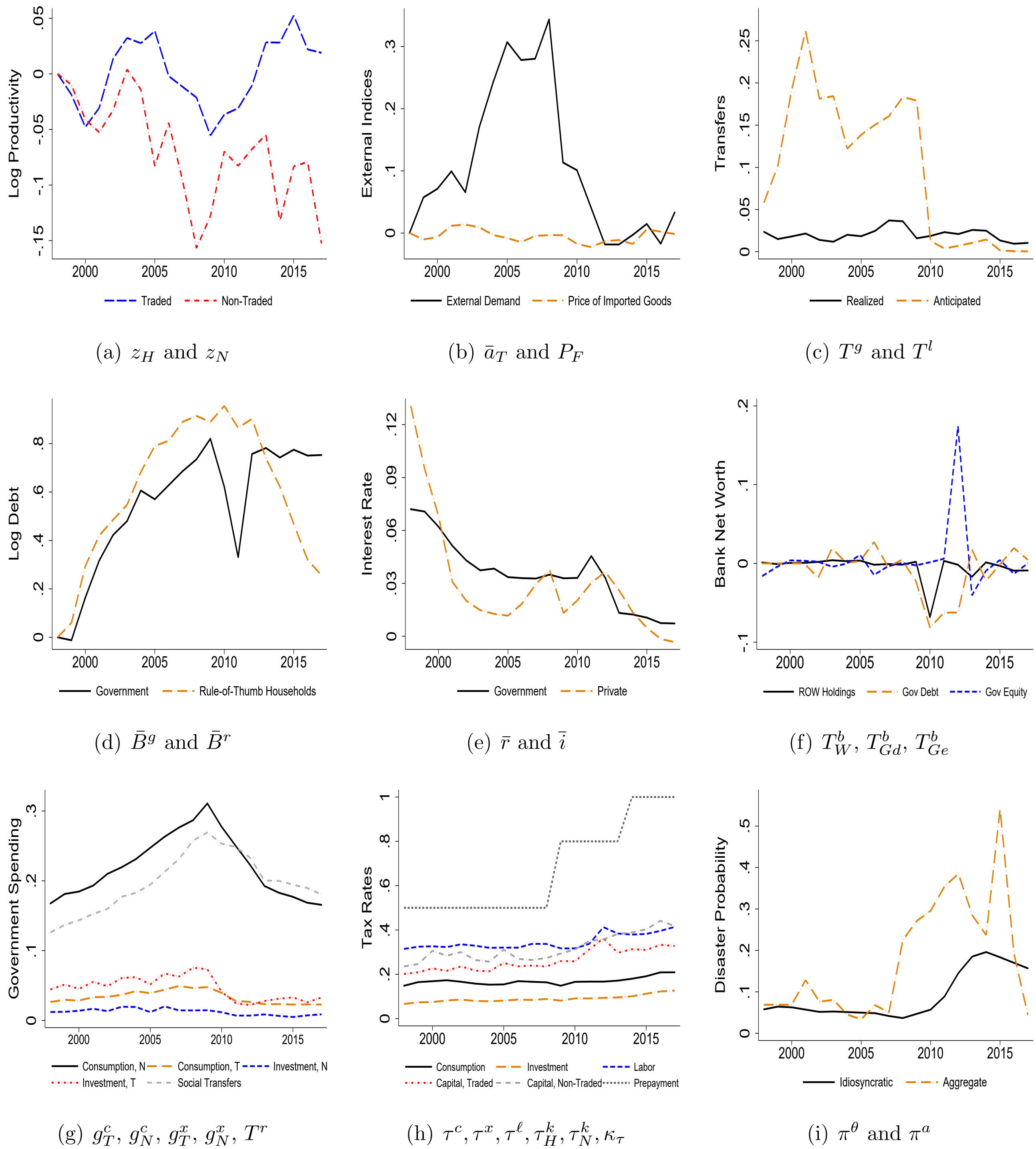
Finally, Figure 2(i) shows the evolution of firm dividends Π^f and bank net worth N. Both series come from the Flow of Funds accounts at the Bank of Greece. Dividends for non-financial corporations are relatively stable over time. Net worth equals the difference between the market value of assets and the market value of non-equity liabilities for financial institutions. Net worth collapses between 2007 and 2010 and recovers to pre-crisis levels soon after that.

3.2 Driving Forces

Productivity. Traded and non-traded productivity, z_H and z_N, equal sectoral TFP net of the contribution of utilization. Figure 3(a) shows that z_N declines in the boom. Both z_N and z_H fluctuate substantially in the bust, but without a clear trend.

External. We measure external demand $\bar{a}_T$ for Greek goods by evaluating equation (14) in the symmetric equilibrium of the model:

$$P_{H,t}y_{H,t} = \gamma \left(\frac{P_{T,t}}{P_{H,t}}\right)^{\eta-1} P_{T,t}\left(c_{T,t} + x_{T,t} + g^c_{T,t} + g^x_{T,t}\right) + (1-\gamma)\left(\frac{P_{F,t}}{P_{H,t}}\right)^{\eta-1} P_{F,t}\bar{a}_{T,t}. \tag{22}$$



(a) z_H and z_N

(b) $\bar{a}_T$ and P_F

(c) T^g and T^l

(d) $\bar{B}^g$ and $\bar{B}^r$

(e) $\bar{r}$ and $\bar{i}$

(f) T^b_W, T^b_{Gd}, T^b_{Ge}

(g) g^c_T, g^c_N, g^x_T, g^x_N, T^r

(h) $\tau^c, \tau^x, \tau^\ell, \tau^k_H, \tau^k_N, \kappa_\tau$

(i) π^θ and π^a

Figure 3: Driving Forces

Figure 3 plots the evolution of driving processes. H denotes the traded sector for production measures and T denotes the traded sector for consumption measures. N denotes the non-traded sector. z is productivity, $\bar{a}_T$ is external demand, P_F is the price of foreign goods, T^g is realized transfers from structural funds, T^l is anticipated transfers, $\bar{B}^g$ is government debt held by the rest of the world, $\bar{B}^r$ is the borrowing limit of the rule-of-thumb household, $\bar{r}$ is the government interest rate, $\bar{i}$ is the private interest rate, T^b_W, T^b_{Gd}, and T^b_{Ge} are changes in bank net worth from values of rest-of-the-world assets, holdings of government debt, and equity injections, g^c_T, g^c_N, g^x_T, and g^x_N are government spending on consumption and investment, T^r is transfers to the rule-of-thumb household, τ^c, τ^x, τ^ℓ, τ^k_H, and τ^k_N are tax rates on consumption, investment, labor income, and capital income, κ_τ is the fraction of taxes firms prepay, π^θ is the probability of idiosyncratic disaster, and π^a is the probability of aggregate disaster.

Equation (22) decomposes expenditure on Greek-produced tradable goods into the part coming from domestic absorption (the first term) and exports (the second term). We invert this equation to solve for $\bar{a}_T$, given values $\gamma = 0.24$ and $\eta = 1.65$, which we estimate below, and data on traded value added, $P_H y_H$, traded domestic demand, $P_T(c_T + x_T + g_T^c + g_T^x)$, and prices of traded goods, P_H and P_F. Figure 3(b) displays a roughly 30 log points increase in $\bar{a}_T$ from the beginning of the sample until 2008, followed by a cumulative decline of roughly 30 log points until the end of the sample. It also shows that the price of foreign traded goods, P_F, does not fluctuate significantly over time. To understand the time series of $\bar{a}_T$, note that with a trade elasticity $\eta > 1$, Greek exports increase when the terms of trade P_F/P_H depreciate. The terms of trade appreciate in the boom and depreciate in the bust. In the absence of movements in $\bar{a}_T$, the behavior of P_F/P_H would initially generate a decrease in Greek exports and then an increase. The increase and then decline in $\bar{a}_T$ rationalizes the boom and bust in exports, given the behavior of P_F/P_H.[20]

How does the behavior of $\bar{a}_T$ align with fluctuations in the demand for Greek products? Greece is a major global freight shipper, with this industry accounting for 30 percent of Greek gross exports in 2008. The path of $\bar{a}_T$ follows closely the boom and bust in global shipping demand (as we show more formally in Appendix B.5). Strong growth in global trade between 2003 and 2007, and especially in raw material imports from China, resulted in high global shipping demand, a sharp increase in freight rates, and a wave of investment in new ships (Greenwood and Hanson, 2014). Given significant time to build and low scrapping value of ships, the 2008 crisis led to substantial overcapacity in shipping, persistent declines in freight rates, and the idling of the existing fleet (Kalouptsidi, 2014). The increase in $\bar{a}_T$ during the early part of the sample also coincides with the entry of Greece into the euro area and the hosting of the Olympic Games, both of which increased

[20] Exports here refer to the value-added content of exports rather than gross exports because $P_H y_H$ is value added and not gross output. Value-added exports differ from gross exports as reported in the national accounts because of imports of intermediate goods used in the production of gross exports. In Greece, gross and value-added exports differ primarily because of the oil-refining sector, which imports crude petroleum and exports refined petroleum products. Conceptually, the value added content of exports measures foreign demand for Greek factors of production (Johnson and Noguera, 2012; Adao, Costinot, and Donaldson, 2017). Using this logic, we have obtained $\bar{a}_T$ in three alternative ways, using only the second term of the right-hand side of equation (22). In the first alternative, we equate the second term to the value-added content of exports obtained by applying the procedure of Johnson and Noguera (2012) to the World Input-Output Database. In the second alternative, we equate the second term to non-petroleum gross exports. In the third alternative, we equate the second term to gross exports of shipping only. Appendix Figure B.7 shows that these alternative $\bar{a}_T$ series closely track each other and our baseline measure obtained using equation (22). Relative to the alternatives, our preferred measure understates the importance of $\bar{a}_T$ in the boom. The measures display similar declines in the bust, and none recovers by the end of the sample.

demand for Greek output in the boom.

Figure 3(c) plots the paths of realized and anticipated foreign transfers to the Greek government. Realized transfers T^g are the sum of transfers to Greek regions from structural funds. They average roughly 2 percent of trend output in the boom and decline somewhat in the bust.

Anticipated transfers T^l measure perceived changes in household wealth when the Greek government misreports its deficit and debt. We measure T^l_t as the difference between gross debt of the general government (Maastricht Treaty definition) at the end of year t as reported in April of $t+1$ to the European Commission and the value reported for year t in 2019.[21] The difference between these two series constitutes an anticipated transfer because it represents the financing of the Greek government debt that workers did not believe would require higher future tax revenues. As seen in Figure 3(c), Greece consistently understated its debt throughout the 2000s, with the understatement exceeding 25 percent of trend output in 2001 and 15 percent on the eve of the crisis. We note that 25 percent and 15 percent should be understood as the equivalent of a one-time transfer. In October 2009 the incoming government announced the misreporting of its budget statistics, prompting T^l to fall essentially to zero beginning in 2010. To operationalize these transfers in our model, we split them into a persistent component $\bar{T}^l$ and a transitory component $\hat{T}^l$ and feed them as a news shock that arrives in each period t but does not materialize in $t+1$.

Financial. Figure 3(d) shows the evolution of government debt held by the rest of the world, $\bar{B}^g$, and debt of the rule-of-thumb household, $\bar{B}^r$. Both series are from the Flow of Funds. Debt $\bar{B}^g$ is the market value of government debt and loans net of assets, currency held, and deposits, and $\bar{B}^r$ is household short-term liabilities in loans and other payables. The decline in $\bar{B}^g$ in 2011 reflects the 20 percent haircut in the net present value of bond holdings of private lenders to the Greek government. The increase in $\bar{B}^g$ after 2012 reflects long-term loans from the European Union and the International Monetary Fund (IMF) under the second bailout program.

Figure 3(e) plots the evolution of government, $\bar{r}$, and private, $\bar{i}$, interest rates. We measure $\bar{r}$

[21]We obtain the historical reported values from `https://bit.ly/3vtDHG1` and from past editions of the OECD Economic Outlook. The sources of understatement varied across years, but many involved improperly keeping some liabilities "off balance sheet." In 2002 the government restated its debt to include convertible and exchangeable bonds and the absorption of the liabilities of a state-owned company. In 2004, it recognized delayed interest payments as debt and corrected the accounting of debt owned by the social security fund. The 2009 and 2010 restatements reflected numerous changes, including putting a number of additional state-owned enterprises on-budget, incorporating the market value of off-market swaps in debt, and correcting misreporting in several categories.

as an effective interest rate on government debt by dividing government (net) interest payments by the market value of debt. The interest rate $\bar{i}$ is the rate on deposits with maturity less than one year at Greek banks. Both interest rates decline over time, consistent with the experience of other southern economies (Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez, 2017).[22]

Figure 3(f) plots the evolution of the three exogenous components of bank net worth. Component T_W^b equals the change in the market value of rest-of-world assets held by banks less net purchases. This variable remains close to zero until 2010, when banks experienced a decline of 7 percent of output on their holdings of foreign assets.

We measure the mark-to-market gain or loss on holdings of Greek government debt, T_{Gd}^b, by comparing the market value from the Flow of Funds with the book values of these holdings from the Bank of Greece. To this unrealized gain or loss we add the realized write-downs that occurred as part of the banks' participation in the 2011 securities exchange program.[23] Our measure of T_{Gd}^b shows that banks experienced cumulative losses of around 20 percent of output from their holdings of government debt between 2009 and 2012. Government equity injection T_{Ge}^b equals the value of bank shares held by the government. This series has small fluctuations, except in 2012 when the government injected equity of roughly 20 percent of output.

Government spending. Government consumption, g_T^c and g_N^c, includes purchases of market goods for consumption and own-account production. We allocate government purchases of market goods to g_T^c and g_N^c using the share of intermediate inputs purchased from each sector by public administration, education, and health and social work in the input-output tables. We allocate all other government consumption, which consists primarily of employee compensation, to the non-traded sector. We allocate the value-added component of government investment in structures to g_N^x and all other investment to g_T^x. Transfers to the rule-of-thumb household T^r include pensions (accounting for more than 70 percent of T^r), health insurance, disability insurance, unemployment insurance, and in-kind benefits. Figure 3(g) shows that g_N^c and T^r are the largest shares of

[22] In Greece, the financial cycle for firm borrowing occurred mainly in quantities rather than prices. While the secondary market interest rate for Greek sovereign debt rose to as high as 30 percent in 2012, the average rate paid by non-financial firms in that year barely exceeded 6 percent. We interpret the endogenously determined borrowing cost i_t as a shadow cost that encompasses these financial developments.

[23] The Bank of Greece's statistics do not report interest income separately for holdings of government debt. The coupons on the securities were sufficiently small relative to the capital losses that ignoring interest income has a small impact. Nor do the data report realized gains or losses at sale separately for government debt, but banks sold relatively few of their holdings between 2009 and 2012.

government spending, with both exceeding 25 percent of trend output at their peak. All categories of spending rise in the boom and contract in the bust.

Tax policy. Our methodology for measuring tax rates builds on Mendoza, Razin, and Tesar (1994), who calculate effective tax rates using national income and product accounts. There are two reasons we prefer to use effective rather than statutory tax rates. First, tax evasion in Greece is rampant (Artavanis, Morse, and Tsoutsoura, 2016). Effective tax rates capture changes in tax compliance over time that would otherwise not show up in statutory rates, because the European System of National Accounts records taxes "only when evidenced by tax assessments, declarations ... and missing taxes are not imputed" (page 106-107 in Eurostat, 2013). Second, income taxes in Greece depend not only on income but also on so-called objective criteria, such as the surface of a house or the type of car engines individuals own. This feature of the tax code makes it difficult to estimate tax rates accurately even in the richest micro datasets.

Greece levies taxes on transactions, individuals, corporations, and property (see Appendix B.7 for more details). We allocate all tax receipts and actual social contributions into taxes on consumption, investment, labor, and capital. Taxes on production and imports less subsidies are allocated to consumption and investment, with the exception of property taxes paid by enterprises, which are allocated to capital income. From taxes on production and imports net of property taxes, we allocate to consumption the part that unambiguously falls on consumption and allocate the residual to consumption and investment in proportion to their expenditure shares. Figure 3(h) shows that τ^c and τ^x increased by roughly 4 and 3 percentage points after 2010. This is consistent with the increase in statutory VAT rates from 19 to 23 percent in 2011 (Eurostat, 2010).

The individual income tax base includes unambiguous labor income (such as income from salaried employment), unambiguous capital income (such as dividends, interest, and rentals), and ambiguous income (such as income from self-employment, agriculture, and liberal professions). We measure the labor income tax rate τ^ℓ as the sum of the tax rate on social security contributions and the tax rate on labor income net of social security contributions. Labor income equals compensation of employees and an adjustment for the income of the self-employed. The labor income tax rate τ^ℓ is adjusted for the gap between the average marginal tax rate and the average average tax rate. Figure 3(h) shows that τ^ℓ increased by roughly 10 percentage points between

2010 and 2012. In Appendix Figure B.9, we document that the timing of these increases coincides with the increases in statutory income tax rates.

We measure capital tax rates τ_H^k and τ_N^k as capital tax payments divided by taxable capital income generated in each sector. There are six types of capital tax payments. Property taxes paid by households are allocated to the non-traded sector. Property taxes paid by corporations are allocated to each sector in proportion to its share of non-residential structures used in production. The other four categories, taxes on dividends and interest, income and capital gains taxes paid by corporations, taxes on capital income paid by households, and other capital taxes, are allocated to each sector in proportion to its share of capital income net of depreciation. Figure 3(h) shows a significant increase in both tax rates after 2012. The increase in τ_N^k exceeds the increase in τ_H^k, reflecting the significant increase in taxes falling on the residential sector after 2011. As in the case of labor income taxes, the timing of these increases coincides with increases in statutory rates.

Finally, we use tax laws 2238/1994, 3697/2008, and 4334/2015 to measure the fraction of income taxes that firm are required to prepay, κ_τ. Figure 3(h) shows that κ_τ is 50 percent before the crisis, rises to 80 percent in 2009, and rises to 100 percent in 2014.

Disaster risk. The stochastic process for individual income in equation (4) captures permanent changes in income. Motivated by the long-term unemployed's significant income losses upon reemployment (Schmieder, von Wachter, and Bender, 2016), we measure the time-varying probability of a permanent decline in income, π^θ, with the fraction of the labor force unemployed for 12 months or more. We choose unemployment as our measure of idiosyncratic risk because this captures both increased job separations and lower job finding rates in recessions. We choose 12 months, as it is the maximum duration of regular unemployment benefits. Figure 3(i) shows that the long-term unemployment rate averages around 5 percent in the boom. It increases to almost 20 percent during the crisis and remains elevated until the end of the sample.

For the aggregate disaster probability π^a, we follow Barro and Liao (2021) and use prices of far-out-of-the-money put options. A far-out-of-the-money put option pays off only when stock prices fall by a significant amount, so the price of such an option provides information about the probability of a disaster occurring (in which case the option becomes in the money), the size of a disaster conditional on one occurring, and risk aversion. Appendix B.6 details our implementation of the Barro and Liao (2021) procedure for Greece. We estimate monthly averages of daily disaster probabilities and then annualize and average in a year to arrive at our series for π^a in Figure 3(i). Figure B.8 reports the monthly series and shows that the peaks of the disaster probability coincide with major political and economic events during the crisis period.

4 Parameterization

Parameters set without solving the model. In the upper panel of Table 1, the coefficient of relative risk aversion is $\sigma = 3$, consistent with the choice of σ by Barro and Liao (2021) and our implementation of their methodology for recovering the aggregate disaster probability. Using their methodology, we estimate $\varphi^a = 0.24$ so that the economy scales down by $\exp(-\varphi^a) = 0.79$, conditional on an aggregate disaster. Goods and labor demand elasticities, ε_p and ε_w, are such that markups equal 10 percent in the flexible price and wage equilibrium, consistent with the range of estimates reported by Basu and Fernald (1997). We estimate average depreciation rates, $\bar{\delta}_H = 0.08$ and $\bar{\delta}_N = 0.05$, using sectoral accounts data on depreciation and capital.

We estimate a trade elasticity of $\eta = 1.65$ (with a standard error of 0.25) in the CES aggregator of traded goods (2), using the first-order conditions for traded goods, which give rise to a regression of $\Delta \ln \left(\frac{P_{H,t} a_{H,t}}{P_{F,t} a_{F,t}} \right)$ on $\Delta \ln \left(\frac{P_{H,t}}{P_{F,t}} \right)$, where $a_{H,t}$ and $a_{F,t}$ denote Greek expenditure on domestic and foreign traded goods. Appendix B.8 presents details of our estimation procedure. Our η estimate is comparable to the value of 1.5 found in Backus, Kehoe, and Kydland (1994) and used extensively in the literature. The preference weight $\gamma = 0.24$ equals the sample average ratio of domestic absorption of domestic traded goods to domestic absorption of all traded goods.

The lower panel of Table 1 displays means of exogenous processes that drive the model.[24] We normalize the mean of traded productivity, external demand, and foreign price to one. The means of all other exogenous processes equal their sample average between 1998 and 2007. Mean values of debt and government spending are relative to the value of output, $P_y y$, as our choice of parameters implies that $P_y = y = 1$ in the steady state of the model.

Parameters calibrated such that the model matches targets in steady state. The upper panel of Table 2 presents values of parameters calibrated from steady state conditions involving endogenous

[24] Appendix Table C.1 displays estimates of the persistence and standard deviation of the autoregressive processes using ordinary least squares between 1998 and 2017.

Table 1: Parameter Values – Without Solving the Model

A. Parameter		Value	Rationale
σ	risk aversion	3.00	Barro and Liao (2021)
φ^a	size of aggregate disaster	0.24	estimation of Barro and Liao (2021) model
ε_p	elasticity of product demand	11.00	10 percent price markup
ε_w	elasticity of labor demand	11.00	10 percent wage markup
$\bar{\delta}_H$	mean depreciation rate, traded	0.08	sample average 1998-2007
$\bar{\delta}_N$	mean depreciation rate, non-traded	0.05	sample average 1998-2007
η	trade elasticity	1.65	regression of $\Delta \ln \left(\frac{P_{H,t} a_{H,t}}{P_{F,t} a_{F,t}}\right)$ on $\Delta \ln \left(\frac{P_{H,t}}{P_{F,t}}\right)$
γ	weight on traded	0.24	absorption of home to all traded
B. Mean of exogenous process		**Value**	**Rationale**
z_H	productivity, traded	1.00	normalization
$\bar{a}_T$	external demand	1.00	normalization
P_F	price of foreign traded goods	1.00	normalization
T^g	capital transfer	0.02	sample average 1998-2007
$\bar{T}^l$	transfer anticipation, persistent	0.00	sample average 1998-2007
$\hat{T}^l$	transfer anticipation, transitory	0.00	sample average 1998-2007
$\bar{B}^g$	government debt	0.89	sample average 1998-2007
$\bar{r}$	government interest rate	0.05	sample average 1998-2007
$\bar{i}$	private interest rate	0.04	sample average 1998-2007
T^b_W	rest of the world asset valuation	0.00	sample average 1998-2007
T^b_{Gd}	sovereign debt valuation	0.00	sample average 1998-2007
T^b_{Ge}	bank equity injection	0.00	sample average 1998-2007
g^c_T	government consumption, traded	0.03	sample average 1998-2007
g^x_T	government investment, traded	0.05	sample average 1998-2007
g^c_N	government consumption, non-traded	0.18	sample average 1998-2007
g^x_N	government investment, non-traded	0.01	sample average 1998-2007
τ^c	tax rate on consumption	0.16	sample average 1998-2007
τ^x	tax rate on investment	0.08	sample average 1998-2007
τ^ℓ	tax rate on labor	0.33	sample average 1998-2007
τ^k_H	tax rate on capital, traded	0.26	sample average 1998-2007
τ^k_N	tax rate on capital, non-traded	0.26	sample average 1998-2007
κ_τ	prepayment fraction	0.50	sample average 1998-2007
π^θ	probability of idiosyncratic disaster	0.05	sample average 1998-2007
π^a	probability of aggregate disaster	0.07	sample average 1998-2007

Table 2: Parameter Values – Solving the Model

A. Parameters calibrated from steady state		Value	Target
χ	disutility of labor	2.22	$y = 1$
$\bar{\xi}_H$	utilization constant, traded	0.23	$u_H = 1$
$\bar{\xi}_N$	utilization constant, non-traded	0.18	$u_N = 1$
z_N	mean productivity, non-traded	0.89	$P_N = 1$
ω_c	weight on traded goods, consumption	0.22	$(p_T c_T)/(P_c c) = 0.22$
ω_x	weight on traded goods, investment	0.77	$(p_T x_T)/(P_x x) = 0.77$
α	capital elasticity	0.44	$(Qk_N)/(P_N y_N) = 3.83$
q_ℓ	firm labor tax	0.02	$(W\ell)/(Py) = 0.52$
$\bar{B}^r$	mean debt of rule-of-thumb	0.41	$(\zeta \bar{B}^r)/(P_y y) = 0.14$
T^r	mean transfers to rule-of-thumb	0.29	$c^r = c^o$
β^o	discount factor, optimizing	0.97	$\bar{i} = 0.04$
β^r	discount factor, rule-of-thumb	0.95	Carroll, Slacalek, and Tokuoka (2014)
κ_b	diversion of funds, bankers	0.53	$B^f/(P_y y) = 0.35$
ω_b	endowment, new bankers	0.17	$N/(P_y y) = 0.25$
$\bar{b}$	steady state debt	1.01	$B/(P_y y) = 1.01$
κ_y	available fraction of output	0.19	multiplier = 0 on constraint (12)

B. Parameters estimated from time series		Prior Mean	Posterior Mean	90 percent interval
ρ	intertemporal elasticity of substitution	0.50	0.97	[0.81,1.14]
ϕ	traded-nontraded elasticity	0.44	3.17	[2.22,4.16]
ϵ	frisch elasticity	1.50	1.16	[0.44,1.88]
κ_x	working capital, investment	0.50	0.60	[0.39,0.80]
κ_ℓ	working capital, labor	0.50	0.06	[0.01,0.10]
ζ	fraction rule-of-thumb	0.23	0.34	[0.21,0.47]
φ^θ	size of idiosyncratic disaster	0.20	0.16	[0.14,0.17]
ξ_H	utilization elasticity, traded	7.00	3.12	[2.89,3.34]
ξ_N	utilization elasticity, non-traded	7.00	3.75	[3.30,4.16]
δ_b	exit rate, bankers	0.50	0.70	[0.53,0.90]
ψ_π	adjustment cost, profits	0.50	0.60	[0.14,1.04]
ψ_x	adjustment cost, investment	7.00	6.28	[3.71,8.74]
ψ_ℓ	adjustment cost, labor	1.00	1.52	[1.00,2.02]
$\psi_{H,p}$	adjustment cost, prices traded	40.0	79.3	[39.5,119.0]
$\psi_{N,p}$	adjustment cost, prices non-traded	40.0	36.5	[18.3,53.7]
ψ_w	adjustment cost, wages	40.0	78.4	[43.1,112.5]

variables. Some parameters are chosen to normalize output, utilization, and the price of non-traded goods to one in the steady state of the model. The other parameters are chosen so that the model reproduces average values of endogenous variables between 1998 and 2007. The targets include expenditure shares of traded goods, the capital-output ratio, the labor share of income, debt-output ratios, interest rates, and net worth in the banking sector.[25]

Estimated parameters. The lower panel of Table 2 presents parameters estimated with Bayesian techniques. We use 16 variables collected in the following vector:

$$\mathbf{y} = \big(\log \ell_H, \log \ell_N, \log \mathrm{TFP}_H, \log \mathrm{TFP}_N, \log u_H, \log u_N, s, \\ \log c, \log(P_N c_N), \log x_T, \log x_N, \log P_H, \log P_N, \log W, \Pi^f/(P_y y), \log N\big). \quad (23)$$

We estimate 16 parameters using as observables in the estimation both the outcome variables $\mathbf{y}$ and the exogenous processes $\mathbf{z}$. Crucially, we feed the time series of $\mathbf{z}$ as measured in the data without adding to them measurement error. This strategy disciplines our exercise because it restricts the freedom of shocks to account for the behavior of outcome variables. For the estimation, we instead add measurement errors to the outcome variables $\mathbf{y}$. We subsequently remove the measurement error component when evaluating the performance of the model and in counterfactual analyses.[26]

Starting from a prior mean of 0.5 (Hall, 2009), we estimate an intertemporal elasticity of substitution $\rho = 0.97$ with a tight confidence interval. A value of $\rho < 1$ implies that aggregate disaster risk π^a increases the stochastic discount factor of the optimizing household and that consumption and labor comove stronger than with a separable utility function. The estimates do not favor a ρ significantly lower than one, because π^a mean reverts quickly whereas consumption

[25] Following Schmitt-Grohé and Uribe (2003), we induce stationarity of net foreign assets by adding a small endogenous component to the interest rate $\bar{i}_t$ faced by the optimizing household and banks. Letting $\bar{i}^*_t$ temporarily denote the deposit rate we feed in as a driving force, we write $\bar{i}_t = \bar{i}^*_t + \psi_b \left(\exp\left(B_{t+1}/(P_{y,t}y_t) - \bar{b}\right) - 1\right)$, where $B_t = \zeta \bar{B}^r_t + (1-\zeta)B^o_t + B^f_t + \bar{B}^g_t = \bar{B}^b_t + (1-\zeta)B^o_t + \bar{B}^g_t$ is total external debt. We set $\psi_b = 0.001$ and choose $\bar{b}$ to target the average debt to output. The in-sample gap between $\bar{i}_t$ and $\bar{i}^*_t$ is negligible, and we ignore their distinction throughout the paper.

[26] Appendix Table C.2 presents details on the parameter priors used in the estimation. Table C.3 and Figure C.1 demonstrate the stability of our results with respect to the prior means for price and wage adjustment costs. We assume that measurement errors of observables are drawn from the same prior and are uncorrelated with each other and over time. Figures C.2, C.3, and C.4 show that changing the prior of the variances of either all measurement errors or the measurement errors on prices and wages has negligible impact on the time series of outcome variables. Parameter estimates, time series of outcomes, and the sources of the boom and the bust do not change significantly when we estimate the model allowing for serially correlated measurement errors (Table C.4, Figure C.5, Table C.5, and Table C.6) and contemporaneously correlated measurement errors (Table C.7, Figure C.6, Table C.8, and Table C.9).

and labor remain persistently depressed until the end of the sample. We estimate a high elasticity between traded and non-traded goods, $\phi = 3.17$, starting from a prior mean of 0.44 (Stockman and Tesar, 1995). The high substitutability allows the model to fit more closely the declines in consumption, prices, and wages in the bust. We estimate a Frisch elasticity of labor supply of $\epsilon = 1.16$ with a wide confidence interval, starting from a prior mean of 1.5. Our estimate is within the range found in studies discussing the role of the extensive margin and the gap between micro and macro estimates (Chetty, Guren, Manoli, and Weber, 2012).

We estimate a low fraction of the wage bill, $\kappa_\ell = 0.06$, and a high fraction of investment expenditures, $\kappa_x = 0.60$, that require working capital. Both estimates come with tight confidence intervals. As a comparison, the value of $\kappa_\ell = 1$ is found in Jermann and Quadrini (2012) in their study of financial sources in U.S. business cycles and in Neumeyer and Perri (2005) in their study of interest rate shocks in emerging markets. Given the size of shocks hitting the Greek economy and the amplification of these shocks through variable utilization, the model generates significant fluctuations in labor without requiring a high κ_ℓ. On the other hand, the model requires a high κ_x to account for the significant decline in investment in the bust.

Using a prior mean of 0.23 from the evidence of Carroll, Slacalek, and Tokuoka (2014) on the marginal propensity to consume in Greece, we estimate that a fraction $\zeta = 0.34$ of households are rule-of-thumb. The existence of the rule-of-thumb household helps the model generate a comovement between consumption and labor income, as observed in both the boom and the bust. Our estimate of ζ falls within the typical range of 0.25 (Drautzburg and Uhlig, 2015) to 0.5 in (Mankiw, 2000; Gali, Lopez-Salido, and Valles, 2007) in the literature. Martin and Philippon (2017) calibrate a value of $\zeta = 0.65$ for Greece, based on the fraction of households with liquid assets below two months of income. Our estimated value is lower partly because our model generates a significant consumption drop of the optimizing household during the bust, in response to the rise of uninsurable idiosyncratic risk. Our estimate for the decline in consumption upon an idiosyncratic disaster is $\varphi^\theta = 0.16$, with a tight confidence interval. This value is consistent with studies documenting declines between 15 and 25 percent of consumption upon unemployment (Chodorow-Reich and Karabarbounis, 2016).

We estimate elasticities of utilization of $\xi_H = 3.1$ and $\xi_N = 3.8$, with small standard errors.

Lower values of ξ_H and ξ_N imply lower responsiveness of depreciation rates to utilization and therefore larger responsiveness of utilization to fluctuations in the marginal revenue product of capital. The estimated low values of ξ_H and ξ_N reflect the sharp decline in utilization in the bust.

We discuss in more detail the identification of the adjustment cost parameters and the exit rate of bankers in Section 5.3 by demonstrating how the model's time series change as we vary selected parameters. To summarize the most important results, we characterize the estimated exit rate of bankers, $\delta_b = 0.7$, as high because it generates significant fluctuations in the borrowing cost in response to shocks in bank net worth. We characterize price and wage rigidities as moderate. The evolution of quantities and prices between 2007 and 2017 under the estimated parameters $\psi_{H,p} = 79$, $\psi_{N,p} = 37$, and $\psi_w = 78$ is similar to their evolution when setting $\psi_{H,p} = \psi_{N,p} = \psi_w = 0$. However, the evolution of quantities and prices between 1998 and 2007 under the estimated parameters is different than their evolution when setting $\psi_{H,p} = \psi_{N,p} = \psi_w = 0$.

5 Quantitative Results

We compare the time series generated by the model to their data counterparts. Next, we assess the importance of driving forces and model elements for generating these time series.

5.1 Model Fit

In the first row of Figure 4, we present aggregate measures of production.[27] Output in the model matches the data in terms of the timing of the boom and the bust, the magnitude of the bust, and the lack of recovery after 2012. The model generates a boom and a bust in capital, but underestimates the magnitude of the boom and overestimates the magnitude of the bust. The model also accounts well for the evolution of TFP, although not for the last years of the sample. The driver of TFP in the model is variable utilization, with the model generating sectoral utilizations that match almost perfectly with their data counterparts, as shown in Appendix Figure C.7.

In the second row, we see that the model performs well in terms of matching the time series

[27] To plot endogenous variables, we feed the exogenous processes $\mathbf{z}$ into the policy functions evaluated at the posterior parameter means. Appendix Table C.10 presents the correlation between data and model variables and R-squared coefficients from regressions of the data on the model variable. The correlation is around or above 90 percent for all variables, except for the two price indices for which it is roughly 60 percent. The model accounts for more than 90 percent of the variation of observables, except for capital (73 percent), wages (73 percent), price of non-traded goods (34 percent), and price of traded goods (32 percent).

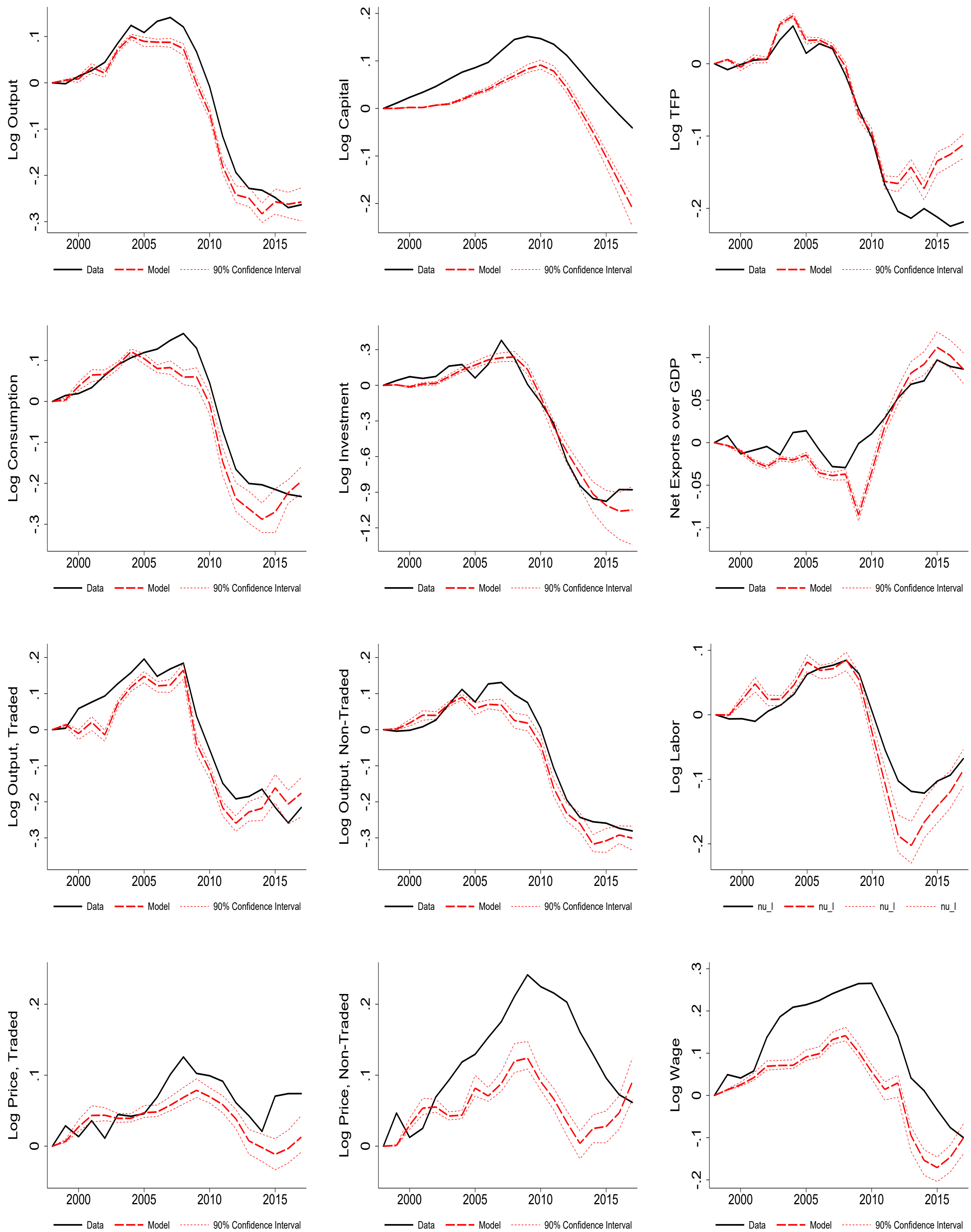


Figure 4: Time Series Comparison between Model and Data

Figure 4 plots the evolution of macroeconomic variables in the data (solid line) and the model (dashed line). In both the data and the model, quantities are detrended with 1.6 percent, TFP with 0.7 percent, prices with 1 percent, and wages with 2.6 percent. All series are normalized to 0 in 1998.

of expenditures. Consumption and investment increase in the boom and collapse in the bust by roughly as much as in the data. Similar to their counterparts in their data, domestic absorption in the model increases by more than domestic production, and net exports decline during the boom. The model also generates a sudden stop at the onset of the bust. As in the data, net exports rise by more than 10 percentage points of GDP after 2009 and remain high until 2017.[28]

The bottom rows present the evolution of sectoral output, sectoral prices, labor, and wages. The model is successful in accounting for the comovement observed in the data, with both sectors experiencing a boom until 2007, followed by a persistent decline after. The model also generates an increase in sectoral prices in the boom and a decline in the bust, but to a smaller extent than the data. Finally, similar to the data, the model generates a boom and bust in labor and wages. Quantitatively, the model accounts more closely for the time series of labor, as it underestimates the increase in wages in the boom and misses by two years their turning point. The lag in the turning point of wages in the data is consistent with a stronger downward wage rigidity in the early part of a recession, as suggested by Schmitt-Grohé and Uribe (2017).[29]

Along with point estimates for the model's time series, Figure 4 shows 90 percent confidence intervals (credible sets) which we construct by drawing vectors of parameters from their joint posterior distribution. The confidence intervals are generally tight and tend to become wider toward the end of the sample. The tightness reflects that crucial parameters for the model's dynamics are estimated precisely and parameters that are estimated imprecisely are not crucial

[28] The value of net exports in the model is $P_H y_H - P_T \left(c_T + x_T + g_T^c + g_T^x\right) -$ adjustment costs. Net exports and the current account comove very closely in our model. We focus our analysis on net exports because the current account does not include valuation effects from foreign asset holdings, which impact banks' balance sheets in our model, and includes items that we do not model but are important for its deterioration during the boom period in the data, such as income earned by foreigners in Greek investments and remittances. Greece had a export deficit of around 10 percent of GDP in 1998. Because we initiate the model in steady state, model net exports are close to zero in 1998. To ease the presentation of the results, we thus normalize net exports over GDP to zero in 1998 both in the data and in the model.

[29] Influential work in the open economy by Schmitt-Grohé and Uribe (2016) emphasizes downward nominal wage rigidity of the form $W_t \geq \gamma W_{t-1}$, where parameter γ disciplines the extent of rigidity. We adopt quadratic adjustment costs because this specification facilitates the use of standard perturbation methods to solve the model and the estimation of its parameters. We acknowledge that downward nominal wage rigidity may have played a role in the initial years of the recession. In Appendix Figure C.8, we display the path of endogenous variables using an alternative specification in which nominal wage adjustment costs are infinite between 2008 and 2010. As the figure shows, this specification is more aligned with the timing of the decline in wages in the data though it features a decline in output, labor, and consumption that precedes the declines observed in the data by one to two years. Importantly, Appendix Table C.11 shows that the changes in endogenous variables through 2017 and the contribution of the shocks to these changes are robust to this specification of adjustment costs. The reason is that wages eventually drop in the data, by 17 percent from 2010 to 2017 (when not detrended), and the model generates a substantial fraction of this decline.

for the model's dynamics. To give some examples, the utilization elasticities are estimated tightly and are crucial for the dynamics of variables, whereas the nominal rigidity parameters are not estimated precisely, but the path of variables is not too sensitive to reasonable changes in their values. The widening of the confidence intervals toward the end of the sample arises because confidence intervals cumulate the effects of earlier shocks and shocks are larger in the bust.

5.2 The Sources of the Greek Boom and Bust

Table 3 documents the sources of the boom (1998-2007) and Table 4 documents the sources of the bust (2007-2017). The first row of each table reports changes in variables in the data and the second row reports changes in the model. In other rows, we shut off the time evolution of particular exogenous processes by setting them equal to a constant. A positive entry indicates that the exogenous process contributes to an increase in a particular variable. Up to rounding, the contributions of all exogenous processes sum up to the reported sum in the model row.

Beginning with Table 3, we find that essentially all of the boom in production is accounted for by two demand shifters, the increase in external demand for traded goods $\bar{a}_T$ and the increase in government spending that mostly falls on non-traded goods g_N^c. The economics are fairly straightforward, as the increase in the demand for Greek goods raises the marginal revenue product of factors and firms accommodate the increase in demand by employing more labor and capital. By contrast, we find limited or no contribution to the production boom from productivity, financial conditions, tax policy, and disaster risk.

The consumption boom comes from both the rule-of-thumb and the optimizing household. Workers in the rule-of-thumb household increase their consumption alongside their labor income. Workers in the optimizing household increase their consumption for two reasons. First, in response to an increase in realized transfers, T^g, and anticipated transfers, T^l, their perceived wealth increases. Second, in response to the decline in idiosyncratic disaster risk, π^θ, workers in the optimizing household lower their precautionary saving. The demand boom is accompanied by an increase in prices and wages. Quantitatively, external factors ($\bar{a}_T$, T^g, and T^l) account for the largest fraction of the boom in prices and wages. Net exports deteriorate in the boom despite the increase in external demand, as the combination of lower borrowing cost, transfers to workers, and government spending causes an even larger import boom.

Table 3: Sources of Macroeconomic Dynamics: Boom Period 1998-2007

	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log$ TFP	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	0.14	0.08	0.12	0.02	0.15	0.10	0.18	0.24	-0.03
Model	0.09	0.07	0.06	0.02	0.08	0.06	0.09	0.13	-0.04
Productivity	0.00	0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
$\log z_H$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log z_N$	0.00	0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
External	0.04	0.03	0.02	0.02	0.05	0.05	0.06	0.08	0.00
$\log \bar{a}_T$	0.04	0.04	0.01	0.02	0.01	0.03	0.03	0.04	0.02
$\log P_F$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^g	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.01	-0.01
T^l	0.00	-0.01	0.01	0.00	0.01	0.01	0.01	0.02	-0.01
Financial	0.00	-0.01	0.01	0.00	0.01	0.01	0.01	0.02	-0.01
$\log \bar{B}^g$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log \bar{B}^r$	-0.01	-0.01	-0.02	0.00	0.00	0.01	0.01	-0.01	0.01
$\bar{r}$	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00
$\bar{i}$	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.02	-0.01
T^b_W	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^b_{Gd}	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
T^b_{Ge}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gov Spending	0.04	0.03	0.03	0.01	0.00	0.00	0.00	0.01	-0.02
$\log g^c_T$	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	-0.01	-0.01
$\log g^c_N$	0.02	0.02	0.00	0.00	-0.03	0.00	0.00	0.00	0.00
$\log g^x_T$	0.01	0.00	0.02	0.00	0.00	-0.01	-0.01	0.00	-0.01
$\log g^x_N$	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
$\log T^r$	0.01	0.00	0.00	0.01	0.03	0.01	0.01	0.02	-0.01
Tax Policy	-0.01	0.00	-0.01	0.00	-0.01	0.00	0.01	0.01	0.00
τ^c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^x	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^ℓ	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^k_H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^k_N	-0.01	-0.01	-0.01	0.00	-0.01	0.00	0.01	0.00	0.00
κ_τ	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Disaster Risk	0.01	0.00	0.00	0.01	0.03	0.01	0.01	0.02	-0.01
π^θ	0.01	0.00	0.00	0.01	0.03	0.01	0.01	0.02	-0.01
π^a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4: Sources of Macroeconomic Dynamics: Bust Period 2007-2017

	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log \mathrm{TFP}$	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	-0.40	-0.14	-0.16	-0.24	-0.38	-0.03	-0.11	-0.34	0.11
Model	-0.34	-0.16	-0.27	-0.14	-0.28	-0.04	0.00	-0.23	0.13
Productivity	-0.02	0.01	0.00	-0.02	-0.03	-0.01	0.03	0.00	0.00
$\log z_H$	0.01	0.00	0.00	0.01	0.00	-0.01	0.00	0.00	0.00
$\log z_N$	-0.02	0.01	0.00	-0.03	-0.03	0.00	0.03	0.00	-0.01
External	-0.06	-0.05	-0.01	-0.03	-0.05	-0.06	-0.07	-0.10	0.00
$\log \bar{a}_T$	-0.06	-0.06	0.00	-0.03	-0.01	-0.03	-0.04	-0.06	-0.03
$\log P_F$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^g	-0.01	-0.01	0.01	0.00	-0.01	0.00	0.00	0.00	0.00
T^l	0.01	0.02	-0.01	0.00	-0.03	-0.03	-0.03	-0.04	0.02
Financial	-0.01	0.02	-0.05	0.01	0.03	0.02	0.03	0.01	-0.01
$\log \bar{B}^g$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log \bar{B}^r$	0.01	0.01	-0.02	0.01	-0.01	0.00	0.00	0.01	-0.01
$\bar{r}$	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	-0.01
$\bar{i}$	0.02	0.03	0.02	0.00	0.05	0.00	0.01	0.01	-0.01
T^b_W	-0.02	-0.01	-0.03	0.00	-0.02	0.00	0.00	-0.01	0.01
T^b_{Gd}	-0.04	-0.02	-0.06	0.00	-0.02	0.02	0.02	-0.02	0.02
T^b_{Ge}	0.02	0.01	0.03	0.00	0.01	-0.01	-0.01	0.01	-0.01
Gov Spending	-0.08	-0.07	-0.05	-0.02	0.02	0.00	0.00	-0.01	0.04
$\log g^c_T$	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01
$\log g^c_N$	-0.04	-0.05	0.00	-0.01	0.06	-0.01	-0.01	0.01	0.01
$\log g^x_T$	-0.02	-0.01	-0.03	0.00	0.00	0.01	0.01	0.00	0.01
$\log g^x_N$	-0.01	0.00	-0.02	0.00	0.00	0.00	0.00	-0.01	0.00
$\log T^r$	-0.01	-0.01	0.01	-0.01	-0.04	-0.01	-0.01	-0.02	0.01
Tax Policy	-0.18	-0.11	-0.12	-0.06	-0.12	0.09	0.12	0.06	0.02
τ^c	-0.01	-0.01	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
τ^x	-0.01	0.00	-0.01	0.00	0.00	0.01	0.01	0.00	0.00
τ^ℓ	-0.03	-0.05	0.00	0.00	-0.03	0.01	0.02	0.07	0.00
τ^k_H	-0.01	0.00	0.00	-0.01	0.00	0.01	0.00	0.00	0.00
τ^k_N	-0.05	-0.01	-0.04	-0.02	-0.03	0.01	0.06	0.00	0.00
κ_τ	-0.07	-0.04	-0.07	-0.02	-0.02	0.04	0.04	-0.02	0.02
Disaster Risk	0.00	0.05	-0.03	-0.01	-0.14	-0.09	-0.10	-0.18	0.07
π^θ	0.00	0.05	-0.03	-0.01	-0.14	-0.09	-0.10	-0.18	0.07
π^a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4 presents the sources of the Greek bust. Tax policy is the most important driver of the bust in production. An increase in the fraction of taxes firms are required to prepay, κ_τ, can be accommodated by either an increase in borrowing or a decrease in expenditures for labor and capital. The model generates a substantial decline in output, labor, and capital in response to the increase in κ_τ because the supply of loans from banks is not perfectly elastic, and thus i increases in response to an increase in loan demand. The increase in capital taxes in the non-traded sector, τ_N^k, also plays an important role for the bust in production, as it lowers after-tax marginal revenue products of labor, capital, and utilization. Finally, the increase in labor income taxes τ^ℓ accounts for a significant fraction of the decline in labor by reducing workers' labor supply.[30]

In the bust, the declines in $\bar{a}_T$ and g_N^c also account for a significant fraction of the output and labor declines. Financial drivers play a moderate role in accounting for the bust in production. However, as we discuss in the context of the bailouts in Section 6.3, this result masks the observation that losses from holdings of sovereign bonds T_{Gd}^b and foreign assets T_W^b are offset by the equity injection to banks T_{Ge}^b.[31]

With respect to the bust in consumption, quantitatively the most important factors are the increase in uninsurable idiosyncratic risk and taxes. To understand the role of idiosyncratic risk, we define the effective discount factor, $\tilde{\beta}_t^o$, of the optimizing household as the product of all exogenous components of the expected stochastic discount factor $\Lambda_{t,t+1}^o$ (which we present in Appendix A):

$$\tilde{\beta}_t^o = \underbrace{\beta^o e^{\left(1-\frac{1}{\rho}\right)\mu}}_{\text{discount factor}} \times \underbrace{\left(1-\pi_t^a+\pi_t^a e^{(\sigma-1)\varphi^a}\right)^{\frac{\frac{1}{\rho}-1}{\sigma-1}}}_{\text{aggregate risk}} \times \left[\underbrace{(1-\pi_t^\theta) e^{-\sigma \log\left(\frac{1-\pi_t^\theta e^{-\varphi^\theta}}{1-\pi_t^\theta}\right)} + \pi_t^\theta e^{\sigma\varphi^\theta}}_{\text{idiosyncratic risk}}\right]. \tag{24}$$

An increase in the effective discount factor $\tilde{\beta}_t^o$ is isomorphic to an increase in the discount factor

[30] We clarify that the role of all driving forces is assessed relative to the least expensive way to balance the government's budget, which is to adjust lump-sum transfers. Thus, the contribution of tax rates should be thought of as an upper bound. When estimating the model, we prefer the assumption that lump-sum transfers adjust to balance the government's budget, because this assumption allows us to match the path of taxes and government spending as observed in the data. Appendix Tables C.12 and C.13 present the sources of the boom and the bust under the alternative assumption that government spending adjusts to balance the budget and lump-sum transfers to the optimizing household are constant. The differences relative to our baseline, in which lump-sum transfers adjust, are relatively small. Tax policy still makes the largest contribution to the bust, but its contribution to the output bust declines to 15 percentage points instead of 18 percentage points. Tax rates by themselves contribute 6 percentage points to the decline in output, a contribution that is closer to that in Section 6, in which we adjust government spending to balance the budget.

[31] Appendix Table C.14 documents the contribution of exogenous processes in the earlier years of the bust (2007-2012). Relative to the results discussed in Table 4, those in Appendix Table C.14 show a somewhat larger role for external demand $\bar{a}_T$ and losses from holdings of sovereign bonds T_{Gd}^b and somewhat smaller roles for fiscal policies.

β^o, because both increase the willingness of the household to postpone consumption for the future. Beginning with the aggregate risk term in parentheses, we note that a higher probability of disaster π^a increases the effective discount factor only if the elasticity of intertemporal substitution $\rho < 1$. Because we estimate ρ close to one, aggregate disaster risk does not matter quantitatively for the time series of the model. By contrast, for the idiosyncratic risk term in brackets, a higher probability of disaster π^θ unambiguously increases the effective discount factor, with the effect being stronger the larger is risk aversion σ. As a result, the rise of idiosyncratic risk increases precautionary saving, lowers consumption, and improves the trade balance.

The rise of idiosyncratic risk acts simultaneously as a negative demand disturbance and as a positive labor supply disturbance, depressing both prices and wages. The rise of idiosyncratic risk accounts for 10 percentage points of the decline in prices and 18 percentage points of the decline in wages. By contrast, increased taxes act as a negative supply disturbance and increase prices and wages in the bust.

5.3 The Importance of Structural Elements

We discuss the mechanisms that allow the model to generate a boom and bust that resemble the Greek boom and bust in the data. The first two rows in each panel of Table 5 report changes in selected variables in the data and the baseline model for the boom (upper panel) and the bust (lower panel). Each other row reports changes in the same variables when we feed the same sequence of shocks but under different parameter values than those in the baseline model. This exercise also clarifies the identification of some of the estimated parameters (see Appendix Table C.15 for additional parameters).

Variable utilization of factors plays a central role in the model's ability to account for the Greek macroeconomic time series. In the absence of variable utilization ($\xi_H = \xi_N = \infty$), the model would generate a significantly smaller bust in output and TFP. Increasing the responsiveness of utilization relative to that in the baseline ($\xi_H = \xi_N = 2.5$) allows the model to generate a larger decline in output and TFP in the bust but at the cost of generating a counterfactual increase in prices. The tension between accounting for the behavior of quantities and prices in the bust explains why our estimated elasticities of utilization lie between these more extreme values.

Eliminating nominal price and wage rigidity ($\psi_p = \psi_w = 0$) does not affect the performance

Table 5: Role of Structural Elements

A. Boom: 1998-2007	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log \text{TFP}$	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	0.14	0.08	0.12	0.02	0.15	0.10	0.18	0.24	-0.03
Baseline Model	0.09	0.07	0.06	0.02	0.08	0.06	0.09	0.13	-0.04
$\xi_H = \xi_N = \infty$	0.06	0.10	0.06	-0.02	0.06	0.07	0.12	0.14	-0.05
$\xi_H = \xi_N = 2.5$	0.09	0.06	0.05	0.03	0.08	0.06	0.08	0.13	-0.04
$\psi_p = \psi_w = 0$	0.03	0.02	0.05	0.00	0.04	0.10	0.13	0.16	-0.05
$\psi_p = \psi_w = 1000$	0.16	0.18	0.07	0.04	0.16	0.02	0.03	0.06	-0.03
$\varphi^\theta = 0$	0.08	0.07	0.05	0.02	0.06	0.05	0.08	0.11	-0.03
$\varphi^\theta = 0.3$	0.11	0.08	0.06	0.04	0.17	0.08	0.12	0.19	-0.06
$\delta_b = 0.3$	0.08	0.06	0.05	0.02	0.08	0.06	0.09	0.13	-0.03
$\delta_b = 0.9$	0.10	0.08	0.06	0.03	0.09	0.05	0.09	0.14	-0.04
No Working Capital	0.05	0.05	0.03	0.01	0.07	0.07	0.11	0.12	-0.03
B. Bust: 2007-2017	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log \text{TFP}$	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	-0.40	-0.14	-0.16	-0.24	-0.38	-0.03	-0.11	-0.34	0.11
Baseline Model	-0.34	-0.16	-0.27	-0.14	-0.28	-0.04	0.00	-0.23	0.13
$\xi_H = \xi_N = \infty$	-0.24	-0.17	-0.26	-0.02	-0.18	-0.11	-0.10	-0.23	0.15
$\xi_H = \xi_N = 2.5$	-0.44	-0.15	-0.27	-0.23	-0.37	0.01	0.08	-0.25	0.11
$\psi_p = \psi_w = 0$	-0.34	-0.13	-0.26	-0.14	-0.28	-0.07	0.03	-0.24	0.12
$\psi_p = \psi_w = 1000$	-0.42	-0.32	-0.26	-0.13	-0.33	0.03	0.05	-0.02	0.11
$\varphi^\theta = 0$	-0.34	-0.20	-0.23	-0.12	-0.14	0.04	0.10	-0.05	0.05
$\varphi^\theta = 0.3$	-0.36	-0.01	-0.37	-0.18	-0.72	-0.32	-0.32	-0.81	0.36
$\delta_b = 0.3$	-0.29	-0.13	-0.19	-0.13	-0.25	-0.06	-0.02	-0.21	0.10
$\delta_b = 0.9$	-0.38	-0.17	-0.31	-0.14	-0.29	-0.03	0.01	-0.25	0.14
No Working Capital	-0.18	-0.07	-0.10	-0.10	-0.21	-0.13	-0.08	-0.18	0.06

of the model in terms of the declines in quantities and prices by 2017. Nominal rigidities play an important role in generating the boom in quantities. However, increasing them to extreme values ($\psi_p = \psi_w = 1000$) introduces a significant deviation of the model from the data in terms of the medium-run boom and bust in prices and wages. The trade-off between accounting for the boom in quantities and the cycle in prices and wages identifies a moderate role for nominal rigidity.

The size of idiosyncratic disasters is identified by the relative movements of consumption, prices, and labor in the bust. Without idiosyncratic disasters ($\varphi^\theta = 0$), the model generates a significantly smaller decline in consumption and prices in the bust. With larger idiosyncratic disasters ($\varphi^\theta = 0.3$), the model generates a larger decline in consumption and prices in the bust, but fails to account for the drop in labor.[32]

The exit rate of bankers, δ_b, affects the responsiveness of the borrowing cost i to underlying shocks. The logic is that a higher δ_b reduces the horizon of banks to smooth negative net worth shocks. As a result, banks need to be compensated with a higher i to satisfy the incentive compatibility constraint (18). In turn, a higher i reduces firms' demand for inputs and generates upward pressure on prices. Consistent with this logic, the table shows that higher values of δ_b are associated with larger movements in production and consumption, and lower values of δ_b are associated with larger price declines in the bust.

We conclude by discussing the importance of the working capital constraint, which intermediates changes in the borrowing cost i into production decisions. The decline in i during the boom and increase during the bust amplifies the boom and bust in production. Thus, in the absence of the working capital constraint, both the boom and the bust in production would have been smaller. The movements of i also affect the marginal cost of production and therefore the presence of a working capital constraint reduces the responsiveness of prices.

6 Policy Experiments

We begin our analysis by changing the mix of spending and taxes used to achieve fiscal consolidation. Next, we discuss how debt accumulation in the boom limited fiscal space in the bust. Finally, we evaluate the importance of bailouts to banks from the government and to Greece from the rest of the world. Our policy counterfactuals in this section differ from those in Tables 3 and 4, in which lump sum transfers T^o adjust to balance the government budget, because we make the more plausible assumption that alternative policy instruments adjust to balance the budget.

6.1 Fiscal Adjustment

The Greek fiscal adjustment fell on both spending cuts and tax increases. Figure 5 evaluates the macroeconomic effects of tilting the adjustment away from increased taxes and entirely toward

[32] Social insurance against long-term unemployment affects the size of idiosyncratic disasters φ^θ. The comparative statics of aggregate consumption with respect to φ^θ are consistent with the stabilization effects of unemployment insurance in Kekre (2022).

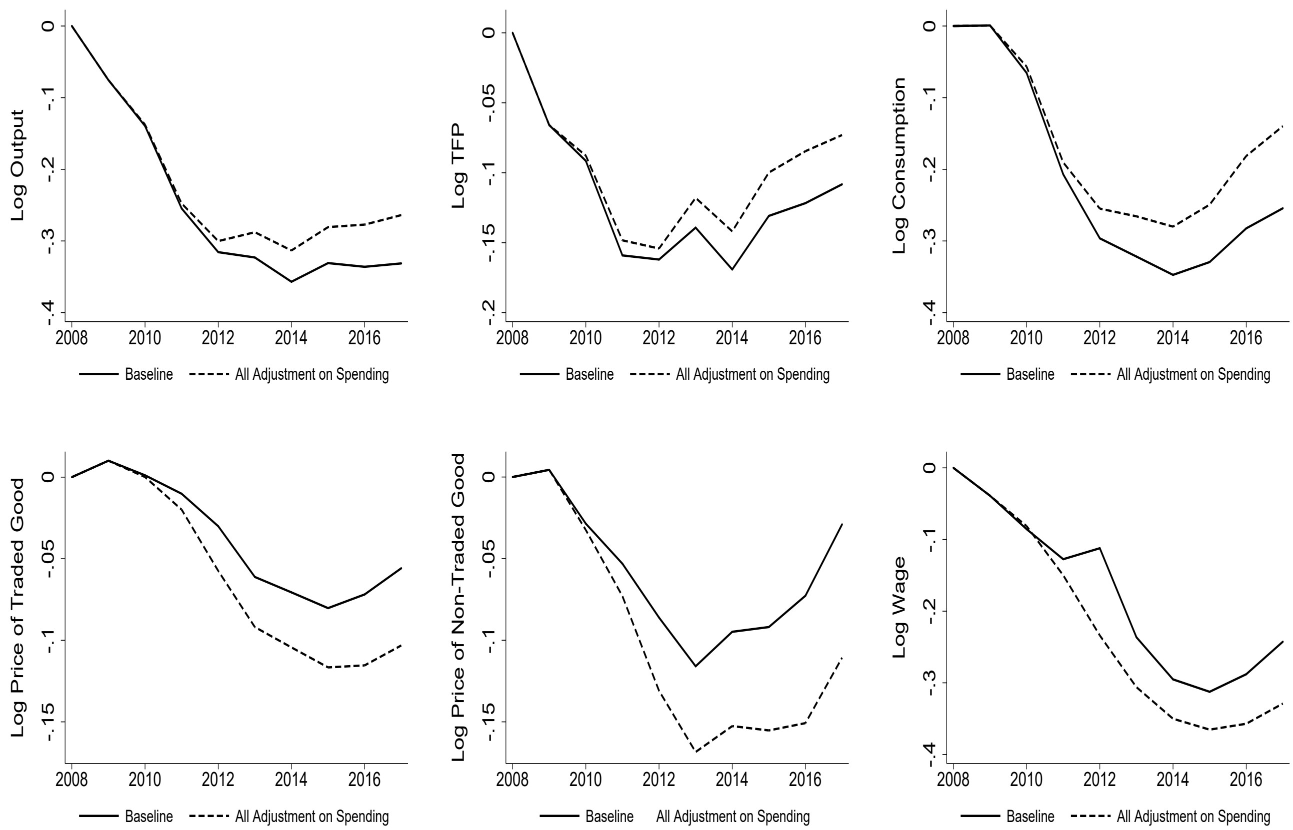


Figure 5: Tilting Fiscal Adjustment to Spending Cuts

Figure 5 plots the evolution of macroeconomic variables relative to 2008 in the model. The solid line shows the baseline path under the observed fiscal adjustment and the dashed line shows the counterfactual path had the fiscal adjustment been concentrated entirely on spending cuts holding tax rates constant to their 2009 values.

reduced spending.[33] In each panel, the solid line presents the baseline path of a variable in our model under the implemented fiscal consolidation program and the dashed line presents the counterfactual path of a variable under the alternative program. Relative to the implemented fiscal adjustment, this alternative program would have increased output by roughly 7 log points in 2017. Around half of the gains in output are accounted for by an increase in TFP. We also find significant gains in consumption. The second row of the figure shows that the adjustment is facilitated by a larger decline in prices and wages, as removing the increase in tax rates makes the economy more competitive.

[33] Appendix Figure C.9 shows that for all variables the difference between the baseline and the counterfactual is statistically significant at conventional levels. To perform this counterfactual, we set all tax innovations to zero starting in 2010 and introduce innovations to government spending $\{g_T^c, g_N^c, g_T^x, g_N^x, T^r\}$ such that the government budget constraint is satisfied at the baseline path of transfers to the optimizing household T^o. The size of the innovations in each instrument is proportional to its steady state expenditure share. We follow the same approach in all our counterfactuals below and when we adjust tax rates we use revenue shares.

Table 6: Output and Revenue Effects of Fiscal Instruments (7-year horizon)

Multiplier	Output Effect	Revenue Cost	Output / Cost
g_N^c	0.56	0.89	0.62
g_T^c	0.14	1.04	0.14
g_N^x	1.24	0.54	2.29
g_T^x	0.62	0.85	0.73
ζT^r	0.21	0.81	0.26
τ^c	-0.27	-0.38	0.72
τ^x	-0.15	-0.12	1.25
τ^ℓ	-0.38	-0.42	0.90
τ_H^k	-0.14	-0.03	4.46
τ_N^k	-0.26	-0.10	2.71

To understand how the composition of the fiscal adjustment affects macroeconomic variables, we calculate the output and revenue effects of each fiscal instrument. The output effects are given by the fiscal multiplier of instrument $f = \{g_T^c, g_N^c, g_T^x, g_N^x, \zeta T^r, \tau^c, \tau^x, \tau^\ell, \tau_H^k, \tau_N^k\}$ at horizon h:

$$M_f^y(h) = \frac{\sum_{t=1}^h (1+\bar{i})^{1-t} \Delta y_t}{\sum_{t=1}^h (1+\bar{i})^{1-t} \Delta f_t}. \tag{25}$$

The multiplier is generated by an initial impulse ν_1^f in fiscal instrument f and its autoregressive process in equation (21). Changes in output Δy_t are calculated as the difference between the path of output given the fiscal impulse and the path of output in the absence of the fiscal impulse, assuming that lump-sum transfers to the optimizing household T^o adjust to balance the budget. Because output in steady state equals one, the tax multipliers can be interpreted as the percent change in output resulting from a one percentage point change in a tax rate. The revenue cost is the change in lump-sum transfers T^o that balances the government budget constraint:

$$M_f^r(h) = -\frac{\sum_{t=1}^h (1+\bar{i})^{1-t} \Delta(1-\zeta) T_t^o}{\sum_{t=1}^h (1+\bar{i})^{1-t} \Delta f_t}. \tag{26}$$

We discount future changes at the steady state interest rate of the optimizing household, $\bar{i} = 0.04$.

Table 6 reports cumulative multipliers at horizon $h = 7$ years to benchmark our results to the fiscal adjustment that began in 2010 (see Appendix Table C.16 for confidence intervals and Table C.17 for contemporaneous and infinite horizon multipliers). Dividing M_f^y by M_f^r yields the cost-based multiplier for instrument f in the last column. For example, a cumulative one percentage point decrease in τ^ℓ costs 0.42 units of revenues. A unit change in revenues induced by lower τ^ℓ increases output by 0.9 units.

Table 6 highlights significant differences across fiscal instruments in their ability to raise revenues and to impact output. Revenue-based tax multipliers generally exceed revenue-based spending multipliers. As a result, shifting the burden of adjustment away from taxes as in Figure 5 increases output in the bust, holding constant the size of the fiscal consolidation.

The model generates a government spending multiplier for non-traded consumption g_N^c of 0.56.[34] Weighting the four g multipliers with their expenditure shares also yields an aggregate multiplier of 0.56, since g_N^c is the largest category of spending. The multiplier on non-traded goods exceeds the multiplier on traded goods, as the former goods are produced domestically, whereas the latter are also imported. Government spending multipliers on investment exceed the multipliers on consumption because public investment augments the capital used in production, as shown in equation (11). Finally, the multiplier on non-traded goods exceeds the transfer multiplier because transfers do not directly augment production.

How do the spending multipliers compare with those in the literature? On the theoretical side, our model contains elements identified by earlier literature (Nakamura and Steinsson, 2014; Farhi and Werning, 2016; House, Proebsting, and Tesar, 2017) as contributing to larger government spending multipliers for countries that belong to a currency union such as Greece. These include nominal price and wage rigidity and liquidity-constrained workers. Despite these shared features, our model generates smaller multipliers than those in these papers for two reasons. First, this literature considers more transient changes in spending than observed in Greece.[35] Second, some of the theoretical literature considers complete asset markets, whereas we model Greece as oper-

[34] This multiplier is under the assumption that lump-sum transfers T^o adjust to balance the budget constraint. Table C.18 reports multipliers under various alternative financing systems and at different horizons.

[35] In the presence of nominal rigidity, the most important parameter for government spending multipliers is the persistence ρ_f of the fiscal shocks, because it determines the required increase in taxes and therefore the degree of crowding-out of private consumption. We report fiscal multipliers for different parameters, different financing methods, and different horizons in Appendix Tables C.19 to C.22. Lowering ρ_f from close to 1 in our baseline to 0.75 raises the g_N^c multiplier to 0.8. In their quantitative evaluation, Farhi and Werning (2016) consider spending that lasts 1.25 years, while Nakamura and Steinsson (2014) and House, Proebsting, and Tesar (2017) consider spending with an annual persistence of 0.75. The European Central Bank (2015) reports multipliers ranging from 0.25 to 0.97 for 15 models maintained by central banks in the European System, with the Bank of Greece model at 0.87.

ating within incomplete international asset markets. In response to government spending shocks, complete asset markets trigger a transfer of wealth that offsets the negative wealth effect on consumption. With incomplete asset markets, the multiplier of Nakamura and Steinsson (2014) falls from 1.4 to 0.8 and the multiplier of House, Proebsting, and Tesar (2017) falls from 2.0 to 1.5.

On the empirical side, the closest analogs are estimates of government spending multipliers in subnational regions belonging to a currency union (such as U.S. states) or in countries with fixed exchange rates. Chodorow-Reich (2019) reviews empirical estimates of subnational multipliers and emphasizes that because subnational spending is financed by the central government, these estimates should be compared to model-generated multipliers for transitory spending shocks for which the associated increase in tax burden is small. Using structural vector autoregressions, Ilzetzki, Mendoza, and Vegh (2013) report multipliers above one for countries with fixed exchange rates, but lower or even negative multipliers for countries with high debt burdens, such as Greece.

Turning to taxes, we find the largest revenue-based multipliers for capital tax rates. In fact, the economy is close to the peak of the Laffer curve with respect to capital tax rates. This result again highlights the importance of variable utilization. The first-order conditions for utilization in each sector $i = \{H, N\}$ imply $u_i = \left(\frac{(1-\tau_i^k)P_i^f y_i}{\bar{\xi}_i Q^k e^{-\mu} k_i}\right)^{\frac{1}{\xi_i}}$. Capital taxes lower utilization and exert a negative impact on output even before capital adjusts.[36]

The closest related evidence for tax multipliers comes from the study of fiscal consolidations by Alesina, Favero, and Giavazzi (2019). Using a panel of countries that excludes Greece, they find that a change in tax rates resulting in a 1 percent increase in revenue to GDP over 4 years decreases GDP by 2 percent. While they do not distinguish among different types of taxes, their estimate is similar to our aggregate revenue-based tax multiplier. If we weight the different tax multipliers in Table 6 with their revenue shares in steady state, the model generates an aggregate revenue-based tax multiplier of 1.34.[37]

[36]Our results corroborate the analysis of Trabandt and Uhlig (2011), who demonstrate that the Greek revenue maximizing capital tax rate is roughly 40 percent, implying small revenue losses from cutting capital taxes.

[37]Other evidence comes from the Mertens and Ravn (2013) implementation of the Romer and Romer (2010) discretionary tax changes for the United States. They report revenue-based multipliers for personal income taxes (roughly -2.5) higher than our labor income tax multiplier (roughly -1). Their revenue-based multipliers for capital taxes are comparable to ours, because in Table 6 we find small revenue effects from changing capital income taxes. Our model-based multipliers for capital income tax rates are consistent with those of Cloyne, Martinez, Mumtaz, and Surico (2022), who estimate a cumulative 7-year GDP multiplier of around 0.2 to 0.3 for the U.S. corporate income tax rate. Our tax rate changes are more persistent than theirs and thus we do not consider the role of endogenous growth to reconcile transitory tax changes with longer-term output effects. Finally, our model-generated

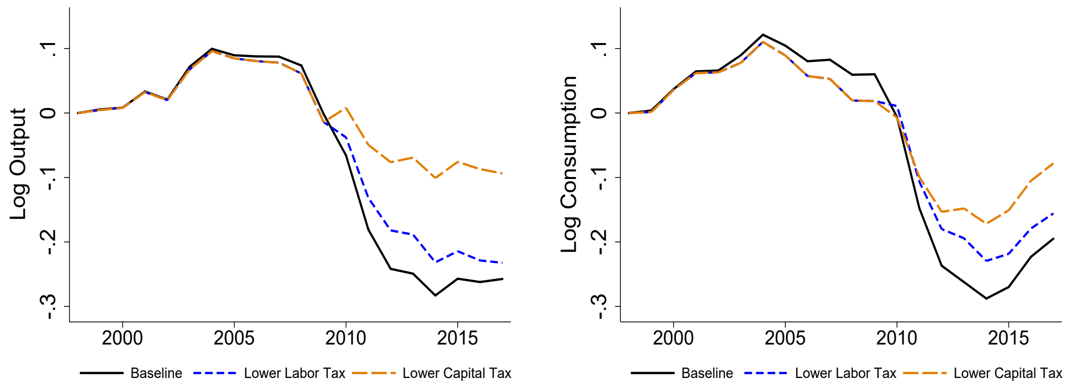


Figure 6: Reducing Transfers in the Boom and Taxes in the Bust

Figure 6 plots the evolution of output relative to 1998 in the model. The solid line shows the baseline path under the observed path of fiscal variables. The panels show the path of output and consumption in the counterfactual in which Greece had held constant transfers to the rule-of-thumb household throughout the sample and used the additional fiscal space in 2010 to either avoid increasing labor taxes (short dash line) or avoid increasing capital taxes (long dash line).

6.2 Fiscal Discipline

Martin and Philippon (2017) argue that reducing spending in the boom would have allowed Greece and other peripheral euro countries to adjust by less in the bust. We repeat the spirit of their exercise within our model economy by shutting off innovations in transfers to the rule-of-thumb household T^r over the entire sample. Between 1998 and 2009, government debt $\bar{B}^g$ adjusts to make the flow government budget constraint hold. We solve for the path of labor taxes τ^ℓ or capital taxes τ_H^k, τ_N^k starting in 2010 such that the flow government budget constraint holds and government debt $\bar{B}^g$ grows linearly back to its observed level in 2017. Effectively, we calculate the macroeconomic outcomes that Greece would have accomplished entering in 2010 with a lower stock of debt and using the freed-up resources to reduce distortionary taxes.

Figure 6 shows that in 2007 removing transfers lowers output by 1 log point and consumption by 3 log points (see Appendix Figure C.10 for the confidence interval of the output and consumption effects for each counterfactual). Using the freed-up resources to lower labor income taxes would have increased output and consumption during the bust but the effects dissipate over time, with output and consumption increasing only by 2 and 4 log points in 2017. By contrast, using the freed-up resources in 2010 to finance a reduction in capital taxes increases output by 16 log points

investment elasticity with respect to changes in the user cost induced by changes in capital tax rates is -0.3 for the traded sector and -0.6 for the non-traded sector. This elasticity falls within the range of estimates reported by Hassett and Hubbard (2002).

and consumption by 12 log points by 2017. The difference between labor and capital income taxes is consistent with our findings in Table 6 that revenue-based multipliers for capital are higher than those for labor taxes. We conclude that fiscal discipline in boom years could have allowed Greece to smooth the bust in production and consumption by lowering distortionary taxes on capital.

6.3 Bailouts

Beginning in 2010, Greece received loans from four separate facilities that jointly constituted the Economic Adjustment Program (EAP). Of these loans, roughly 40 percent were earmarked at disbursement for reducing debt owed to private sector creditors, 20 percent were earmarked for equity injections into the banking sector, and the remainder was available to Greece for general budgetary needs. We use our model to assess the impact of these programs.

Constructing counterfactuals without the EAP requires answering two questions. First, since EAP loans had lower interest rates and longer maturities than Greek debt trading on secondary markets, how much of the assistance constituted a transfer of resources and how much constituted a loan? We adopt the approach of Gourinchas, Martin, and Messer (2020), who measure the transfer component as the present discounted value of the differences between disbursements and repayments (including interest), discounted using the IMF's internal rate of return. This approach assumes that institutions lending to Greece had better enforcement technology for repayment than the private sector, thus allowing Greece to borrow at lower rates, but only up to the rate charged by the IMF on its programs.

Second, how would Greece have balanced its government budget without the assistance? We assume that Greece could not have raised additional private financing, as it was effectively excluded from private credit markets at the time of the programs. By the same reasoning, we exclude from the EAP resources the part used to reduce debt to private sector creditors.[38] Thus, we divide the

[38] The Greek Loan Facility (GLF) disbursed funds in 2010 and 2011 during the first EAP, the European Financial Stability Facility (EFSF) disbursed funds between 2012 and 2014 during the second EAP, the European Stability Mechanism (ESM) disbursed funds starting in 2015 during the third EAP, and the IMF disbursed funds between 2010 and 2014 during the first and second EAPs. We obtain the time series of disbursements under the GLF from European Commission (2011), for the EFSF from Corsetti, Erce, and Uy (2017), for the ESM from https://bit.ly/3t8jiEN, and for the IMF from European Commission (2011), https://bit.ly/331Ovip, and https://bit.ly/3eBC1n8. The part used to reduce debt owed to private sector creditors and hence excluded from the counterfactual exercise includes 37.1 billion euros from the GLF used to repay debt maturing between May 2010 and September 2011, 45.9 billion from the EFSF earmarked for the March 2012 debt exchange and December 2012 debt buyback, and 10.5 billion from the ESM earmarked to rollover other credit or pay down arrears. We also

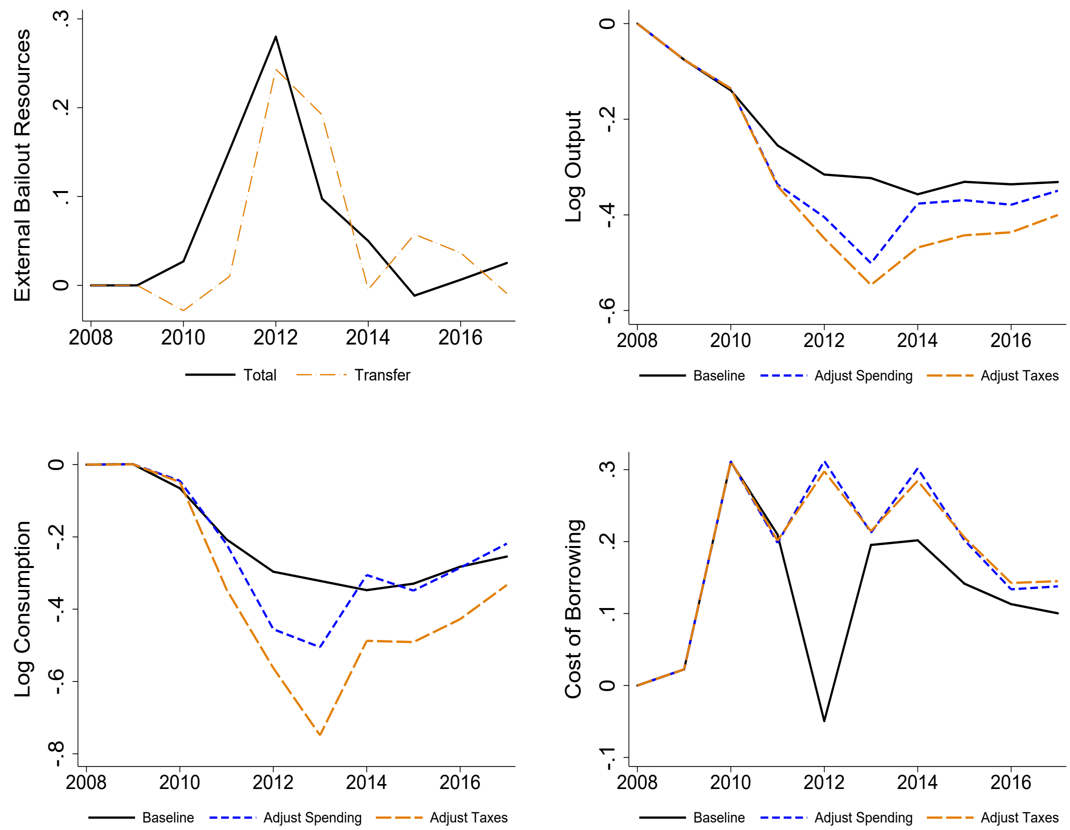


Figure 7: External Bailout of Greek Government

The first panel of Figure 7 plots the components of the external bailout. The other three panels plot the evolution of outcome variables in the model. The solid line shows the baseline path under the observed external bailout. The short dashed line shows the counterfactual path if Greece had not received the external bailout and instead further reduced government spending. The long dashed line shows the counterfactual path if Greece had not received the external bailout and instead further increased tax rates.

remaining EAP disbursements in each year in the government budget constraint into a component that augments transfers T_t^g and a component that results in a change in debt $\bar{B}_{t+1}^g$.[39] We then study alternative scenarios under which, without the programs, Greece would not have bailed out the banks and either further cut spending or further raised taxes.

The first panel of Figure 7 reports the total resources from the EAP and the transfer component of the EAP in T_t^g. Without the EAP, the transfer component would be lower by roughly 20 percent of output in 2012 and 2013. The other three panels of Figure 7 show the paths of output, consumption, and the borrowing cost in a counterfactual in which we change T^g, $\bar{B}^g$, and T_{Ge}^b by the amounts due to the EAP and then balance the budget by either further reducing spending (short

count only the part of EAP assistance earmarked for bank capital injections that Greece actually used to purchase bank equity, as measured in the Flow of Funds.

[39]We calculate T_t^g, which is a flow transfer in the government budget constraint, as the difference between annual disbursements and the change in the present value of disbursements net of repayments (including interest) calculated using the IMF's internal rate of return.

dashed blue line) or further increasing taxes (long dashed orange line). In 2013, the programs increased output by roughly 20 log points and consumption by between 20 and 40 log points, depending on whether spending or taxes adjust to absorb the foregone resources. The magnitude of these effects highlights why Greece actively considered leaving the euro and defaulting further in the absence of the bailout, an alternative that we do not consider. The last panel shows that without the EAP, the borrowing cost increases by roughly 30 percentage points in 2012. The drop in the cost of capital due to the EAP is consistent with the reversal of bank net worth by 2013 to its pre-crisis levels (shown previously in Figure 2(i)). The stabilization of the borrowing cost persists throughout the sample period, leading to significant effects of the EAP on output and consumption by 2017.

Figure 8 isolates the macroeconomic effects coming from only injecting equity into banks.[40] The counterfactual paths of output, consumption, and borrowing cost are constructed under the assumption that the resources channeled to banks through the EAP would instead have been used to either increase government spending or cut taxes. While reduced fiscal austerity stimulates output by roughly 7 log points in 2012, lower bank equity is associated with lower output and consumption by 2017. This result reflects a revenue-based multiplier for T^b_{Ge} over a 7-year horizon of more than 5, which exceeds both the tax and spending multipliers reported in Table 6. We conclude that financial policy helped mitigate the persistence of the bust.

7 Conclusion

Greece experienced a boom in the early 2000s, followed by a depression whose magnitude and persistence have no precedent among modern developed economies. To study this cycle, we develop and estimate a rich macroeconomic model with heterogeneous households, multiple sectors of production, a banking sector, a government sector, and an external sector. Methodologically, one contribution of our study is to discipline the shocks by feeding them directly into an estimated model without adding to them any measurement error. This approach may prove useful in future studies of particular episodes.

[40] Appendix Figures C.11 and C.12 present the difference in variables between the counterfactual without external assistance or bank bailouts and the baseline with these transfers. As the figures show, in general the macroeconomic effects are statistically different from zero.

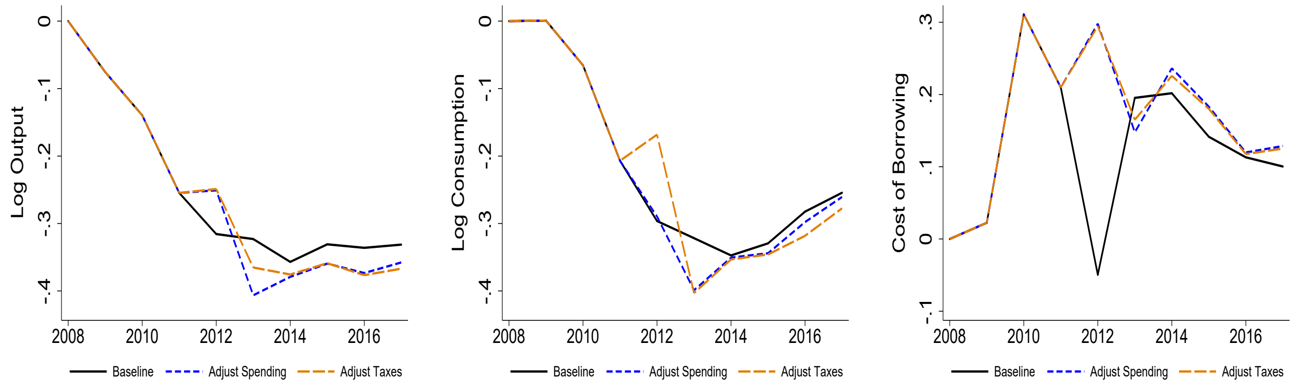


Figure 8: Bailout of Domestic Banks

Figure 8 plots the evolution of macroeconomic variables relative to 2008 in the model. The solid line shows the baseline path under the observed external bailout with some of the bailout funds being directed to inject equity to banks. The short dashed line shows the counterfactual path under which Greece had used the equity injection resources to increase government spending. The long dashed line shows the counterfactual path under which Greece had used the equity injection resources to decrease tax rates.

While the Greek experience shares some elements present in standard narratives of boom-bust cycles in small open economies with a currency peg, it differs profoundly in terms of the magnitude and the persistence of the bust in quantities and the adjustment of nominal prices and wages. For Greece, we find that increased demand from the rest of the world and the government fuelled the boom in production and realized or anticipated external transfers fuelled the boom in consumption. Contractionary tax policies, amplified by a decline in factor utilization and financial frictions, accounted for the largest fraction of the bust in production. The rise of idiosyncratic risk accounted for the largest fraction of the bust in consumption and prices and the sudden stop of capital flows.

The mechanisms amplifying shocks into the Greek depression and the policies mitigating them also differ from those during relatively smaller contractions. We find that Greece could have reaped substantial benefits by avoiding the debt-financed rise of household transfers in the boom and using the additional fiscal space to reduce capital taxes in the bust. Further, we find that fiscal policy amplified the depression by concentrating the burden of adjustment on taxes instead of spending and by raising the fraction of taxes that firms prepay before revenues are realized. By contrast, equity injections to banks mitigated the depression by lowering the borrowing cost.

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The Macroeconomics of the Greek Depression

Online Appendix

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A Model Appendix

Appendix A.1 shows how the assumption of random walk of individual income simplifies the model with heterogeneity. Appendix A.2 lists the equilibrium conditions of the model. Appendix A.3 describes how we incorporate rare disasters into the model.

A.1 Heterogeneity

We focus on workers in household o because workers in household r are identical in income. We impose the conjecture $W^o_{\iota t} = W_t$ to ease the notation. The first-order conditions of worker ι in household o are:

$$\frac{c^o_{T,\iota t}}{c^o_{N,\iota t}} = \frac{\omega_c}{1-\omega_c}\left(\frac{P_{N,t}}{P_{T,t}}\right)^{\phi},$$

$$\frac{c^o_{H,\iota t}}{c^o_{F,\iota t}} = \frac{\gamma}{1-\gamma}\left(\frac{P_{H,t}}{P^*_{F,t}}\right)^{-\eta},$$

$$\frac{\varepsilon_w}{\varepsilon_w - 1}\frac{\chi c^o_{\iota t}(\ell^o_{\iota t})^{\frac{1}{\epsilon}}}{\rho + (1-\rho)\frac{\chi(\ell^o_{\iota t})^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}}} = \frac{1-\tau^\ell_t}{1+\tau^c_t}\frac{\theta^o_{\iota t}W_t}{P_{c,t}}\times$$

$$\left[1 + \frac{\psi_w}{\varepsilon_w - 1}\left(\left(\frac{(1-\tau^\ell_t)W_t}{(1-\tau^\ell_{t-1})W_{t-1}} - 1\right)\frac{(1-\tau^\ell_t)W_t}{(1-\tau^\ell_{t-1})W_{t-1}}\right.\right.$$

$$\left.\left. - \mathbb{E}_t\Lambda^o_{\iota t,t+1}\frac{\theta^o_{\iota t+1}}{\theta^o_{\iota t}}\left(\frac{(1-\tau^\ell_{t+1})W_{t+1}\ell^o_{t+1}}{(1-\tau^\ell_t)W_t\ell^o_t}\right)\left(\frac{(1-\tau^\ell_{t+1})W_{t+1}}{(1-\tau^\ell_t)W_t} - 1\right)\frac{(1-\tau^\ell_{t+1})W_{t+1}}{(1-\tau^\ell_t)W_t}\right)\right],$$

$$(1+\tau^c_t)P_{c,t}c^o_{\iota t} + (1+\bar{i}_t)e^{-\mu}B^o_{\iota t} - B^o_{\iota t+1} + Q^\varsigma_t\varsigma^o_{\iota t+1}$$

$$= \theta^o_{\iota t}\left[\left(1-\tau^\ell_t\right)\int W_t\ell^o_{\iota t}\mathrm{d}\iota - \int \mathrm{AC}^o_{w,\iota t}\mathrm{d}\iota + T^o_t + \frac{\Pi^b_t + T^l_t}{1-\zeta}\right] + (Q^\varsigma_t + \Pi^f_t)\varsigma^o_{\iota t},$$

$$\mathrm{AC}^o_{w,\iota t} = \frac{\psi_w}{2}\left(\frac{(1-\tau^\ell_t)W_t}{(1-\tau^\ell_{t-1})W_{t-1}} - 1\right)^2(1-\tau^\ell_t)W_t\ell^o_t,$$

$$c^o_{\iota t} = \left(\omega_c^{\frac{1}{\phi}}\left(c^o_{T,\iota t}\right)^{\frac{\phi-1}{\phi}} + (1-\omega_c)^{\frac{1}{\phi}}\left(c^o_{N,\iota t}\right)^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}},$$

$$c^o_{T,\iota t} = \left(\gamma^{\frac{1}{\eta}}(c^o_{H,\iota t})^{\frac{\eta-1}{\eta}} + (1-\gamma)^{\frac{1}{\eta}}(c^o_{F,\iota t})^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}},$$

$$
\begin{aligned}
\Lambda^o_{\iota t,t+1} &= \beta^o e^{-\frac{1}{\rho}\mu}\left(1-\pi^a_t+\pi^a_t e^{-\varphi^a(1-\sigma)}\right)^{\frac{1-\frac{1}{\rho}}{1-\sigma}} (\mathrm{ce}^o_{\iota t})^{\sigma-\frac{1}{\rho}} (v^o_{\iota t+1})^{\frac{1}{\rho}-\sigma}\times \\
&\quad \frac{(c^o_{\iota t+1})^{-\frac{1}{\rho}}\left(1+\left(\frac{1}{\rho}-1\right)\frac{\chi\left(\ell^o_{\iota t+1}\right)^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}}\right)^{\frac{1}{\rho}}}{(c^o_{\iota t})^{-\frac{1}{\rho}}\left(1+\left(\frac{1}{\rho}-1\right)\frac{\chi(\ell^o_{\iota t})^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}}\right)^{\frac{1}{\rho}}}\frac{(1+\tau^c_t)P_{c,t}}{(1+\tau^c_{t+1})P_{c,t+1}}, \\
1 &= \mathbb{E}_t\Lambda^o_{\iota t,t+1}(1+\bar{i}_{t+1}), \\
Q^\varsigma_t &= \mathbb{E}_t\Lambda^o_{\iota t,t+1}e^{\mu}\left(\Pi^f_{t+1}+Q^\varsigma_{t+1}\right), \\
(v^o_{\iota t})^{1-\frac{1}{\rho}} &= (c^o_{\iota t})^{1-\frac{1}{\rho}}\left(1+\left(\frac{1}{\rho}-1\right)\frac{\chi\left(\ell^o_{\iota t+1}\right)^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}}\right)^{\frac{1}{\rho}} \\
&\quad +\beta^o e^{\left(1-\frac{1}{\rho}\right)\mu}\left(1-\pi^a_t+\pi^a_t e^{-\varphi^a(1-\sigma)}\right)^{\frac{1-\frac{1}{\rho}}{1-\sigma}}(\mathrm{ce}^o_{\iota t})^{1-\frac{1}{\rho}}, \\
\mathrm{ce}^o_{\iota t} &= \left(\mathbb{E}_t(v^o_{\iota t+1})^{1-\sigma}\right)^{\frac{1}{1-\sigma}}.
\end{aligned}
$$

Next, we conjecture that individual-level variables are related to household-level variables:

$$
\begin{aligned}
c^o_{\iota t} &= \theta^o_{\iota t}c^o_t, \\
c^o_{T,\iota t} &= \theta^o_{\iota t}c^o_{T,t}, \\
c^o_{H,\iota t} &= \theta^o_{\iota t}c^o_{H,t}, \\
c^o_{F,\iota t} &= \theta^o_{\iota t}c^o_{F,t}, \\
c^h_{N,\iota t} &= \theta^o_{\iota t}c^o_{N,t}, \\
\ell^o_{\iota t} &= \ell^o_t, \\
v^h_{\iota t} &= \theta^o_{\iota t}v^o_t, \\
ce^h_{\iota t} &= \theta^o_{\iota t}ce^o_t
\end{aligned}
$$

and that

$$
\begin{aligned}
&B^o_{\iota t+1}-(1+\bar{i}_t)e^{-\mu}B^o_{\iota t}+(Q^\varsigma_t+\Pi^f_t)\varsigma^o_{\iota t}-Q^\varsigma_t\varsigma^o_{\iota t+1}= \\
&\qquad\qquad \theta^o_{\iota t}\left[B^o_{t+1}-(1+\bar{i}_t)e^{-\mu}B^o_t+(Q^\varsigma_t+\Pi^f_t)\varsigma^o_t-Q^\varsigma_t\varsigma^o_{t+1}\right],
\end{aligned}
$$

for household-level $\{c^o_t, c^o_{T,t}, c^h_{N,t}, \ell^o_t, B^o_{t+1}, \varsigma^o_{t+1}, v^o_t, ce^o_t\}$ characterized in Appendix A.2. The final step is to verify that an allocation solving the equilibrium conditions in Appendix A.2 necessarily solves the first-order conditions of the individual worker, thus validating the conjecture.

A.2 Equilibrium Conditions

We present the equilibrium conditions in blocks.

A.2.1 Households (24 equations)

The first-order conditions for household $h \in \{o, r\}$ are:

$$\frac{c^h_{T,t}}{c^h_{N,t}} = \frac{\omega_c}{1-\omega_c}\left(\frac{P_{N,t}}{P_{T,t}}\right)^{\phi},$$

$$\frac{c^h_{H,t}}{c^h_{F,t}} = \frac{\gamma}{1-\gamma}\left(\frac{P_{H,t}}{P^*_{F,t}}\right)^{-\eta},$$

$$\frac{\varepsilon_w}{\varepsilon_w - 1}\frac{\chi c^h_t (\ell^h_t)^{\frac{1}{\epsilon}}}{\rho + (1-\rho)\frac{\chi\left(\ell^h_t\right)^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}}} = \frac{1-\tau^\ell_t}{1+\tau^c_t}\frac{W_t}{P_{c,t}}\times$$
$$\Bigg[1 + \frac{\psi_w}{\varepsilon_w - 1}\Bigg(\left(\frac{(1-\tau^\ell_t)W_t}{(1-\tau^\ell_{t-1})W_{t-1}} - 1\right)\frac{(1-\tau^\ell_t)W_t}{(1-\tau^\ell_{t-1})W_{t-1}}$$
$$- \mathbb{E}_t\Lambda^h_{t,t+1}\left(\mathbb{I}(h=o)e^{\nu^\theta_{\iota t+1}} + \mathbb{I}(h=r)\right)\times$$
$$\left(\frac{(1-\tau^\ell_{t+1})W_{t+1}\ell^h_{t+1}}{(1-\tau^\ell_t)W_t\ell^h_t}\right)\left(\frac{(1-\tau^\ell_{t+1})W_{t+1}}{(1-\tau^\ell_t)W_t} - 1\right)\frac{(1-\tau^\ell_{t+1})W_{t+1}}{(1-\tau^\ell_t)W_t}\Bigg)\Bigg],$$

$$(1+\tau^c_t)\,P_{c,t}c^h_t + (1+i(B^h_t))e^{-\mu}B^h_t + Q^\varsigma_t\varsigma^h_{t+1} + \mathrm{AC}^h_{w,t}$$
$$= \left(1-\tau^\ell_t\right)W_t\ell^h_t + T^h_t + \mathbb{I}(h=o)\frac{\Pi^b_t + T^l_t}{1-\zeta} + B^h_{t+1} + (Q^\varsigma_t + \Pi^f_t)\varsigma^h_t,$$

$$\mathrm{AC}^h_{w,t} = \frac{\psi_w}{2}\left(\frac{(1-\tau^\ell_t)W^h_t}{(1-\tau^\ell_{t-1})W^h_{t-1}} - 1\right)^2(1-\tau^\ell_t)W^h_t\ell^h_t,$$

$$c^h_t = \left(\omega_c^{\frac{1}{\phi}}\left(c^h_{T,t}\right)^{\frac{\phi-1}{\phi}} + (1-\omega_c)^{\frac{1}{\phi}}\left(c^h_{N,t}\right)^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}},$$

$$c^h_{T,t} = \left(\gamma^{\frac{1}{\eta}}(c^h_{H,t})^{\frac{\eta-1}{\eta}} + (1-\gamma)^{\frac{1}{\eta}}(c^h_{F,t})^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}},$$

$$\Lambda^h_{t,t+1} = \beta^h e^{-\frac{1}{\rho}\mu}\left(\mathbb{I}(h=o)e^{-\sigma\nu^\theta_{\iota t+1}} + \mathbb{I}(h=r)\right)\left(1-\pi^a_t + \pi^a_t e^{-\varphi^a(1-\sigma)}\right)^{\frac{1-\frac{1}{\rho}}{1-\sigma}}(\mathrm{ce}^h_t)^{\sigma-\frac{1}{\rho}}(v^h_{t+1})^{\frac{1}{\rho}-\sigma}\times$$
$$\frac{(c^h_{t+1})^{-\frac{1}{\rho}}\left(1 + \left(\frac{1}{\rho}-1\right)\frac{\chi\left(\ell^h_{t+1}\right)^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}}\right)^{\frac{1}{\rho}}}{(c^h_t)^{-\frac{1}{\rho}}\left(1 + \left(\frac{1}{\rho}-1\right)\frac{\chi\left(\ell^h_t\right)^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}}\right)^{\frac{1}{\rho}}}\frac{(1+\tau^c_t)P_{c,t}}{(1+\tau^c_{t+1})P_{c,t+1}},$$

where

$$(v_t^h)^{1-\frac{1}{\rho}} = \left(c_t^h\right)^{1-\frac{1}{\rho}} \left(1 + \left(\frac{1}{\rho} - 1\right) \frac{\chi \left(\ell_{t+1}^h\right)^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}}\right)^{\frac{1}{\rho}}$$
$$+ \beta^h e^{\left(1-\frac{1}{\rho}\right)\mu} \left(1 - \pi_t^a + \pi_t^a e^{-\varphi^a(1-\sigma)}\right)^{\frac{1-\frac{1}{\rho}}{1-\sigma}} (\mathrm{ce}_t^h)^{1-\frac{1}{\rho}},$$
$$\mathrm{ce}_t^h = \left(\mathbb{E}_t \left(\mathbb{I}(h=o) e^{(1-\sigma)\nu_{\iota t+1}^{\theta}} + \mathbb{I}(h=r)\right) (v_{t+1}^h)^{1-\sigma}\right)^{\frac{1}{1-\sigma}},$$

and for household o:

$$1 = \mathbb{E}_t \Lambda_{t,t+1}^o (1 + \bar{i}_{t+1}),$$
$$Q_t^{\varsigma} = \mathbb{E}_t \Lambda_{t,t+1}^o e^{\mu} \left(\Pi_{t+1}^f + Q_{t+1}^{\varsigma}\right),$$

and for household r:

$$B_{t+1}^r = \bar{B}_{t+1}^r,$$
$$\varsigma_{t+1}^r = 0.$$

A.2.2 Firms (26 equations)

Production. Let μ_t be the multiplier on the borrowing constraint (12) and λ_t be the multiplier on the firm's flow of funds constraint (13).

$$\Pi_t^f = \frac{P_{F,t}}{P_F} \Pi^f + \left(\frac{P_{F,t}}{\psi_\pi}\right) \left(\frac{1-\lambda_t}{\lambda_t}\right),$$
$$\frac{(1-\alpha) P_{H,t}^f y_{H,t}}{\ell_{H,t}} + \mathbb{E}_t \Lambda_{t,t+1}^o e^{\mu} \left(\frac{\lambda_{t+1}}{\lambda_t}\right) W_{t+1} \frac{\psi_\ell}{2(1-\tau_{H,t}^k)} \left(\left(\frac{\ell_{t+1}}{\ell_t}\right)^2 - 1\right)$$
$$= W_t \left(1 + \frac{q_\ell}{1-\tau_{H,t}^k} + \frac{\kappa_\ell \mu_t}{(1-\tau_{H,t}^k)\lambda_t} + \frac{\psi_\ell}{1-\tau_{H,t}^k} \left(\frac{\ell_t}{\ell_{t-1}} - 1\right)\right),$$
$$\frac{(1-\alpha) P_{N,t}^f y_{N,t}}{\ell_{N,t}} + \mathbb{E}_t \Lambda_{t,t+1}^o e^{\mu} \left(\frac{\lambda_{t+1}}{\lambda_t}\right) W_{t+1} \frac{\psi_\ell}{2(1-\tau_{N,t}^k)} \left(\left(\frac{\ell_{t+1}}{\ell_t}\right)^2 - 1\right)$$
$$= W_t \left(1 + \frac{q_\ell}{1-\tau_{N,t}^k} + \frac{\kappa_\ell \mu_t}{(1-\tau_{N,t}^k)\lambda_t} + \frac{\psi_\ell}{1-\tau_{N,t}^k} \left(\frac{\ell_t}{\ell_{t-1}} - 1\right)\right),$$
$$u_{H,t} = \left(\frac{(1-\tau_{H,t}^k) P_{H,t}^f y_{H,t}}{\bar{\xi}_H Q_t^k s_t e^{-\mu} k_t}\right)^{\frac{1}{\xi_H}},$$
$$u_{N,t} = \left(\frac{(1-\tau_{N,t}^k) P_{N,t}^f y_{N,t}}{\bar{\xi}_N Q_t^k (1-s_t) e^{-\mu} k_t}\right)^{\frac{1}{\xi_N}},$$

$$\left(\frac{(1-\tau_{H,t}^k)\alpha P_{H,t}^f y_{H,t}}{s_t e^{-\mu}k_t} - \frac{(1-\tau_{N,t}^k)\alpha P_{N,t}^f y_{N,t}}{(1-s_t)e^{-\mu}k_t}\right)$$

$$= \left[Q_t^k\left(\delta_{H,t}-\delta_{N,t}\right) - Q_t^k(\tau_{H,t}^k\bar{\delta}_H - \tau_{N,t}^k\bar{\delta}_N)\right],$$

$$Q_t^k = (1+\tau_t^x)P_{x,t}\left(1+\kappa_x\frac{\mu_t}{(1+\tau_t^x)\lambda_t}\right)+$$

$$\psi_x\left[P_{F,t}\left(e^{\mu}\frac{x_t}{x_{t-1}}-e^{\mu}\right)-\frac{1}{2}\mathbb{E}_t\Lambda_{t,t+1}^o\frac{\lambda_{t+1}}{\lambda_t}P_{Ft+1}\left(\left(e^{\mu}\frac{x_{t+1}}{x_t}\right)^2-(e^{\mu})^2\right)\right],$$

$$\frac{x_{T,t}}{x_{N,t}} = \frac{\omega_x}{1-\omega_x}\left(\frac{P_{N,t}}{P_{T,t}}\right)^{\phi},$$

$$Q_t^k = \mathbb{E}_t\Lambda_{t,t+1}^o\left(\frac{\lambda_{t+1}}{\lambda_t}\right)\left[\left(\frac{(1-\tau_{H,t+1}^k)\alpha P_{H,t+1}^f y_{H,t+1}+(1-\tau_{N,t+1}^k)\alpha P_{N,t+1}^f y_{N,t+1}}{e^{-\mu}k_{t+1}}\right)\right.$$

$$\left. + (1-\delta_{t+1}+\tau_{H,t+1}^k s_{t+1}\bar{\delta}_H+\tau_{N,t+1}^k(1-s_{t+1})\bar{\delta}_N)Q_{t+1}^k\right],$$

$$\lambda_t+\mu_t = \mathbb{E}_t\Lambda_{t,t+1}^o\left[\lambda_{t+1}\left(1+(1-(s_{t+1}\tau_{H,t+1}^k+(1-s_{t+1})\tau_{N,t+1}^k))i_{t+1}\right)+\mu_{t+1}(1+i_{t+1})\right],$$

$$y_{H,t} = z_{H,t}u_{H,t}\left(e^{-\mu}s_t k_t\right)^{\alpha}\left(\ell_{H,t}\right)^{1-\alpha},$$

$$y_{N,t} = z_{N,t}u_{N,t}\left(e^{-\mu}\left(1-s_t\right)k_t\right)^{\alpha}\left(\ell_{N,t}\right)^{1-\alpha},$$

$$\delta_{H,t} = \bar{\delta}_H + \frac{\bar{\xi}_H}{\xi_H}(u_{H,t}^{\xi_H}-1),$$

$$\delta_{N,t} = \bar{\delta}_N + \frac{\bar{\xi}_N}{\xi_N}(u_{N,t}^{\xi_N}-1),$$

$$\delta_t = s_t\delta_{H,t}+(1-s_t)\delta_{N,t},$$

$$\Pi_t^f = \left(1-\tau_{H,t}^k\right)\left(P_{H,t}^f y_{H,t}-W_t\ell_{H,t}+\Pi_{H,t}\right)+\left(1-\tau_{N,t}^k\right)\left(P_{N,t}^f y_{N,t}-W_t\ell_{N,t}+\Pi_{N,t}\right)-\mathrm{AC}_{\ell,t}^f$$

$$-(1+\tau_t^x)P_{x,t}x_t-\mathrm{AC}_{x,t}^f+B_{t+1}^f-e^{-\mu}(1+i_t)B_t^f$$

$$+\tau_{H,t}^k s_t e^{-\mu}\left(\bar{\delta}_H Q_t^k k_t+i_t B_t^f\right)+\tau_{N,t}^k(1-s_t)e^{-\mu}\left(\bar{\delta}_N Q_t^k k_t+i_t B_t^f\right)-\mathrm{AC}_{\pi,t}^f,$$

$$\mathrm{AC}_{\pi,t}^f = \frac{\psi_\pi}{2}\left(\frac{\Pi^f}{P_{F,t}}-\frac{\Pi^f}{P_F}\right)^2 P_{F,t},$$

$$\mathrm{AC}_{\ell,t}^f = \frac{\psi_\ell}{2}\left(\frac{\ell_t}{\ell_{t-1}}-1\right)^2 W_t\ell_{t-1},$$

$$\mathrm{AC}_{x,t}^f = e^{\mu}\frac{\psi_x}{2}\left(\frac{x_t}{x_{t-1}}-1\right)^2 P_{F,t}x_{t-1},$$

$$B_{t+1}^f+\kappa_y\left(P_{H,t}y_{H,t}+P_{N,t}y_{N,t}\right) = \kappa_x(1+\tau_t^x)P_{x,t}x_t+\kappa_\ell W_t\ell_t$$

$$+\kappa_{\tau,t}\left[\tau_{H,t}^k\left(P_{H,t}^f y_{H,t}-W_t\ell_{H,t}+\Pi_{H,t}-s_t e^{-\mu}\left(\bar{\delta}_H Q_t^k k_t+i_t B_t^f\right)\right)\right.$$

$$+\tau^k_{N,t}\left(P^f_{N,t}y_{N,t}-W_t\ell_{N,t}+\Pi_{N,t}-(1-s_t)e^{-\mu}\left(\bar{\delta}_N Q^k_t k_t+i_t B^f_t\right)\right)\Bigg]+(1+i_t)e^{-\mu}B^f_t.$$

Price setting. For price setting firm in sector $i\in\{H,N\}$:

$$\begin{aligned}
&P_{i,t}-\left(\frac{\varepsilon_p}{\varepsilon_p-1}\right)P^f_{i,t}\\
&\quad+\frac{\psi_{i,p}}{\varepsilon_p-1}P_{i,t}\left(\left(\frac{P_{i,t}}{P_{i,t-1}}-1\right)\frac{P_{i,t}}{P_{i,t-1}}-\mathbb{E}_t\Lambda^o_{t,t+1}e^{\mu}\frac{P_{i,t+1}y_{i,t+1}}{P_{i,t}y_{i,t}}\left(\frac{P_{i,t+1}}{P_{i,t}}-1\right)\frac{P_{i,t+1}}{P_{i,t}}\right)=0,\\
&\Pi_{i,t}=(P_{i,t}-P^f_{i,t})y_{i,t}-\mathrm{AC}_{i,t},\\
&\mathrm{AC}_{i,t}=\frac{\psi_{i,p}}{2}\left(\frac{P_{i,t}}{P_{i,t-1}}-1\right)^2P_{i,t}y_{i,t}.
\end{aligned}$$

A.2.3 Banks (9 equations)

We first conjecture $J^b_t=e^{-\mu}\iota^b_tN_t$, where ι^b_t is banks' marginal value of net worth. Letting μ^b_t be the multiplier on banks' incentive compatibility constraint (18), we then obtain the first-order conditions below.

$$\begin{aligned}
&J^b_t=e^{-\mu}\iota^b_tN_t,\\
&\kappa_b\mu^b_t=\mathbb{E}_t\Lambda^o_{t,t+1}\left[\delta_b+(1-\delta_b)\iota^b_{t+1}\right](i_{t+1}-\bar{i}_{t+1}),\\
&\iota^b_t=\frac{\mathbb{E}_t\Lambda^o_{t,t+1}\left[\delta_b+(1-\delta_b)\iota^b_{t+1}\right](1+\bar{i}_{t+1})}{1-\mu^b_t},\\
&\kappa_b\left(B^f_{t+1}+\zeta B^r_{t+1}\right)=e^{-\mu}\iota^b_tN_t,\\
&N_t=e^{\mu}\left(B^f_{t+1}+\zeta B^r_{t+1}-B^b_{t+1}\right),\\
&N_t=(1-\delta_b)N^c_t+N^e_t+e^{\mu}T^b_{G,t}+e^{\mu}T^b_{W,t},\\
&N^e_t=\omega_bP_{y,t-1}y_{t-1},\\
&N^c_t=(1+\bar{i}_t)e^{-\mu}N_{t-1}+(i_t-\bar{i}_t)\left(B^f_t+\zeta B^r_t\right),\\
&\Pi^b_t=e^{-\mu}\left(\delta_bN^c_t-N^e_t\right).
\end{aligned}$$

A.2.4 Government (2 equations)

$$g^x_t=\left(\omega_x^{\frac{1}{\phi}}\left(g^x_{T,t}\right)^{\frac{\phi-1}{\phi}}+(1-\omega_x)^{\frac{1}{\phi}}\left(g^x_{N,t}\right)^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}},$$

$$T^g_t+\tau^c_tP_{c,t}\left(\zeta c^r_t+(1-\zeta)c^o_t\right)+\tau^x_tP_{x,t}x_t+\tau^l_t\left(\zeta W_t\ell^r_t+(1-\zeta)W_t\ell^o_t\right)$$

$$
\begin{aligned}
&+ \tau^k_{H,t}\left(P^f_{H,t}y_{H,t} - W_t\ell_{H,t} + \Pi_{H,t} - e^{-\mu}s_t\left(\bar{\delta}_H Q^k_t k_t + i_t B^f_t\right)\right)\\
&+ \tau^k_{N,t}\left(P^f_{N,t}y_{N,t} - W_t\ell_{N,t} + \Pi_{N,t} - e^{-\mu}(1-s_t)\left(\bar{\delta}_N Q^k_t k_t + i_t B^f_t\right)\right)\\
&= (1+\bar{r}_t)e^{-\mu}\bar{B}^g_t - \bar{B}^g_{t+1} + T^b_{G,t} + P_{T,t}\left(g^c_{T,t} + g^x_{T,t}\right) + P_{N,t}\left(g^c_{N,t} + g^x_{N,t}\right) + \zeta T^r_t + (1-\zeta)T^o_t.
\end{aligned}
$$

A.2.5 Market Clearing (5 equations)

$$
\begin{aligned}
&\zeta\varsigma^r_{t+1} + (1-\zeta)\varsigma^o_{t+1} = 1,\\
&k_{t+1} = e^{-\mu}(1-\delta_t)k_t + x_t + g^x_t,\\
&\ell_{H,t} + \ell_{N,t} = \zeta\ell^r_t + (1-\zeta)\ell^o_t,\\
&y_{N,t} = \zeta c^r_{N,t} + (1-\zeta)c^o_{N,t} + x_{N,t} + g^c_{N,t} + g^x_{N,t},\\
&y_{H,t} = \gamma\left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\eta}\left(\zeta c^r_{T,t} + (1-\zeta)c^o_{T,t} + x_{T,t} + g^c_{T,t} + g^x_{T,t}\right) + (1-\gamma)\left(\frac{P_{H,t}}{P_{F,t}}\right)^{-\eta}\bar{a}_{T,t}.
\end{aligned}
$$

A.2.6 Auxiliary (25 equations)

Aggregate consumption and its associated price index are:

$$
\begin{aligned}
&c_t = \zeta c^r_t + (1-\zeta)c^o_t,\\
&P_{c,t} = \left(\omega_c {P_{T,t}}^{1-\phi} + (1-\omega_c)P^{1-\phi}_{N,t}\right)^{\frac{1}{1-\phi}}.
\end{aligned}
$$

Aggregate traded consumption and its associated price index are:

$$
\begin{aligned}
&c_{T,t} = \zeta c^r_{T,t} + (1-\zeta)c^o_{T,t},\\
&P_{T,t} = \left(\gamma(P_{H,t})^{1-\eta} + (1-\gamma)(E_t P^*_{F,t})^{1-\eta}\right)^{\frac{1}{1-\eta}}.
\end{aligned}
$$

Aggregate investment and its associated price index are:

$$
\begin{aligned}
&x_t = \left(\omega_x^{\frac{1}{\phi}}\left(x_{T,t}\right)^{\frac{\phi-1}{\phi}} + (1-\omega_x)^{\frac{1}{\phi}}\left(x_{N,t}\right)^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}},\\
&P_{x,t} = \left(\omega_x {P_{T,t}}^{1-\phi} + (1-\omega_x)P^{1-\phi}_{N,t}\right)^{\frac{1}{1-\phi}}.
\end{aligned}
$$

Aggregate output and its associated Paasche index are:

$$
y_t = \frac{P_{H,t}y_{H,t} + P_{N,t}y_{N,t}}{P_{y,t}},
$$

$$\frac{P_{y,t}}{P_{y,t-1}} = \left(\frac{P_{H,t}}{P_{H,t-1}}\right)^{\frac{P_{H,t}y_{H,t}}{P_{H,t}y_{H,t}+P_{N,t}y_{N,t}}} \left(\frac{P_{N,t}}{P_{N,t-1}}\right)^{\frac{P_{N,t}y_{N,t}}{P_{H,t}y_{H,t}+P_{N,t}y_{N,t}}}.$$

Nominal GDP, net exports, the Paasche price index of GDP, and real GDP are defined as:

$$\begin{aligned}
&\mathrm{GDP}_t = (1+\tau_t^c)P_{c,t}c_t + (1+\tau_t^x)P_{x,t}x_t + P_{T,t}(g^c_{T,t}+g^x_{T,t}) + P_{N,t}(g^c_{N,t}+g^x_{N,t}) + \mathrm{NX}_t,\\
&\mathrm{NX}_t = P_{H,t}y_{H,t} - P_{T,t}c_{T,t} - P_{T,t}x_{T,t} - P_{T,t}(g^c_{T,t}+g^x_{T,t})\\
&\quad - \zeta \mathrm{AC}^r_{w,t} - (1-\zeta)\mathrm{AC}^o_{w,t} - \mathrm{AC}_{H,t} - \mathrm{AC}_{N,t} - \mathrm{AC}^f_{\pi,t} - \mathrm{AC}^f_{x,t} - \mathrm{AC}^f_{\ell,t},\\
&\frac{P_{\mathrm{gdp},t}}{P_{\mathrm{gdp},t-1}} = \left(\frac{(1+\tau_t^c)P_{c,t}}{(1+\tau_{t-1}^c)P_{c,t-1}}\right)^{\frac{(1+\tau_t^c)P_{c,t}c_t}{\mathrm{GDP}_t}} \left(\frac{(1+\tau_t^x)P_{x,t}}{(1+\tau_{t-1}^x)P_{x,t-1}}\right)^{\frac{(1+\tau_t^x)P_{x,t}x_t}{\mathrm{GDP}_t}} \left(\frac{P_{T,t}}{P_{T,t-1}}\right)^{\frac{P_{T,t}(g^c_{T,t}+g^x_{T,t})}{\mathrm{GDP}_t}} \times\\
&\quad \left(\frac{P_{N,t}}{P_{N,t-1}}\right)^{\frac{P_{N,t}(g^c_{N,t}+g^x_{N,t})}{\mathrm{GDP}_t}} \left(\frac{P_{H,t}}{P_{H,t-1}}\right)^{\frac{P_{H,t}y_{H,t}}{\mathrm{GDP}_t}} \times\\
&\quad \left(\frac{P_{T,t}}{P_{T,t-1}}\right)^{-\frac{P_{T,t}c_{T,t}}{\mathrm{GDP}_t}} \left(\frac{P_{T,t}}{P_{T,t-1}}\right)^{-\frac{P_{T,t}x_{T,t}}{\mathrm{GDP}_t}} \left(\frac{P_{T,t}}{P_{T,t-1}}\right)^{-\frac{P_{T,t}(g^c_{T,t}+g^x_{T,t})}{\mathrm{GDP}_t}},\\
&\mathrm{gdp}_t = \frac{\mathrm{GDP}_t}{P_{\mathrm{gdp},t}}.
\end{aligned}$$

Aggregate labor is:

$$\ell_t = \ell_{H,t} + \ell_{N,t}.$$

Sectoral and aggregate capital as measured in the national accounts is:

$$\begin{aligned}
&\tilde{k}_{H,t+1} = e^{-\mu}(1-\bar{\delta}_H)\tilde{k}_{H,t} + s_t\left(k_t - e^{-\mu}(1-\delta_{H,t})k_{t-1}\right),\\
&\tilde{k}_{N,t+1} = e^{-\mu}(1-\bar{\delta}_N)\tilde{k}_{N,t} + (1-s_t)\left(k_t - e^{-\mu}(1-\delta_{N,t})k_{t-1}\right),\\
&\tilde{k}_t = \tilde{k}_{H,t} + \tilde{k}_{N,t}.
\end{aligned}$$

Aggregate TFP (inclusive of utilization) is defined as:

$$\begin{aligned}
&\frac{\mathrm{TFP}_t}{\mathrm{TFP}_{t-1}} = \frac{y_t}{y_{t-1}}\left(\frac{\ell_t}{\ell_{t-1}}\right)^{-\left(\frac{1}{2}\mathrm{lsh}_t+\frac{1}{2}\mathrm{lsh}_{t-1}\right)} \left(\frac{\tilde{k}_t}{\tilde{k}_{t-1}}\right)^{-\left(1-\left(\frac{1}{2}\mathrm{lsh}_t+\frac{1}{2}\mathrm{lsh}_{t-1}\right)\right)},\\
&\mathrm{lsh}_t = \frac{W_t\ell_t}{P_{H,t}y_{H,t}+P_{N,t}y_{N,t}}.
\end{aligned}$$

TFP in each sector $i \in \{H, N\}$ is:

$$\frac{\mathrm{TFP}_{i,t}}{\mathrm{TFP}_{i,t-1}} = \frac{y_{i,t}}{y_{i,t-1}}\left(\frac{\ell_{i,t}}{\ell_{i,t-1}}\right)^{-\left(\frac{1}{2}\mathrm{lsh}_{i,t}+\frac{1}{2}\mathrm{lsh}_{i,t-1}\right)} \left(\frac{\tilde{k}_{i,t}}{\tilde{k}_{i,t-1}}\right)^{-\left(1-\left(\frac{1}{2}\mathrm{lsh}_{i,t}+\frac{1}{2}\mathrm{lsh}_{i,t-1}\right)\right)},$$

$$\text{lsh}_{i,t} = \frac{W_t \ell_{i,t}}{P_{i,t} y_{i,t}}.$$

Quantities of imports and exports are defined as:

$$\begin{aligned}
\text{im}_t &= (1-\gamma)\left(\frac{P_{F,t}}{P_{T,t}}\right)^{-\eta}\left(\zeta c^r_{T,t} + (1-\zeta)c^o_{T,t} + x_{T,t} + g^c_{T,t} + g^x_{T,t}\right) \\
&\quad + \left[\zeta \text{AC}^r_{w,t} + (1-\zeta)\text{AC}^o_{w,t} + \text{AC}_{H,t} + \text{AC}_{N,t} + \text{AC}^f_{\pi,t} + \text{AC}^f_{x,t} + \text{AC}^f_{\ell,t}\right]/P_{F,t}, \\
\text{ex}_t &= y_{H,t} - \gamma\left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\eta}\left(\zeta c^r_{T,t} + (1-\zeta)c^o_{T,t} + x_{T,t} + g^c_{T,t} + g^x_{T,t}\right).
\end{aligned}$$

so that $\text{NX} = P_{H,t}\text{ex}_t - P_{F,t}\text{im}_t$. The current account is defined as the change in the net foreign assets held by the country:

$$\begin{aligned}
\text{CA}_t &\equiv e^{-\mu}[(1-\zeta)B^o_t + B^b_t + \bar{B}^g_t] - [(1-\zeta)B^o_{t+1} + B^b_{t+1} + \bar{B}^g_{t+1}] \\
&= \text{NX}_t + T^b_{W,t} - e^{-\mu}[\bar{i}_t(1-\zeta)B^o_t + \bar{i}_t B^b_t + \bar{r}_t \bar{B}^g_t] + T^g_t + T^l_t.
\end{aligned}$$

Note that B^f_t and ζB^r_t are debt that domestic firms and workers in the rule-of-thumb household owe to domestic banks and, therefore, are not part of the current account. The second line shows that the current account equals net exports, net foreign income from abroad $T^b_{W,t} - e^{-\mu}[\bar{i}_t(1-\zeta)B^o_t + \bar{i}_t B^b_t + \bar{r}_t \bar{B}^g_t]$, and net current transfers $T^g_t + T^l_t$. The realized T^l_t is always zero because it does not reflect an actual transfer or resource. Finally, $T^b_{G,t}$, T^o_t, and T^r_t are transfers between domestic agents and, therefore, they are also not part of the current account.

A.2.7 Summary

We have 91 equations in 91 unknowns:

$$\begin{aligned}
&c^o_t, c^o_{T,t}, c^o_{N,t}, c^o_{H,t}, c^o_{F,t}, \ell^o_t, B^o_{t+1}, \varsigma^o_{t+1}, \text{AC}^o_{w,t}, \Lambda^o_{t,t+1}, v^o_t, \text{ce}^o_t, \\
&c^r_t, c^r_{T,t}, c^r_{N,t}, c^r_{H,t}, c^r_{F,t}, \ell^r_t, B^r_{t+1}, \varsigma^r_{t+1}, \text{AC}^r_{w,t}, \Lambda^r_{t,t+1}, v^r_t, \text{ce}^r_t, \\
&P^f_{H,t}, y_{H,t}, \ell_{H,t}, u_{H,t}, \delta_{H,t}, P^f_{N,t}, y_{N,t}, \ell_{N,t}, u_{N,t}, \delta_{N,t}, \delta_t, \Pi^f_t, s_t, x_{T,t}, x_{N,t}, k_{t+1}, B^f_{t+1}, \text{AC}^f_{\pi,t}, \text{AC}^f_{x,t}, \text{AC}^f_{\ell,t}, \\
&\lambda_t, \mu_t, P_{H,t}, P_{N,t}, \Pi_{H,t}, \Pi_{N,t}, \text{AC}_{H,t}, \text{AC}_{N,t}, N_t, N^e_t, N^c_t, \Pi^b_t, J^b_t, \iota^b_t, \mu^b_t, i_t, B^b_{t+1}, g^x_t, T^o_t, W_t, Q^k_t, Q^\varsigma_t, \\
&c_t, P_{c,t}, c_{T,t}, P_{T,t}, x_t, P_{x,t}, y_t, P_{y,t}, \text{GDP}_t, \text{gdp}_t, P_{\text{gdp},t}, \text{NX}_t, \ell_t, \tilde{k}_{H,t+1}, \tilde{k}_{N,t+1}, \tilde{k}_{t+1}, \\
&\text{TFP}_t, \text{lsh}_t, \text{TFP}_{H,t}, \text{lsh}_{H,t}, \text{TFP}_{N,t}, \text{lsh}_{N,t}, \text{im}_t, \text{ex}_t, \text{CA}_t.
\end{aligned}$$

A.3 Aggregate Disaster Risk

In this appendix we discuss how we incorporate aggregate disasters into the model. As described in the main text, a time-varying probability of a rare disaster π_t^a enters multiplicatively with the discount factor in the intertemporal optimality conditions of the model. This simplifies significantly the solution and estimation of the model with time-varying disasters because it allows us to use standard perturbation techniques. This result, adapted from Gourio (2012), is a consequence of the assumptions that all endogenous and exogenous state variables scale with the cumulative realization of disasters over time. Owing to this assumption, we can reformulate the economy with disaster risk into a transformed economy in which the probability of disaster only enters into the intertemporal optimality conditions.

We denote by $\hat{n}$ some variable in the primitive formulation of the economy and by n the same variable in the transformed economy. We assume here that the primitive variables also grow at trend rate μ. The disaster process is:

$$\hat{\varphi}_{t+1}^a = \begin{cases} 0 \ \text{ with probability } \ 1-\pi_t^a, \\ \varphi^a \ \text{ with probability } \ \pi_t^a, \end{cases}$$

and the permanent level of productivity is:

$$\log \hat{\Phi}_t = \log \hat{\Phi}_{t-1} - \hat{\varphi}_t^a + \mu.$$

The exogenous state variables affected by disasters are given by:

$$\begin{aligned}
\log \hat{z}_{H,t} &= \log z_{H,t} + (1-\alpha)\log \hat{\Phi}_t, \\
\log \hat{z}_{N,t} &= \log z_{N,t} + (1-\alpha)\log \hat{\Phi}_t, \\
\log \hat{g}_{T,t}^c &= \log g_{T,t}^c + \log \hat{\Phi}_t, \\
\log \hat{g}_{N,t}^c &= \log g_{N,t}^c + \log \hat{\Phi}_t, \\
\log \hat{g}_{T,t}^x &= \log g_{T,t}^x + \log \hat{\Phi}_t, \\
\log \hat{g}_{N,t}^x &= \log g_{N,t}^x + \log \hat{\Phi}_t, \\
\log \hat{T}_t^r &= \log T_t^r + \log \hat{\Phi}_t, \\
\log \hat{\bar{a}}_{T,t} &= \log \bar{a}_{T,t} + \log \hat{\Phi}_t, \\
\log \hat{T}_t^g &= \log T_t^g + \log \hat{\Phi}_t,
\end{aligned}$$

$$\log \hat{T}^l_t = \log T^l_t + \log \hat{\Phi}_t,$$

$$\log \hat{\bar{B}}^g_{t+1} = \log \bar{B}^g_t + \log \hat{\Phi}_t,$$

$$\log \hat{\bar{B}}^r_{t+1} = \log \bar{B}^r_t + \log \hat{\Phi}_t,$$

$$\log \hat{T}^b_{W,t} = \log T^b_{W,t} + \log \hat{\Phi}_t,$$

$$\log \hat{T}^b_{G,t} = \log T^b_{G,t} + \log \hat{\Phi}_t.$$

The endogenous state variables affected by a disaster are given by:

$$\hat{k}_{t+1} \equiv \hat{k}'_{t+1} e^{-\hat{\varphi}^a_{t+1}} = ((1-\delta)\hat{k}_t + \hat{x}_t) e^{-\hat{\varphi}^a_{t+1}},$$

$$\hat{x}_t \equiv \hat{x}'_t e^{-\hat{\varphi}^a_{t+1}},$$

$$\hat{B}^o_{t+1} \equiv (\hat{B}^{o\prime}_{t+1}) e^{-\hat{\varphi}^a_{t+1}},$$

$$\hat{B}^f_{t+1} \equiv (\hat{B}^{f\prime}_{t+1}) e^{-\hat{\varphi}^a_{t+1}},$$

$$\hat{N}_{t+1} \equiv (\hat{N}'_{t+1}) e^{-\hat{\varphi}^a_{t+1}},$$

$$\hat{W}_t \equiv (\hat{W}'_t) e^{-\hat{\varphi}^a_{t+1}}.$$

In the last set of equations, primes denote choice variables at the end of the period which — due to a disaster — may differ from the endogenous state variables the next period.

For any endogenous variable n_t in a period we then define:

$$n_t \equiv \frac{\hat{n}_t}{\hat{\Phi}_t}, \tag{A.1}$$

except for the certainty equivalent for which we define:[1]

$$\text{ce}_t \equiv \left(\mathbb{E}_t v^{1-\sigma}_{t+1} \right)^{\frac{1}{1-\sigma}}. \tag{A.2}$$

Solving for the equilibrium conditions of the original economy and then making use of equations (A.1) and (A.2) repeatedly, we obtain the equilibrium conditions of the transformed economy.

[1]In particular, equations (A.1) and (A.2) imply that:

$$\frac{1}{\hat{\Phi}_t} \hat{\text{ce}}_t = \frac{1}{\hat{\Phi}_t} \left(\mathbb{E}_t (\hat{v}_{t+1})^{1-\sigma} \right)^{\frac{1}{1-\sigma}} = \left(\mathbb{E}_t \left(v_{t+1} \left(\frac{\hat{\Phi}_{t+1}}{\hat{\Phi}_t} \right) \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} = e^{\mu} \left(\mathbb{E}_t \left(v_{t+1} e^{-\varphi^a_{t+1}} \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$
$$= e^{\mu} \left(1 - \pi^a_t + \pi^a_t e^{-\varphi^a(1-\sigma)} \right)^{\frac{1}{1-\sigma}} \left(\mathbb{E}_t v^{1-\sigma}_{t+1} \right)^{\frac{1}{1-\sigma}} = e^{\mu} \left(1 - \pi^a_t + \pi^a_t e^{-\varphi^a(1-\sigma)} \right)^{\frac{1}{1-\sigma}} \text{ce}_t.$$

B Data Appendix

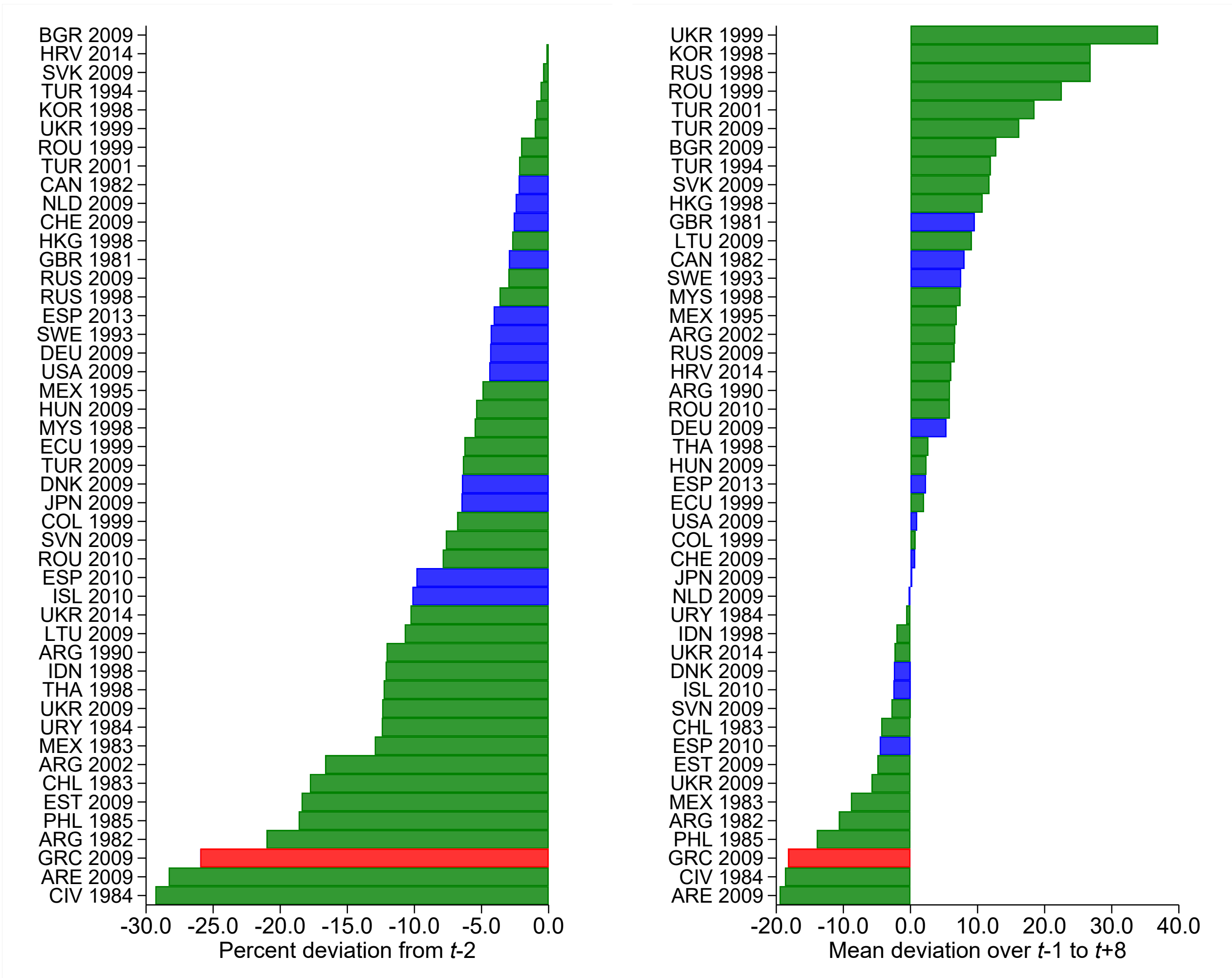
Appendix B.1 compares the Greek depression to other episodes. Appendix B.2 presents evidence on the decline in value added and employment by firm size and decomposes the decline in aggregate labor productivity. Appendix B.3 details the growth accounting methodology and the measurement of utilization. Appendix B.4 presents alternative measures of wages and wage rigidity. Appendix B.5 presents alternative measures of value-added exports and external demand and decomposes the change in exports in the bust by industry. Appendix B.6 provides additional details on the estimation of disaster probabilities using options data. Appendix B.7 provides additional details on the measurement of effective tax rates. Appendix B.8 describes the estimation of the trade elasticity. Appendix B.9 summarizes the data sources for all of the variables used in the estimation of the model.

B.1 Greece Relative to Other Episodes

This appendix compares the experience of Greece to sudden stop episodes in other countries. The comparison cases come from Gourinchas, Philippon, and Vayanos (2016) who build on Calvo, Izquierdo, and Talvi (2006) and Korinek and Mendoza (2014). An episode qualifies as a sudden stop when net capital inflows fall more than two standard deviations away from the mean and the country experiences a decline in output that exceeds the median among its country group (advanced or emerging market). Figure 1(a) shows the maximum decline in annual per capita output relative to two years before the sudden stop. Figure 1(b) shows the average annual output deviation from one year before to eight years after the sudden stop occurs, which combines both the severity and persistence of the episode. Bars in Green are emerging markets, bars in blue are advanced economies, and the Greece 2009 episode is in red. The vertical axis lists the World Bank country code and year of the sudden stop. By either metric, the Greek episode is larger than any other episode except Cote d'Ivoire in 1984 and the United Arab Emirates in 2009.

B.2 Value Added, Employment, and Productivity by Size Class

In this appendix we use data between 2009 and 2014 from the Structural Business Statistics to analyze the declines in value added, employment, and labor productivity for firms of different size



(a) Maximum Deviation

(b) Mean Deviation

Figure B.1: Output Declines in Sudden Stop Episodes

The figure plots real per capita output (World Development Indicators code NY.GDP.PCAP.KN) around sudden stop episodes as defined in Gourinchas, Philippon, and Vayanos (2016). The left panel shows the maximum decline in annual output relative to two years before the sudden stop. The right panel shows the average annual output deviation from one year before to eight years after the sudden stop occurs. Bars in Green are emerging markets, bars in blue are advanced economies, and the Greece 2009 episode is in red.

classes. The Structural Business Statistics provide value added and employment aggregates for firms belonging to different employment sizes, ranging from firms with 1-9 employees to firms with more than 250 employees. The data are available at the industry level for up to four digits of disaggregation.

Figure B.2 presents value added and employment trends by firm size class. The decline in value added and employment is observed throughout the size distribution.

Figure B.3 decomposes the decline in labor productivity into a within-firm size component and a between-firm size component. Each industry is represented by a dot in the figure. For almost all industries, the decline in labor productivity is accounted for by declines in labor productivity within firms belonging to a particular size class rather than by a reallocation of economic activity across firms with different size classes and different levels of productivity.

B.3 Growth Accounting

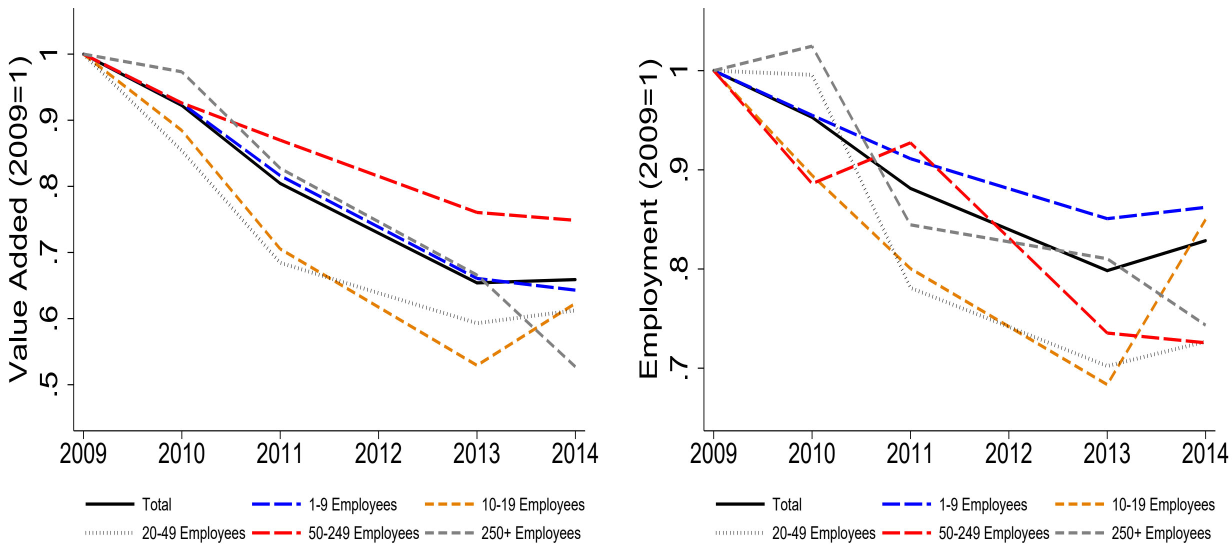
This appendix details the construction of total factor productivity (TFP) and utilization.

B.3.1 Total Factor Productivity

We measure TFP as the Solow residual. Data on value-added and total hours worked come directly from Eurostat. We construct capital services by aggregating four types of capital (structures, machinery and equipment, cultivated biological resources, and intellectual property assets) using user cost weights based on actual depreciation and a required 5 percent net return.[2] Capital type-by-industry data come from the Eurostat non-financial asset accounts. Under the assumptions of competitive output markets and constant-returns-to-scale production, we calculate the hours elasticity by multiplying total labor compensation by the ratio of total to employee hours in each industry and obtain the capital elasticity as a residual.[3]

[2] We have experimented with thresholds for the required return up to 20 percent and an internal return based on capital income payments with little change in the results.

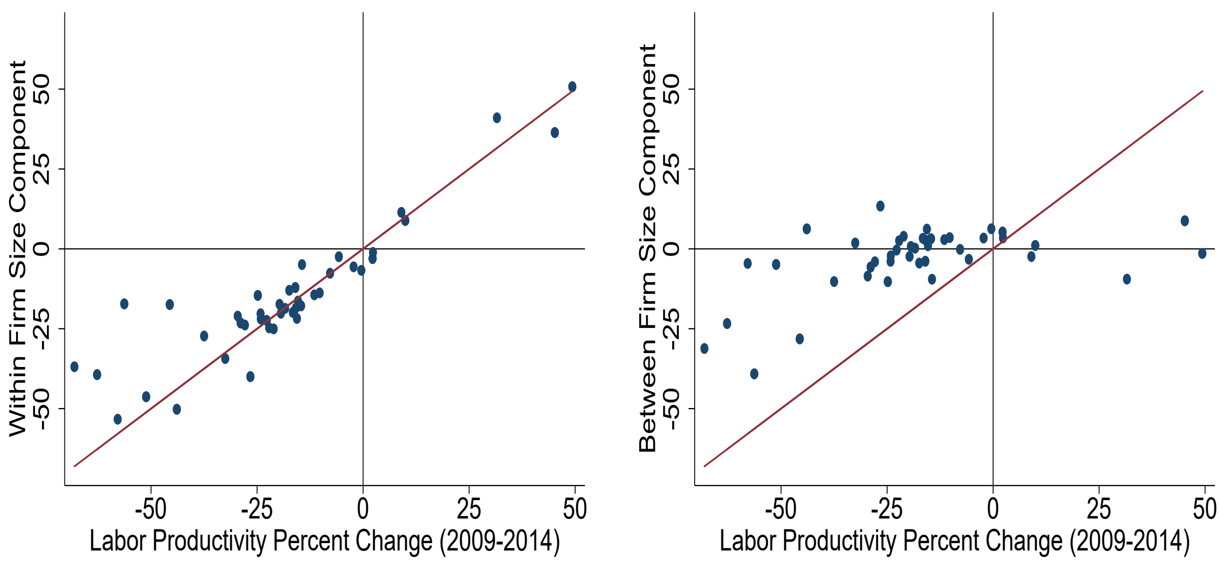
[3] As is well known, with non-competitive output markets the output elasticities equate to factor cost shares rather than factor revenue shares. It follows immediately that a time-invariant markup scales TFP growth by the markup. Time-varying markups pose additional difficulties which we do not pursue since we lack independent evidence on this margin.



(a) Value Added (b) Employment

Figure B.2: Value Added and Employment Trends by Size Class

Figure B.2 plots value-added and employment by firm size class based on data from the Structural Business Statistics.



(a) Within Component (b) Between Component

Figure B.3: Labor Productivity Decomposition

Figure B.3 plots the within-firm size and between-firm size components of labor productivity growth based on data from the Structural Business Statistics.

B.3.2 Utilization Measurement

Our main measures of utilization come from the Joint Harmonised European Union Industry Survey and the Joint Harmonised European Union Services Survey. Both surveys are administered quarterly by the European Commission and are representative of firms in their respective sectors. Since 1985, The Industry Survey has asked the question (INDU13QPS):

At what capacity is your company currently operating (as a percentage of full capacity)?

We average the quarterly responses to obtain annual utilization for the manufacturing sector. In 2011 the Services Survey added the question (SERV8QPS):

If the demand expanded, could you increase your volume of activity with your present resources? If so, by how much?"

For 2011 forward, we use the annual average of responses to this question to obtain utilization for the services sector. We extend the measure of utilization in the services sector further back in time using the fraction of respondents reporting "None" to the question (SERV7F1S):

What main factors are currently limiting your business?

Specifically, a regression over the period 2012Q3-2017Q4 of the four quarter change to question SERV8QPS, Δ_4SERV8QPS, on the four quarter change in this fraction, Δ_4SERV7F1S, yields:

$$\Delta_4\text{SERV8QPS} = -0.72 + 0.54\Delta_4\text{SERV7F1}, \;\; N = 22.$$

The Newey-West standard error with bandwidth of 4 on the coefficient for Δ_4SERV7F1 is 0.11 and the R^2 of the regression is 0.58, making the question a plausible proxy for the utilization question asked starting in 2011. We use the fitted values from this regression to impute SERV8QPS for quarters prior to 2011 and then take annual averages and cap the resulting measure at 100. Finally, as no survey measures exist covering agriculture or mining and quarrying, we assume no utilization margin exists in these industries.

We construct an alternative measure of utilization by building on the framework of Basu (1996). Suppressing superscripts for simplicity, this approach starts by specializing the production function for gross output to a CES aggregate of value-added $V(.)$ and materials m:

$$z\left[\xi_v^{\frac{1}{\sigma}} V\left(u_k k, u_\ell \ell\right)^{\frac{\sigma-1}{\sigma}} + \xi_m^{\frac{1}{\sigma}} m^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}},$$

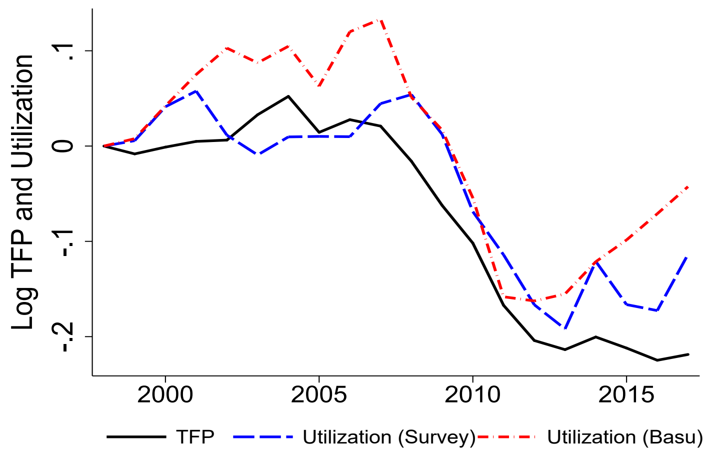


Figure B.4: Aggregate TFP and Alternative Measures of Utilization

where u_k and u_ℓ denote utilization of capital k and labor ℓ, ξ_v and ξ_m are distribution parameters, and σ is the elasticity of substitution between value added and materials. Letting R_v and R_m be the shadow costs of a unit of value-added and materials, cost minimization implies:

$$\mathrm{d}\log u \equiv \alpha_\ell \mathrm{d}\log u_\ell + \alpha_k \mathrm{d}\log u_k = \mathrm{d}\log m - (\alpha_\ell \mathrm{d}\log \ell + \alpha_k \mathrm{d}\log k) - \sigma\left(\mathrm{d}\log R_v - \mathrm{d}\log R_m\right). \quad \text{(B.1)}$$

Equation (B.1) says that when the growth of materials exceeds the weighted average growth of labor and capital, either the cost of materials must have risen by less than the cost of value-added or unobserved utilization of capital and labor must have risen. When production is Leontief between value-added and materials ($\sigma = 0$), any excess growth of materials over labor and capital must reflect unobserved utilization. We implement equation (B.1) in the Leontief case. Figure B.4 plots aggregate TFP along with the two measures of utilization. As the figure shows, the survey measure of utilization displays a similar drop between 2007 and 2011 with the drop observed in the Basu (1996) measure of utilization.

B.4 Alternative Measures of Wages and Wage Rigidity

Appendix B.4 reports alternative wage series. The wage data in this figure have not been detrended. The solid black line reports the measure used in the main analysis, equal to the ratio of total employee compensation to total employee hours worked. The dashed blue lines show the same wage concept separately for non-traded and traded industries. The dashed green line shows the labor cost index series for the total economy. The green triangles and diamonds show the labor

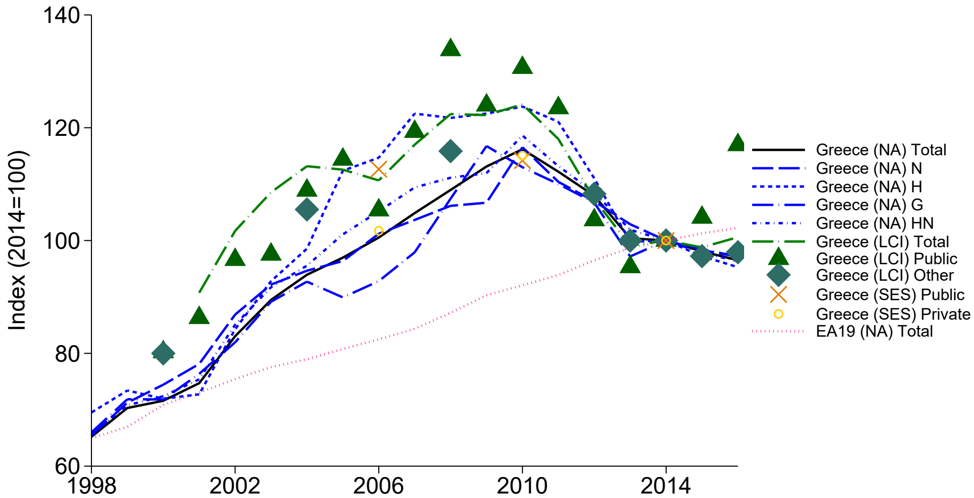


Figure B.5: Alternative Wage Series

Notes: The solid black line reports the ratio of total national accounts employee compensation to total employee hours worked. The dashed blue lines show the same wage concept separately for non-traded and traded industries. The dashed green line shows the labor cost index series for the total economy. The green triangles and diamonds show the labor cost indexes separately for public sector and private sector employees, respectively. The orange X and yellow o report public and private sector wages from the quadrennial Structure of Earnings Survey. The dotted pink line shows the national accounts wage measure for the total euro area.

cost indexes separately for public sector and private sector employees, respectively. The orange X and yellow o report public and private sector wages from the quadrennial Structure of Earnings Survey. Finally, for comparison the dotted pink line shows the national accounts wage measure for the total euro area.

We next examine changes in hourly wages (not detrended) in the bust for different types of workers. These changes come from the Structure of Earnings Survey, a large sample enterprise-level survey conducted every four years by Eurostat. The sampling frame includes all establishments with at least 10 employees, excluding public administration. Table B.1 reports hourly wage changes between 2010 and 2014, by worker age, skill, and position in the within age-skill wage distribution. Strikingly, nominal wage declines occur across age groups, skill categories, and in all parts of the wage distribution. These patterns militate against interpretations of the aggregate data focused only on compositional effects or changes specific to certain parts of the wage distribution that arise, for example, from changes in the statutory minimum wage.[4]

[4]However, we caution readers that higher frequency movements in aggregate wages could be more sensitive to compositional changes because lower-wage workers are the first to be laid off. For example, the EU KLEMS

Table B.1: Hourly Earnings Changes by Group

Category	2010 emp. share	2010 mean wage	Percent change by mean/quantile, 2010-2014:			
			Mean	Decile 1	Median	Decile 9
All ages						
Non manual workers	74.4	11.6	-12.6	-15.4	-7.1	-8.4
Skilled manual workers	15.4	10.3	-14.8	-17.9	-11.6	-14.4
Elementary occupations	10.3	7.4	-18.9	-22.8	-27.2	-7.6
Total	100.0	11.0	-13.6	-31.0	-11.6	-10.1
Age less than 30						
Non manual workers	78.7	7.4	-22.5	-40.7	-24.2	-18.0
Skilled manual workers	12.6	7.4	-18.4	-41.3	-28.2	-14.3
Elementary occupations	8.7	6.3	-21.8	-36.8	-16.0	-15.2
Total	100.0	7.3	-22.8	-40.4	-24.1	-24.2
Age 30-39						
Non manual workers	77.6	10.1	-16.6	-16.7	-8.8	-15.4
Skilled manual workers	13.9	9.1	-14.0	-32.7	-17.5	-16.3
Elementary occupations	8.5	6.9	-18.0	-22.5	-24.5	-9.1
Total	100.0	9.7	-16.7	-31.7	-17.1	-18.5
Age 40-49						
Non manual workers	73.6	12.8	-14.1	-25.4	-14.5	-11.9
Skilled manual workers	15.9	11.1	-17.0	-25.9	-16.1	-14.0
Elementary occupations	10.5	7.5	-17.0	-23.4	-14.5	-10.4
Total	100.0	12.0	-14.7	-21.6	-13.8	-14.0
Age 50-59						
Non manual workers	66.2	15.8	-12.7	-17.8	-13.2	-15.7
Skilled manual workers	19.6	12.5	-17.0	-28.5	-14.6	-20.2
Elementary occupations	14.2	8.2	-19.6	-27.1	-18.9	-13.6
Total	100.0	14.1	-13.0	-24.5	-10.8	-18.1
Age greater than 59						
Non manual workers	72.3	19.9	-16.5	-10.3	-13.7	-21.9
Skilled manual workers	14.6	9.5	-6.1	-39.0	-15.6	7.7
Elementary occupations	13.1	7.8	-19.9	-29.0	-15.0	-19.6
Total	100.0	16.8	-15.8	-25.1	-8.7	-23.9

B.5 Alternative Measures of Exports and External Demand

This appendix reports alternative measures of value-added exports and external demand $\bar{a}_{T,t}$.

We first document why value-added and gross exports differ in Greece and show that value-added exports closely follow shipping exports. Figure B.6 plots several measures of Greek trade. Panel (a) compares value-added exports (VAX) as implied by equation (22) of the main text (the solid blue line) to two alternative measures of exports: value-added exports using the procedure of Johnson and Noguera (2012) applied to the World Input-Output Database (WIOD), as described in detail in Appendix B.8 (the dashed red line), and gross exports as reported in the national accounts (the dotted green line). Gross exports in the bust grow much faster than either measure of value-added exports.

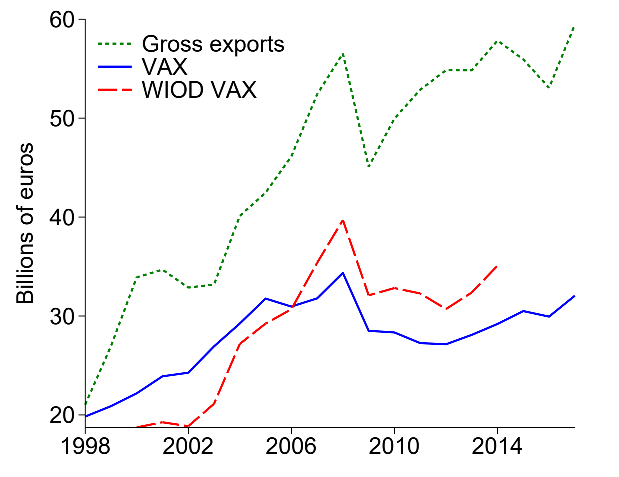
Panel (b) plots gross exports in the shipping industry (dashed purple line) against our preferred measure of VAX (solid blue line). (For readability, VAX are shifted down relative to the axis labels by €17 billion.) The boom and bust in VAX closely follows the boom and bust in shipping exports. As described in the main text, Greece is a major global freight shipper and the global shipping industry experienced a substantial boom in the 2000s and bust beginning around 2008.

Panel (c) shows that gross and value-added exports differ quantitatively because of trade in oil. The panel splits gross exports into refined petroleum (CPA code 1920) and other, using COMEXT data from Eurostat. Total non-oil gross exports closely track the path of value-added exports in the bust. Thus, the difference between the performance of value-added and gross exports in the bust comes entirely from gross exports of refined petroleum.

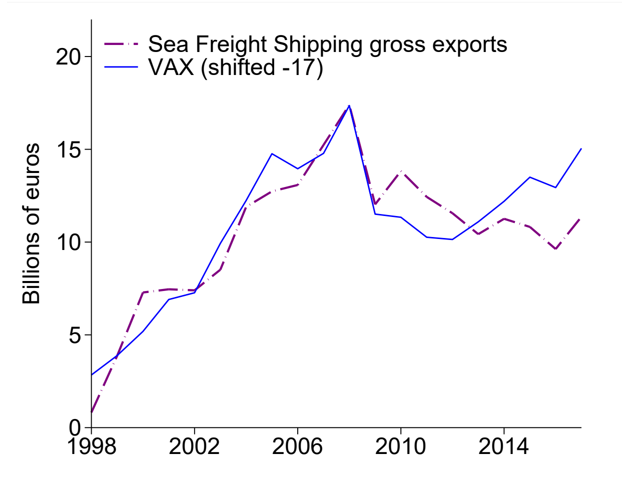
Panel (d) shows why gross and value-added exports in the oil sector differ. Greece has a number of oil refineries that import crude and export refined petroleum. As a result, the €7.1 billion increase in Greek exports of refined petroleum between 2007 and the series peak in 2012 (solid gold line) is nearly matched by a €6.1 billion increase in crude imports (dashed orange line). Total nominal value added in the petroleum refining sector (NACE C19) rose by only €0.4 billion over this period (dotted black line). Thus, only a small part of the boom in exports of refined petroleum translated into demand for Greek capital and labor in the refining sector.

We next compare alternative measures of external demand $\bar{a}_T$. We can slightly rewrite the

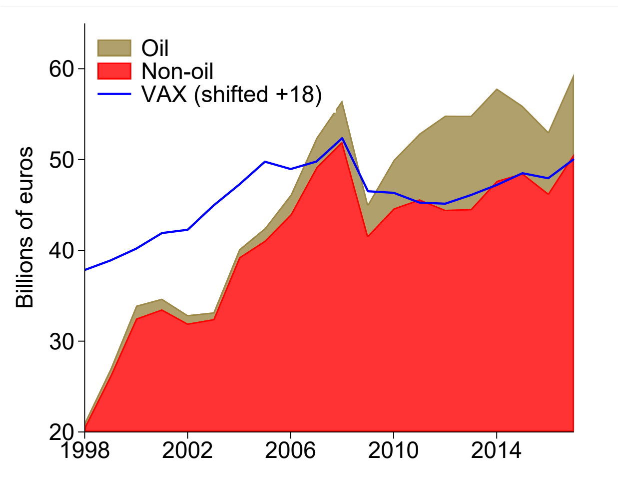
data shows in increase of 3.4 percent in labor quality between 2008 and 2010, which is characterized by a lack of aggregate wage decline.



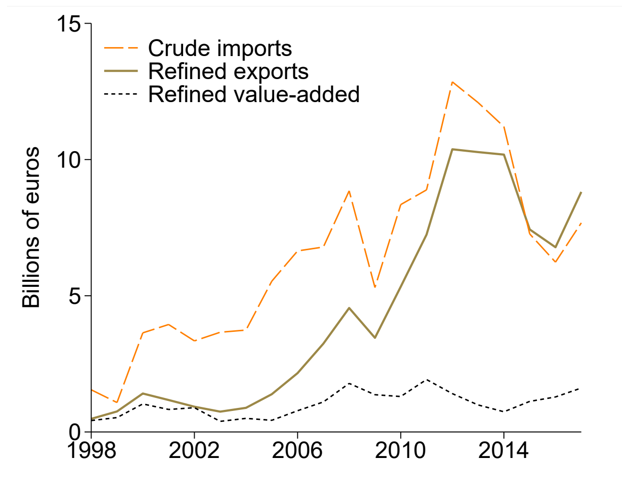
(a) Exports Measures



(b) Shipping Gross Exports and VAX



(c) Non-oil and Oil Exports and VAX



(d) Crude Imports, Refined Exports, and Value-added

Figure B.6: Subcomponents of Exports

VAX stands for value-added exports and WIOD for the World Input-Output Database. Panel (a) compares VAX using the procedure described in equation (22) of the main text to the VAX obtained from applying the Johnson and Noguera (2012) procedure to the WIOD and to gross exports as reported in the national accounts. Panel (b) compares our preferred measure of VAX (shifted down relative to the axis labels by €17 billion for readability) to gross sea shipping exports. Panel (c) compares our preferred measure of VAX (shifted up relative to the axis labels by €18 billion for readability) to gross exports other than refined petroleum and exports of refined petroleum. Panel (d) plots gross imports of crude petroleum, gross exports of refined petroleum, and value-added in the oil refining sector.

measurement equation for $\bar{a}_T$ as:

$$\bar{a}_{T,t} = \left[(1-\gamma) \left(\frac{P_{H,t}}{P_{F,t}} \right)^{1-\eta} P_{F,t} \right]^{-1} EX_t, \tag{B.2}$$

where $P_{H,t}$ is the price of Greek tradable goods, $P_{F,t}$ is the price of foreign tradable goods and also the foreign composite tradable good (since Greece is small), and EX_t is nominal Greece

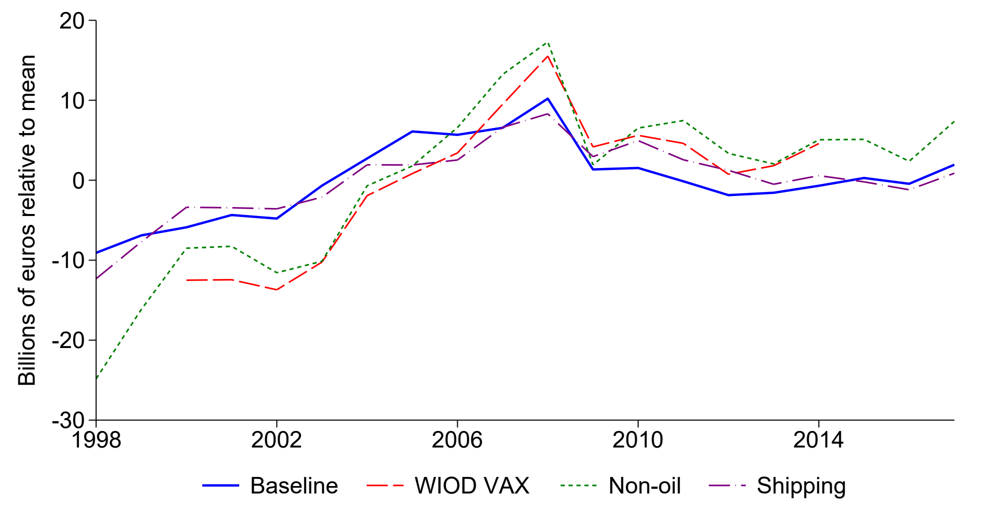


Figure B.7: Alternative Measures of $\bar{a}_T$

exports. This formula extends straightforwardly to the case of multiple types of traded goods. If we assume a common elasticity of substitution between domestic and foreign varieties η and that foreign sectoral prices remain in fixed proportion (so that we can ignore the elasticity of substitution across good types), we have that for any good i:

$$\bar{a}_{T,t} = \left[(1-\gamma_i) \left(\frac{P_{H,t}(i)}{P_{F,t}(i)} \right)^{1-\eta} P_{F,t}(i) \right]^{-1} EX_t(i). \tag{B.3}$$

Thus, we can alternatively obtain log deviations of $\bar{a}_T$ from subsectors of tradables.

Figure B.7 plots four alternative measures of $\bar{a}_T$. The solid blue line shows the baseline measure. The dashed red line shows $\bar{a}_T$ using value-added exports from the WIOD. The dotted green line shows $\bar{a}_T$ using non-oil gross exports. The dashed purple line shows $\bar{a}_T$ using gross exports of freight shipping and the relative price of shipping output.[5] All four of these measures display similar behavior in the bust. Our baseline measure if anything minimizes the contribution of external demand in the boom, as it rises less than the measure based on non-oil exports or the WIOD.

B.6 Estimation of the Aggregate Disaster Probability

We follow Barro and Liao (2021) to recover the time series of disaster probabilities π_t^a from prices of far-out-of-the-money put options. Important assumptions in the Barro and Liao (2021) model

[5]Eurostat does not report a price index for shipping output for the euro area. Instead, we equate $P_F(ship)$ with the output price of shipping in the Netherlands, another major European shipper.

are: (i) a representative agent with Epstein-Zin preferences; (ii) a downward jump component in the process for output; and (iii) a power law distribution of output loss conditional on a downward jump occurring.

Let $\Omega_{i,t}$ denote the price, expressed as a ratio to the date t stock price, of put option i at date t with strike S_i and remaining maturity $T_{i,t}$ in days. Let "moneyness" $M_{i,t}$ denote the ratio of S_i to the date t stock price. Equation (25) of Barro and Liao (2021) prices a put option with short enough maturity $T_{i,t}$ and low enough moneyness $M_{i,t}$ such that drift and diffusion components of the process for output growth have negligible effect on the option's price:

$$\Omega_{i,t} = \left[\frac{\alpha L_0^{\alpha}}{(\alpha-\sigma)(1+\alpha-\sigma)}\right] T_{i,t} M_{i,t}^{1+\alpha-\sigma} \pi_t^a, \tag{B.4}$$

where α is the Pareto coefficient for loss conditional on a disaster occurring, L_0 is the minimum disaster size, σ is the coefficient of relative risk aversion, and π_t^a is the daily disaster probability. Thus, the model predicts a unit elasticity of the option price with respect to time-to-maturity and an elasticity with respect to moneyness which is a function of the Pareto coefficient and risk aversion.

Our data contain the universe of put options traded on the Athens Stock Exchange between 2001 and 2017.[6] Starting from the universe of transactions (53,121 observations), we keep only options on the FTSE/Athex Large Cap Index (renamed from FTSE/ATHEX 20 on December 3, 2012, 49,154 observations) and further follow Barro and Liao (2021) in restricting the estimation sample to options with maturity remaining of less than six months and moneyness less than 0.9 (4,025 observations). The estimation is robust to restricting maturity remaining to less than 60 or 30 days and to restricting to options at least 15 percent out of the money.

We take logs of equation (B.4) and estimate using OLS the log-linear equation:

$$\ln \Omega_{i,t} = b_T \ln T_{i,t} + b_M \ln M_{i,t} + d_{t_m} + \text{error}_{i,t}, \tag{B.5}$$

where b_T and b_M are coefficients to be estimated and d_{t_m} is a month fixed effect.[7] The model fits the data well. We estimate $\hat{b}_T = 1.16$, $\hat{b}_M = 5.82$, and obtain an $R^2 = 0.83$ and a "within" R^2

[6]These data are available for purchase from the exchange: `https://bit.ly/2S5g0dA` (last accessed November 29, 2018).

[7]With more data, we could estimate a date fixed effect d_t rather than a month fixed effect d_{t_m}. The month fixed effect constrains the date fixed effects to be the same for every day in a month.

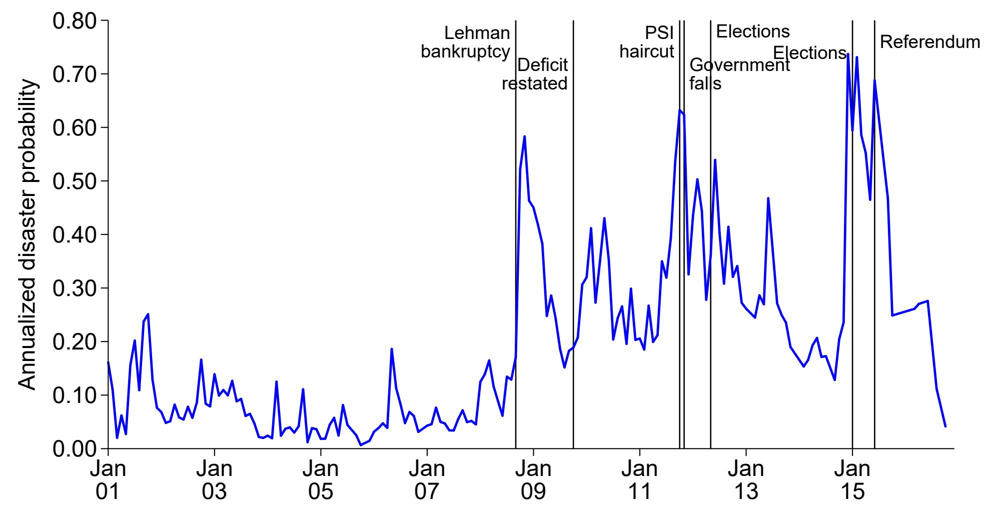


Figure B.8: Monthly Probability of Disaster

of 0.71. The estimate of $\hat{b}_T$ is close to the theory-predicted value of one and our recovered time series of π_t^a changes little if we impose $b_T = 1$ in the estimation. The estimate of $\hat{b}_M = 5.82$ is nearly identical to the estimate reported in Barro and Liao (2021) of 5.83 pooling across the nine countries in their data (none of which is Greece).

The exponentiated fixed effect $\exp(d_{t_m})$ pins down changes over time but not the level of the disaster probability. To obtain the level requires parameterizing the term in brackets in equation (B.4). We follow Barro and Liao (2021) and assume a minimum size of disaster L_0 of 10 percent and a coefficient of risk aversion $\sigma = 3$. Matching coefficients in equation (B.4) and equation (B.5), we obtain $\alpha = \hat{b}_M + \sigma - 1 = 7.82$. Given this estimate of α, we then recover the bracketed term in equation (B.4) and back out monthly averages of daily disaster probability as $\pi_t^a = \exp(d_{t_m}) / \left[\frac{\alpha L_0^\alpha}{(\alpha-\sigma)(1+\alpha-\sigma)}\right]$. We annualize these daily disaster probabilities and average across months in a year to arrive at the disaster probability series used in our analyses. Figure B.8 reports the monthly probabilities along with markers of important political and economic events. Finally, given the minimum size of disaster L_0 and our estimate of α, we recover a mean decline in output conditional on a disaster occurring equal 21 percent.

B.7 Measurement of Tax Rates

Greece levies taxes on transactions, individuals, corporations, and property. We allocate all tax receipts and actual social contributions into taxes on consumption, investment, labor, and capital.

The two largest revenue categories are taxes on production and imports (code D.2) that account for roughly 60 percent of tax receipts and current taxes on income and wealth (D.5) that account for roughly 40 percent of tax receipts. Taxes on production and imports less subsidies are allocated to consumption and investment, with the exception of property taxes paid by enterprises (D.29) which are allocated to capital income. From taxes on production and imports net of property taxes, we allocate to consumption the taxes that unambiguously fall into consumption such as excise duties, taxes on entertainment, lotteries, and gambling, taxes on insurance premiums, and other taxes on specific services. We then allocate the residual to consumption taxes and investment taxes in proportion to their expenditure shares and calculate the tax rates as:

$$\tau^c = \frac{\text{consumption taxes}}{\text{consumption} - \text{consumption taxes}}, \quad \tau^x = \frac{\text{investment taxes}}{\text{investment} - \text{investment taxes}}. \tag{B.6}$$

The denominators subtract taxes from spending because in national accounts spending is at market prices and includes taxes.

Current taxes on individual's income fall on both labor and capital and current taxes on the income of corporations fall on capital. We measure the labor income tax rate τ^ℓ as the sum of the tax rate on social security contributions τ^{SS} and the tax rate on labor income net of social security contributions τ^{NL}, where:

$$\tau^{\text{SS}} = \frac{\text{social security contributions}}{\text{labor income}}, \quad \tau^{\text{NL}} = \tau^y \left(1 - \frac{\text{social security contributions}}{\text{labor income}}\right). \tag{B.7}$$

Labor income in the denominators equals compensation of employees, which includes social security contributions, adjusted for the income of the self-employed that we allocate proportionally between labor and capital. For τ^{SS}, we use an average tax rate because contribution rates are generally flat within each occupation up to a cap that, according to the Statistics of Income (SOI), affects less than two percent of tax payers.

The tax rate τ^{NL} equals the fraction of labor income not subject to social security contributions taxed at the individual income tax rate τ^y, where:

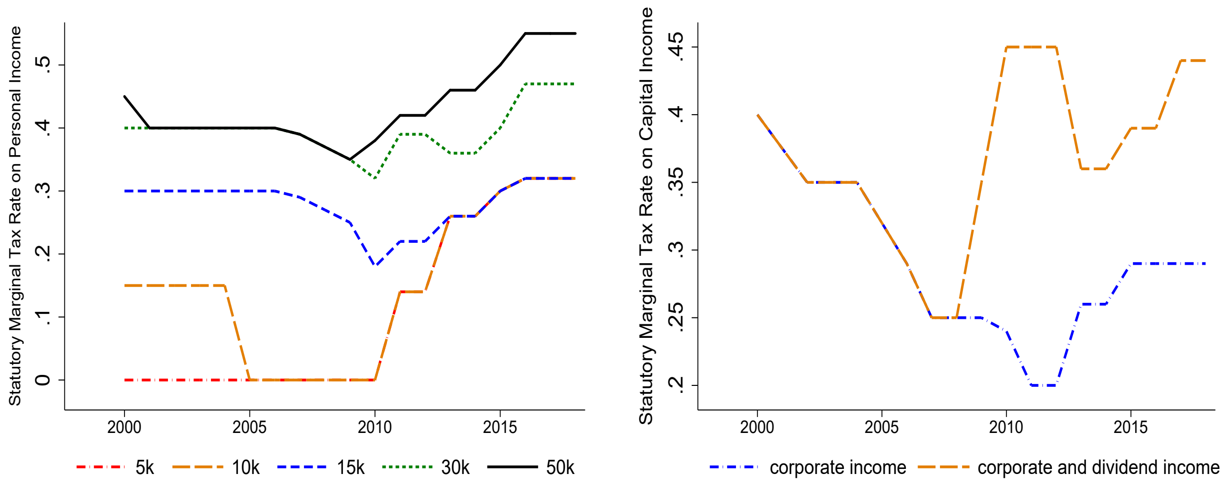
$$\tau^y = \frac{2.08 \times (\text{taxes on individual income} - \text{taxes on dividends and interest})}{\text{GDP} - \text{production, imports taxes, contributions, depreciation, dividends, interest}}. \tag{B.8}$$

In Greece taxes are levied on individual income which consists of unambiguous labor income (such as income from salaried workers), unambiguous capital income (such as dividends, interest, and rentals), and ambiguous income (such as income from self-employment, agriculture, and liberal professions). The denominator of equation (B.8) denotes taxable income which, in addition to taxes on production and imports, contributions, and depreciation, excludes dividends and interest because for those types of capital income we have independent information on their taxes and allocate them directly to capital taxes. The factor 2.08 represents our estimate of the gap between the average marginal tax rate and the average average tax rate.[8]

We measure capital tax rates τ_H^k and τ_N^k as capital tax payments divided by taxable capital income generated in each sector. There are six types of capital tax payments. Property taxes paid by households are allocated to the non-traded sector. Property taxes paid by corporations are allocated to each sector in proportion to its share of non-residential structures used in production. The other four categories, taxes on dividends and interest, income and capital gains taxes paid by corporations, taxes on capital income paid by households, and other capital taxes, are allocated to each sector in proportion to its share of capital income net of depreciation. Dividend and interest taxes are calculated as the product of their respective time-varying statutory tax rates with the size of dividends and interests from the national accounts. Income and capital gains taxes paid by corporations come directly from national accounts (in code D.51). Capital income taxes paid by individuals equals the product of the individual income tax rate τ^y in equation (B.8) with the share of net income accruing to capital. Other capital taxes (code D.91) include inheritance taxes, death duties, taxes on gifts, and capital levies. Finally, taxable capital income equals the capital share of GDP less net taxes on products and imports less depreciation.

In Figure B.9 we document the time series of statutory measures of taxes. Statutory tax rates on corporate income increased from 20 percent to 26 percent in 2013 and to 29 percent in 2017. Taxes for properties with objective values above 400,000 euros in 2011 and 200,000 in 2012 were introduced as part of the fiscal adjustment programs. In 2014, Greece introduced taxes on the unified property owned by individuals (ENFIA) without exemptions.

[8] To estimate this ratio, we use binned up data from the Statistics of Income (SOI) between 2006 and 2011. This ratio is relatively stable over time. The SOI data has not been publicly disclosed after 2011. Corporate income taxes are generally flat in Greece and, so, we focus on average capital tax rates. Using the SOI, we have confirmed that the ratio of marginal to average corporate income tax is close to one.



(a) Personal Income Tax Rates by Income Level

(b) Capital Tax Rates

Figure B.9: Statutory Labor and Capital Tax Rates

B.8 Estimation of the Trade Elasticity of Substitution

Aggregating equation (14) across retailers and using the corresponding expression for the demand for the foreign traded good, we obtain an expression relating relative expenditure on domestic and foreign traded goods and the relative prices of these bundles:

$$\ln(P_{H,t}a_{H,t}/P_{F,t}a_{F,t}) = \ln\left(\gamma/\left(1-\gamma\right)\right) + \left(1-\eta\right)\ln(P_{H,t}/P_{F,t}), \tag{B.9}$$

where $a_{H,t}$ and $a_{F,t}$ denote Greek expenditure on the domestic and foreign traded goods, respectively. First differencing equation (B.9) and allowing for a normalizing constant and measurement error in relative absorption yields the estimating equation:

$$\Delta\ln(P_{H,t}a_{H,t}/P_{F,t}a_{F,t}) = b_0 + b_1\Delta\ln(P_{H,t}/P_{F,t}) + e_t, \tag{B.10}$$

where $\eta = 1 - b_1$. The identifying assumption is that preferences for Greek versus foreign goods, γ in our notation, are stable over time and hence do not appear in the linearized equation (B.10).

We estimate equation (B.10) using Eurostat data and identifying F with the euro area. Since our model abstracts from intermediate inputs in production, the price indexes and quantities in equation (B.10) correspond to a value-added concept. Value-added price indexes for the Greek (H) and euro area (F) traded goods sector come directly from the national accounts. However, national accounts do not report either value-added exports or imports. We extend the procedure in Johnson and Noguera (2012) and apply it to the World Input-Output Database (WIOD) described to recover Greek value-added exports to and imports from the euro area.[9] Estimating equation (B.10) over the period 2000-14, the maximum sample for which we have data from the WIOD, yields $\eta = 1.65$ with standard error equal to 0.25.

We now describe the Johnson and Noguera (2012) procedure for obtaining value-added exports to and imports from the euro area. The key equation is the (nominal) market-clearing condition:

$$\mathbf{Q} = \sum_j (\mathbf{I} - \mathbf{M})^{-1} \mathbf{c_j}, \tag{B.11}$$

where $\mathbf{Q}$ is an $NS \times 1$ vector of nominal gross output in each industry $s \in S$ and country $j \in N$, $\mathbf{c_j}$ is an $NS \times 1$ vector of final demand in country j of output from each country-sector, $\mathbf{M}$ is a global input-output matrix with generic entry given by the share of intermediate goods produced in sector s in country j used in sector s' of country i as a share of output of sector s' in country i, and we have dropped time subscripts for simplicity since the relationship in equation (B.11) holds statically. Under the assumption that the value-added content of an industry does not depend on whether the output is used domestically or exported, one can pre-multiply both sides by a diagonal matrix $\mathbf{R}$ of value-added shares of gross output in each country-sector to obtain:

$$\mathbf{Py} = \mathbf{R} \sum_j (\mathbf{I} - \mathbf{M})^{-1} \mathbf{c_j}, \tag{B.12}$$

where $\mathbf{Py}$ is the vector of nominal value-added. Total value-added exports from Greece are then:

$$P_H a_H^* = \iota'_{Greece} \mathbf{R} \sum_{j \neq Greece} (\mathbf{I} - \mathbf{M})^{-1} \mathbf{c_j}, \tag{B.13}$$

where ι_j is an $NS \times 1$ selection vector with a value of one in the rows corresponding to the traded sectors in country j and zeros elsewhere.[10] Greek value-added absorption of Greek traded goods is:

$$P_H a_H = P_H y_H - P_H a_H^*. \tag{B.14}$$

Similarly, we obtain Greek value-added imports from the euro area as:

$$P_F a_F = \sum_{j \in euro\ area} \iota'_j \mathbf{R} (\mathbf{I} - \mathbf{M})^{-1} \mathbf{c}_{Greece}. \tag{B.15}$$

[9]For a description of the WIOD, see Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J. (2015), "An Illustrated User Guide to the World InputOutput Database: the Case of Global Automotive Production", Review of International Economics 23: 575605.

[10]In practice, we sum over the sectors which we include in the traded sector aggregate, even though other sectors may have small but positive value-added exports.

We make five remarks on the estimation of η. First, most Greek trade occurs with partners outside of the euro area. This fact does not invalidate the above procedure, because equation (B.9) follows directly from a first order condition for the relative expenditure between any two bundles of goods available to Greeks. Second, our model assumes the same elasticity governs both imports and exports. In that case, one can also estimate η using relative absorption of Greek and euro area products by euro area residents. Using the WIOD data, we obtain an almost identical coefficient of 1.64 for this specification (standard error 0.80). Third, two recent papers have raised criticisms of regressions designed to uncover the Armington elasticity. Imbs and Mejean (2015) argue that elasticity estimates based on aggregate data may understate the true elasticity because most aggregate variation comes from sectors with volatile prices which may also have low elasticities.[11] In our data, however, the aggregate elasticity exceeds the weighted mean sectoral elasticity, which is almost exactly unity. Feenstra, Luck, Obstfeld, and Russ (2018) argue the relevant elasticity in most models is that between domestic goods and imports but many papers instead estimate an elasticity across exports from different countries.[12] Equation (B.10) directly estimates the appropriate elasticity as advocated by Feenstra, Luck, Obstfeld, and Russ (2018). Fourth, we prefer the first-differenced specification (B.10) because any changes to preferences likely accumulate over time, making the levels specification (B.9) more vulnerable to mis-specification. Nonetheless, estimating the equation in levels implies a slightly lower estimate of η of 1.25 (standard error 0.15). Fifth, the WIOD does not measure local purchases by non-residents and hence the WIOD VAX measure excludes tourism exports. Effectively, we impute the same elasticity to the tourism sector as we obtain for other traded sectors.

We obtain γ as the sample average ratio of domestic absorption of domestic traded to domestic absorption of all traded, where we first normalize each variable by domestic output:

$$\gamma = \left[\left(\overline{\frac{P_{H,t} y_{H,t}}{P_t y_t}} \right) - \left(\overline{\frac{a_{H,t^*}}{P_t y_t}} \right) \right] \Big/ \left(\overline{\frac{P_{H,t} a_{H,t}}{P_t y_t}} \right).$$

Here, since γ depends on properly measuring the level of Greek absorption of Greek traded value-added, we add to the WIOD VAX Greek tourism exports reported in the Balance of Payments

[11] Imbs, J., and I. Mejean (2015): "Elasticity Optimism," American Economic Journal: Macroeconomics, 7(3), 43-83.

[12] Feenstra, R. C., P. Luck, M. Obstfeld, and K. N. Russ (2018): "In Search of the Armington Elasticity," The Review of Economics and Statistics, 100(1), 135-150.

scaled by the ratio of value-added to gross output in accommodation and food services to arrive at a measure of value-added exports.

B.9 Summary of Data Sources

Table B.2 describes the construction of the variables used as observables in the estimation. Table B.3 describes the construction of the driving forces. Table B.4 provides sources of some auxiliary variables used in the construction of the observables and driving forces.

C Additional Results

In this appendix we present additional results from the model.

- Table C.1 presents the persistence and standard deviation of the exogenous stochastic processes. Due to rounding some processes are displayed with a persistence of one in the table. We set to 0.999 the persistence of processes estimated to be above 0.999.

- Table C.2 presents the priors used in the estimation and various other statistics of the parameter estimates.

- Table C.3 presents parameter estimates under a higher prior mean for the adjustment costs of prices and wages. Figure C.1 shows the model-generated paths of variables under the parameters estimated with these higher mean priors.

- Figure C.2 reports time series of outcomes when we decrease the prior mean and prior standard deviation of the variance of the measurement error uniformly for all observables by a factor of 5. Figure C.3 reports time series of outcomes when we decrease the prior mean and prior standard deviation of the variance of the measurement error of only prices and wages by a factor 5. Figure C.4 reports time series of outcomes when we decrease the prior mean and prior standard deviation of the variance of the measurement error of only wages by a factor 5.

- Table C.4 reports parameter estimates when we estimate the model allowing for serially correlated measurement error on observables. Figure C.5 reports time series of outcomes when

Table B.2: Observable Outcomes

Variable	Description	Source
ℓ_H, ℓ_N	Sectoral labor	Eurostat nama_10_a64_e, item EMP_DC (total employment, domestic concept), thousands of hours worked
TFP_H,TFP_N	Sectoral TFP	$y_i/(\ell_i^{1-\alpha} KS_i^{\alpha}),\ i \in \{H, N\}$ (see Appendix B.3)
u_H, u_N	Sectoral utilization	Joint Harmonised European Union Industry Survey and Joint Harmonised European Union Services Survey, questions INDU13QPS, SERV8QPS, SERV7F1S. See Appendix B.3.
$\tilde{s}$	Capital share in tradeable sector	$\tilde{k}_H/(\tilde{k}_H + \tilde{k}_N)$
c	Real consumption	Eurostat nama_10_gdp, item P31_S14_S15 (household and NPISH final consumption expenditure)
$P_N c_N$	Nominal non-tradeable consumption expenditure	$P_N y_N - (P_N g_N^c + P_N g_N^x + P_N x_N)$
x_N	Private purchases of non-tradeable investment	Construction investment (Eurostat nama_10_nfa_fl, asset N11KG) scaled by the value-added share of gross output in the construction sector (Eurostat nama_10_a64, NACE_r2 F, item B1G divided by item P1)
x_T	Private purchases of tradeable investment	Total private investment (Eurostat nama_10_gdp, item P51G less gov_10a_main, sector S13, item P51G) less construction investment (Eurostat nama_10_nfa_fl, asset N11KG) scaled by the value-added share of gross output in the construction sector (Eurostat nama_10_a64, NACE_r2 F, item B1G divided by item P1)
P_H, P_N	Sectoral producer price	Eurostat nama_10_a64, item B1G
W	Wage	National account wages and salaries (Eurostat nama_10_a10, NACE_r2 TOTAL, item D1) divided by total employment hours (Eurostat nama_10_a10_e, NACE_r2 TOTAL, item SAL_DC)
$\Pi^f/(P_y y)$	Profits/GDP	Bank of Greece financial accounts, non-financial corporates, dividends paid minus equity issuances over value added by non-financial corporates
N	Net worth in banking sector	Bank of Greece financial accounts, monetary financial institutions excluding Bank of Greece, net financial assets + listed shares + unlisted shares and other equity + investment fund shares

Table B.3: Driving Forces

Variable	Description	Source
z_H, z_N	Sectoral productivity	$TFP_i/u_i,\ i \in \{H, N\}$
$\bar{a}_T$	External demand	$\left[(1-\gamma)\left(\frac{P_H}{P_F}\right)^{1-\eta} P_F\right]^{-1} EX$
P_F	Foreign price level	Eurostat nama_10_a64, geography EA19, item B1G
T^g	Capital transfers from structural funds	Historic EU payments, https://bit.ly/2RLZk6d
T^l	Debt misperception	General government Maastricht Treaty definition gross debt at the end of year t as reported in April of $t+1$ to the European Commission and the value reported for year t in 2019, https://bit.ly/3vtDHG1 and OECD Economic Outlook variable GGFLM
$\bar{B}^g$	Government debt held by rest of the world	$B^g - (B^g - \bar{B}^g)$
$\bar{B}^r$	Borrowing limit of r agents	Bank of Greece financial accounts, Households and Non-profit Institutions, short-term loans + accounts payable
$\bar{r}$	Interest rate on government debt	Net interest payments (Eurostat gov_10a_main, sector S13, item D41PAY less D41REC)/B^g
$\bar{i}$	Bank deposit rate	Time deposits with maturity up to 1 year (ECB key MIR.M.GR.B.L22.F.R.A.2230.EUR.N)
T^b_W	Capital gain/loss on banks' rest-of-world assets	Bank of Greece financial accounts, Monetary Financial Institutions Excluding Bank of Greece, Assets, sector rest of world, short-term debt + long-term debt + short-term loans + long-term loans + listed shares + unlisted shares and other equity + investment fund shares, first difference in asset levels less asset-flows
$T^b_{G,d}$	Capital gain/loss on banks' holdings of sovereign debt	Change in market minus book value of sovereign holdings plus realized write-downs. Market value: $B^g - \bar{B}^g$. Book value: Bank of Greece, Monetary and Banking Statistics, Aggregate Balance Sheet of MFIs excluding Bank of Greece, Claims on non MFIs, Domestic, General Government. Write-downs: August 2011, 4 billion euro, January 2012, 5.8 billion euro, March 2012, 15.2 billion euro, April 2012, 4.1 billion euro.
$T^b_{G,e}$	Equity injections from government to banks	Bank of Greece financial accounts, Monetary Financial Institutions Excluding Bank of Greece, Liabilities-Flows, General government listed shares + unlisted shares and other equity

Driving Forces, continued

Variable	Description	Source
g_T^c	Real government purchases of tradeable consumption	Government intermediate consumption expenditure (Eurostat gov_10a_main, sector S13, item P2) deflated by intermediate inputs price index for O-Q and scaled by share of intermediate inputs from H sector in NACE_r2 O-Q in 2010-2012 input-output table naio_10_cp16
g_N^c	Real government purchases of non-tradeable consumption	Total government final consumption expenditure (Eurostat nama_10_gdp, item P3_S13) less g_T^c
g_T^x	Real government purchases of tradeable investment	Total government investment expenditure (gov_10a_main, sector S13, item P51G) deflated by investment price index, less g_N^x
g_N^x	Real government purchases of non-tradeable investment	$P_N g_N^x$ deflated by construction investment price index
T^r	Government transfers to r households	Government social benefits (Eurostat gov_10a_main, sector S13, item P62PAY)
τ^c	Consumption tax	Annual national accounts Tables 1 and 10
τ^x	Investment tax	Annual national accounts Tables 1 and 10
τ^ℓ	Labor income tax	Annual national accounts Tables 10 and 14
τ_H^K	Capital income tax in the tradeable sector	Annual national accounts Tables 10 and 14
τ_N^K	Capital income tax in the non-tradeable sector	Annual national accounts Tables 10 and 14
κ_τ	Firm tax pre-payment	Tax laws 2238/1994, 3697/2008, and 4334/2015
π^θ	Idiosyncratic disaster risk probability	12 month plus unemployment rate (Eurostat lfsa_ugad, age Y20-64)
π^a	Aggregate disaster risk probability	Athens Stock Exchange option prices and Barro and Liao (2021). See Appendix B.6

Table B.4: Auxiliary Definitions

Variable	Description	Source
H	Tradeables produced by Greece	NACE_r2 A-C,H49,H50,H51,I,N79
N	Non-tradeables	NACE_r2 D-G,H52,H53,J-M,N77,N78,N80_N82,O-S
$P_N g_N^c$	Nominal government non-tradeable consumption purchases	Total government final consumption expenditure (gov_10a_main, sector S13, item P3) less intermediate consumption expenditure (gov_10a_main, sector S13, item P2) scaled by share of intermediate inputs from H sector in NACE_r2 O-Q in 2010-2012 input-output table naio_10_cp16
$P_T g_T^x + P_N g_N^x$	Nominal government investment purchases	Eurostat gov_10a_main, sector S13, item P51G
$P_T x_T + P_N x_N$	Nominal private investment purchases	Eurostat nama_10_gdp,item P51G less $(P_T g_T^x + P_N g_N^x)$
$P_N g_N^x$	Nominal government non-tradeable investment purchases	Total government construction investment $((P_T g_T^x + P_N g_N^x)\times$construction share from nama_10_nfa_fl, sectors O-Q, asset N11KG/N11G) scaled by the value-added share of gross output in the construction sector (Eurostat nama_10_a64, NACE_r2 F, item B1G divided by item P1)
$P_N x_N$	Nominal private investment purchases from non-tradeable sector	Total construction investment (Eurostat nama_10_nfa_fl, asset N11KG) scaled by the value-added share of gross output in the construction sector (Eurostat nama_10_a64, NACE_r2 F, item B1G divided by item P1) less $P_N g_N^x$
$P_T y_T, P_N y_N$	Sectoral nominal value-added	Eurostat nama_10_a64 item B1G
$\tilde{P}_{x,j}$	Price of investment of type j	Eurostat nama_10_nfa_st, assets $j \in$\{N11KN, N11MN, N115N, N117N\}
$(1+\tau^C)P_c c$	Nominal consumption expenditure	Eurostat nama_10_gdp, item P31_S14_S15 (household and NPISH final consumption expenditure)
$\tilde{k}_{H,j}, \tilde{k}_{N,j}$	Sectoral replacement cost capital stock of type j	$\tilde{k}_{i,j,t}/\tilde{P}_{x,j,t} = (1-\delta_j)\tilde{k}_{i,j,t-1}/\tilde{P}_{x,j,t-1} + x_{i,j,t},\ i \in \{H,N\}$
$\tilde{k}_H, \tilde{K}_N$	Sectoral replacement cost capital stock	$\sum_j \tilde{k}_{i,j},\ i \in \{H,N\}$
KS_H, KS_N	Capital services	$\sum_j (r+\delta_j)\tilde{K}_{i,j},\ i \in \{H,N\}$
P_T	Price index of tradeable absorption	$\left(\gamma P_H^{1-\eta} + (1-\gamma)\, P_F^{1-\eta}\right)^{\frac{1}{1-\eta}}$
EX	Value-added exports	$P_H y_H - \gamma\,(P_H/P_T)^{1-\eta} \times (P_c c - P_N c_N + P_T x_T + P_T g_T^x)$
B^g	Total government debt	Bank of Greece financial accounts, General Government, Liabilities, short-term debt securities + long-term debt securities + short-term loans + long-term loans + other accounts payable less Assets, Currency and deposits + short-term debt securities + long-term debt securities + short-term loans + long-term loans
$B^g - \bar{B}^g$	Government debt held by Greek banks	Bank of Greece financial accounts, Monetary Financial Institutions Excluding Bank of Greece, Assets, sector S13, short-term debt + long-term debt + short-term loans + long-term loans

we estimate the model allowing for serially correlated measurement error on observables. Tables C.5 and C.6 report the sources of the boom and bust under the new parameters with serially correlated measurement error on observables. For these results, we treat the persistence of the measurement errors as additional parameters, and estimate these parameters jointly with other parameters of the model.

- Table C.7 reports parameter estimates when we estimate the model allowing for contemporaneously correlated measurement error on observables. Figure C.6 reports time series of outcomes when we estimate the model allowing for contemporaneously correlated measurement error on observables. Tables C.8 and C.9 report the sources of the boom and bust under the new parameters with contemporaneously correlated measurement error on observables. For these results, we treat the contemporaneous correlations of the measurement errors as fixed parameters, because estimating all correlations proves too computationally demanding. The assigned values of these correlations equal the correlations of the measurement errors that we calculate ex-post in the baseline estimation, which assumed uncorrelated measurement errors.

- Table C.10 presents the correlation between data and model variables and R-squared coefficients from a regression of data on model variables.

- Figure C.7 presents labor, investment, and utilization time series by sector in the model and the data.

- Figure C.8 shows the time series of outcomes when we estimate the model under the restriction that the parameter on nominal wage rigidity $\psi_W = \infty$ between 2008 and 2010. We treat the changes in 2008 and 2011 in ψ_W as unanticipated. Wages are not exactly constant because we specify the rigidity in terms of after-tax wages and taxes are time varying. Table C.11 reports the sources of the bust when we restrict $\psi_W = \infty$ between 2008 and 2010.

- Tables C.12 and C.13 presents the sources of the boom and the bust under the alternative assumption that government spending adjusts to balance the budget. For this exercise, we fix lump-sum transfers to the optimizing household T^o to a constant and adjust the five spending variables, $g^c_T, g^c_N, g^x_T, g^x_N, T^r$ proportionally to their size in steady state to balance the budget in every period. Thus, only relative government spending matters for the sources of the boom and the bust.

- Table C.14 presents the sources of macroeconomic dynamics in the first part of the bust (2007-2012).
- Table C.15 presents the sources of the boom and the bust under alternative parameters.
- Figure C.9 presents the differences in variables between the counterfactual fiscal adjustment and the baseline in Figure 5 along with their 90 percent confidence intervals.
- Table C.16 reports 90 percent confidence intervals for the fiscal and revenue multipliers at horizon $h = 7$.
- Table C.17 reports the fiscal and revenue multipliers for various horizons.
- Table C.18 reports multipliers under various financing systems and horizons.
- Table C.19 reports fiscal multipliers financed with lump sum transfers T^o at horizon $h = 1$ for various alternative parameter values.
- Table C.20 reports fiscal multipliers financed with lump sum transfers T^o at horizon $h = 7$ for various alternative parameter values.
- Table C.21 reports fiscal multipliers financed initially with deficit $\bar{B}^g$ and then with lump sum transfers T^r and T^o at horizon $h = 1$ for various alternative parameter values.
- Table C.22 reports fiscal multipliers financed initially with deficit $\bar{B}^g$ and then with lump sum transfers T^r and T^o at horizon $h = 7$ for various alternative parameter values.
- Figure C.10 presents the differences in variables between the counterfactual path of fiscal policy and the baseline in Figure 6 along with their 90 percent confidence intervals.
- Figure C.11 presents the differences in variables between the counterfactual path without external bailout of the Greek government and the baseline in Figure 7 along with their 90 percent confidence intervals.

- Figure C.12 presents the differences in variables between the counterfactual path without bailout of domestic banks and the baseline in Figure 8 along with their 90 percent confidence intervals.

Table C.1: Persistence and Volatility of Exogenous Processes

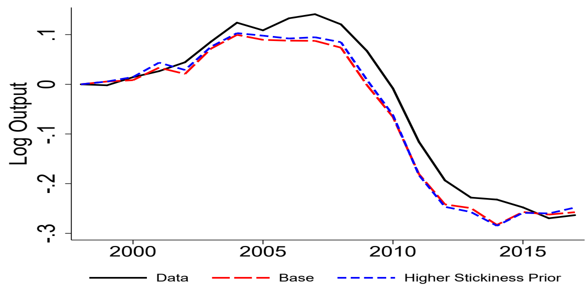
Exogenous process		Persistence	Standard Deviation
$\log z_H$	productivity, traded	0.71	0.02
$\log z_N$	productivity, non-traded	0.56	0.04
$\log \bar{a}_T$	external demand	0.81	0.07
$\log P_F$	price of foreign traded goods	0.54	0.01
T^g	capital transfer	0.92	0.01
$\bar{T}^l$	transfer anticipation, persistent	1.00	0.01
$\hat{T}^l$	transfer anticipation, transitory	0.00	0.11
$\log \bar{B}^g$	government debt	0.73	0.13
$\log \bar{B}^r$	rule-of-thumb debt	0.85	0.10
$\bar{r}$	government interest rate	0.87	0.01
$\bar{i}$	private interest rate	0.64	0.01
T^b_W	rest of the world asset valuation	-0.05	0.02
T^b_{Gd}	sovereign debt valuation	-0.08	0.04
T^b_{Ge}	bank equity injection	-0.08	0.04
$\log g^c_T$	government consumption, traded	0.89	0.12
$\log g^x_T$	government investment, traded	0.82	0.23
$\log g^c_N$	government consumption, non-traded	1.00	0.03
$\log g^x_N$	government investment, non-traded	0.76	0.28
$\log T^r$	transfers to rule-of-thumb	0.85	0.06
τ^c	tax rate on consumption	0.91	0.01
τ^x	tax rate on investment	1.00	0.01
τ^ℓ	tax rate on labor	0.86	0.02
τ^k_H	tax rate on capital, traded	0.84	0.03
τ^k_N	tax rate on capital, non-traded	1.00	0.03
κ_τ	prepayment fraction	0.96	0.08
π^θ	probability of idiosyncratic disaster	1.00	0.02
π^a	probability of aggregate disaster	0.76	0.12

Table C.2: Parameter Estimates

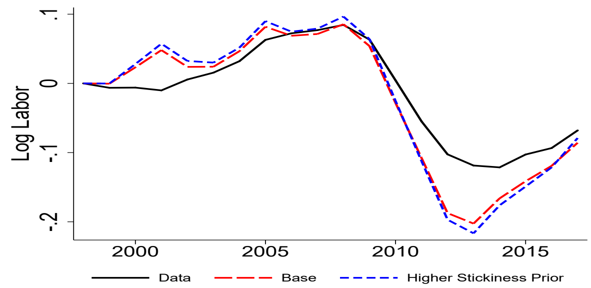
	Priors				Posteriors		
Parameter	Distribution	Support	Mean	St. Deviation	Mean	Median	90 Percent Interval
ρ	Beta	$[0, 2]$	0.50	0.40	0.97	0.97	[0.81,1.14]
ϕ	Gamma	$(0, \infty)$	0.44	0.40	3.17	3.14	[2.21,4.16]
ϵ	Gamma	$(0, \infty)$	1.50	0.75	1.16	1.06	[0.44,1.88]
κ_x	Beta	$[0, 1]$	0.50	0.20	0.60	0.60	[0.39,0.80]
κ_ℓ	Beta	$[0, 1]$	0.50	0.20	0.06	0.06	[0.01,0.10]
ζ	Beta	$[0, 1]$	0.23	0.13	0.34	0.35	[0.21,0.47]
φ^θ	Beta	$[0, 1]$	0.20	0.04	0.16	0.16	[0.14,0.17]
ξ_H	Gamma	$(0, \infty)$	7.00	1.00	3.12	3.11	[2.89,3.34]
ξ_N	Gamma	$(0, \infty)$	7.00	1.00	3.75	3.72	[3.30,4.16]
δ_b	Beta	$(0, \infty)$	0.50	0.20	0.70	0.71	[0.53,0.90]
ψ_π	Gamma	$(0, \infty)$	0.50	0.25	0.60	0.55	[0.14,1.04]
ψ_x	Gamma	$(0, \infty)$	7.00	2.00	6.28	6.12	[3.71,8.74]
ψ_ℓ	Gamma	$(0, \infty)$	1.00	0.25	1.52	1.50	[1.00,2.02]
$\psi_{H,p}$	Gamma	$(0, \infty)$	40.00	25.00	79.3	76.0	[39.5,119.0]
$\psi_{N,p}$	Gamma	$(0, \infty)$	40.00	25.00	36.5	35.3	[18.3,53.7]
ψ_w	Gamma	$(0, \infty)$	40.00	25.00	78.4	74.8	[43.1,112.5]

Table C.3: Parameter Estimates with Higher Prior Means for Price and Wage Adjustment Costs

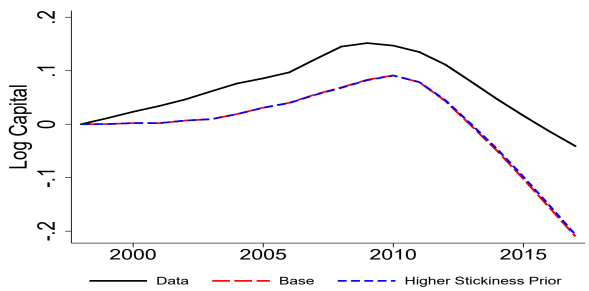
	Priors				Posteriors		
Parameter	Distribution	Support	Mean	St. Deviation	Mean	Median	90 Percent Interval
ρ	Beta	$[0,2]$	0.50	0.40	0.97	0.97	[0.81,1.13]
ϕ	Gamma	$(0,\infty)$	0.44	0.40	3.64	3.59	[2.57,4.67]
ϵ	Gamma	$(0,\infty)$	1.50	0.75	0.89	0.83	[0.43,1.38]
κ_x	Beta	$[0,1]$	0.50	0.20	0.56	0.58	[0.29,0.79]
κ_ℓ	Beta	$[0,1]$	0.50	0.20	0.06	0.05	[0.01,0.10]
ζ	Beta	$[0,1]$	0.23	0.13	0.31	0.31	[0.18,0.44]
φ^θ	Beta	$[0,1]$	0.20	0.04	0.16	0.16	[0.14,0.17]
ξ_H	Gamma	$(0,\infty)$	7.00	1.00	3.21	3.19	[2.96,3.48]
ξ_N	Gamma	$(0,\infty)$	7.00	1.00	3.93	3.88	[3.40,4.44]
δ_b	Beta	$(0,\infty)$	0.50	0.20	0.66	0.68	[0.39,0.89]
ψ_π	Gamma	$(0,\infty)$	0.50	0.25	0.62	0.57	[0.14,1.09]
ψ_x	Gamma	$(0,\infty)$	7.00	2.00	6.63	6.42	[3.76,9.29]
ψ_ℓ	Gamma	$(0,\infty)$	1.00	0.25	1.54	1.52	[1.03,2.06]
$\psi_{H,p}$	Gamma	$(0,\infty)$	100.00	25.00	110.8	108.7	[72.5,148.1]
$\psi_{N,p}$	Gamma	$(0,\infty)$	100.00	25.00	66.6	65.1	[42.4,90.4]
ψ_w	Gamma	$(0,\infty)$	100.00	25.00	101.9	99.6	[67.5,136.2]



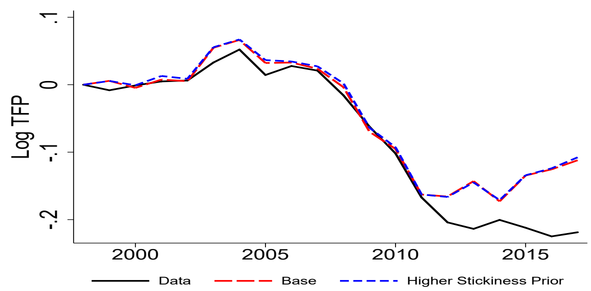
(a) Time Series of y



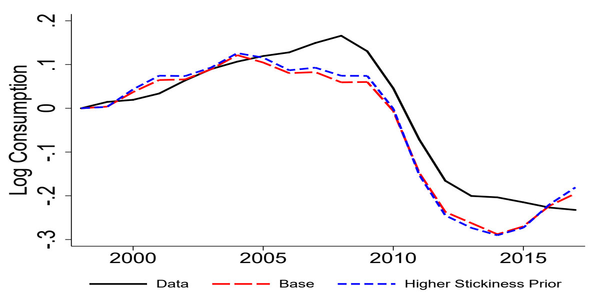
(b) Time Series of ℓ



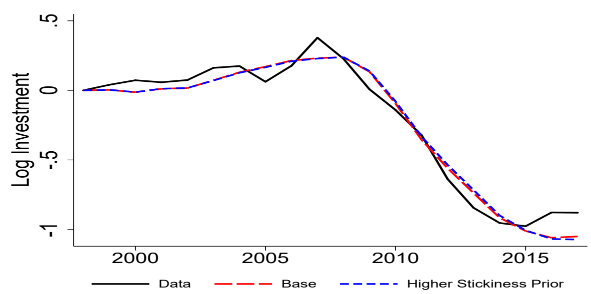
(c) Time Series of $\tilde{k}$



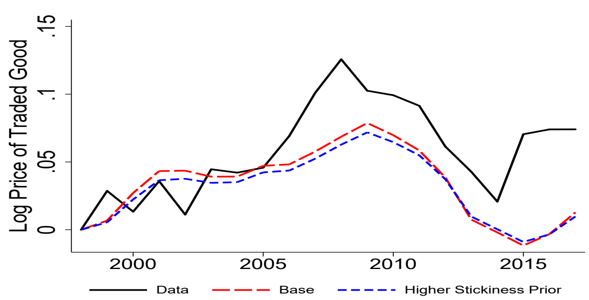
(d) Time Series of TFP



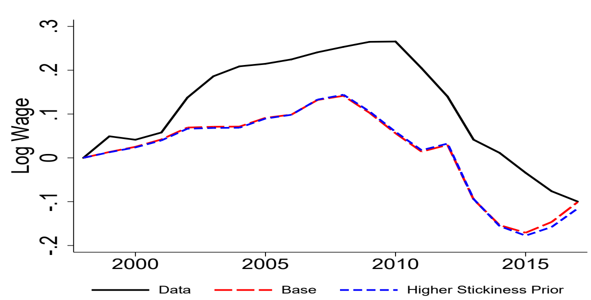
(e) Time Series of c



(f) Time Series of x

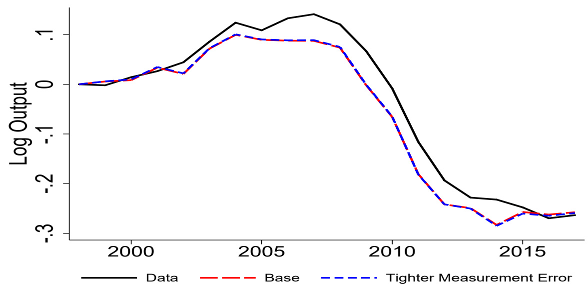


(g) Time Series of P_H

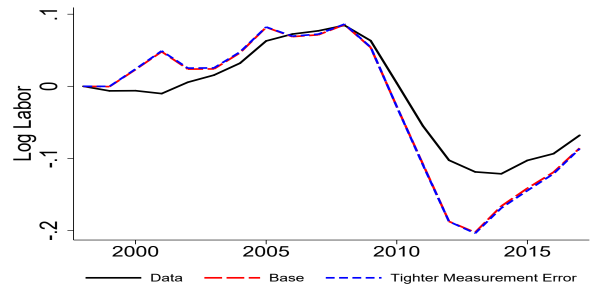


(h) Time Series of W

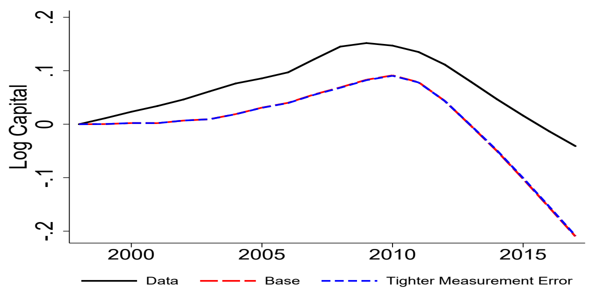
Figure C.1: Path of Variables with Higher Priors Means for Price and Wage Adjustment Costs



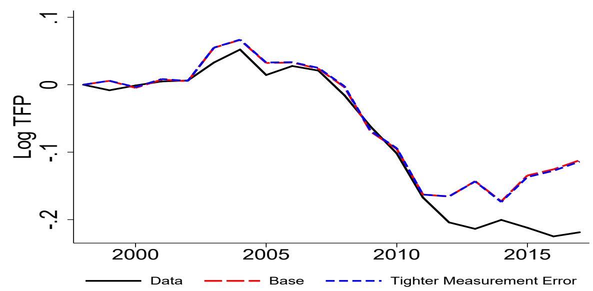
(a) Time Series of y



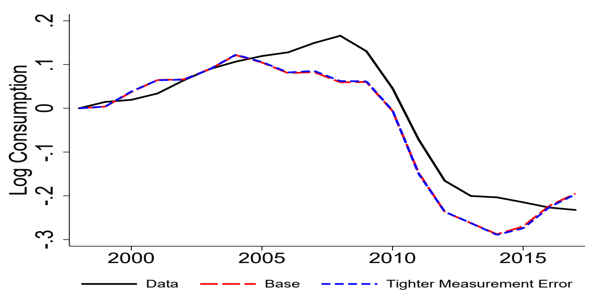
(b) Time Series of ℓ



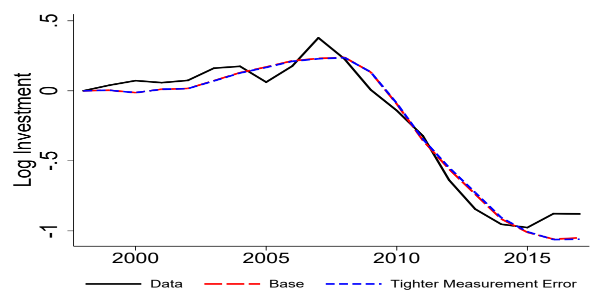
(c) Time Series of $\tilde{k}$



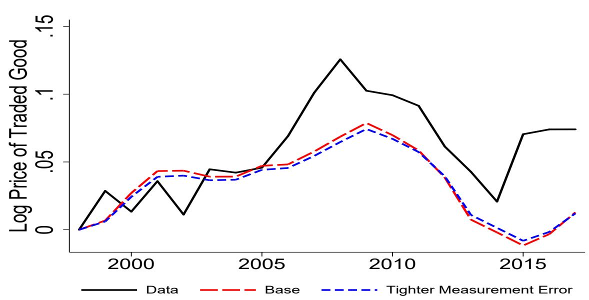
(d) Time Series of TFP



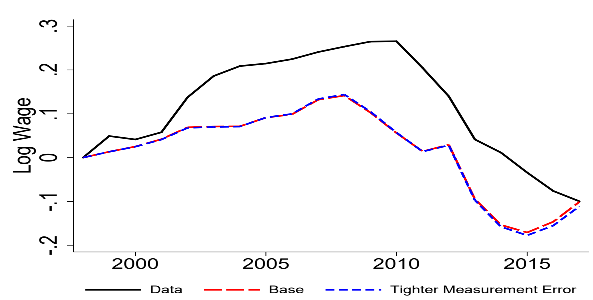
(e) Time Series of c



(f) Time Series of x

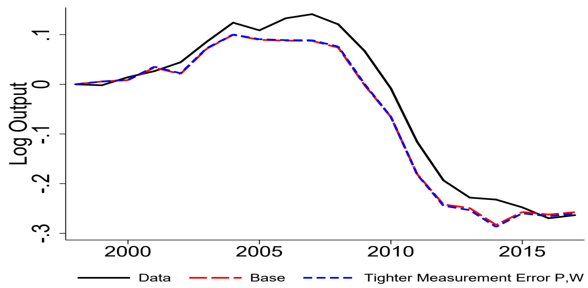


(g) Time Series of P_H

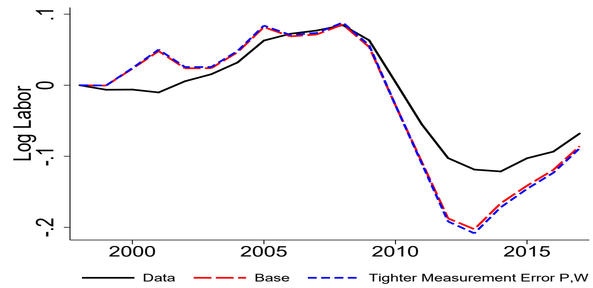


(h) Time Series of W

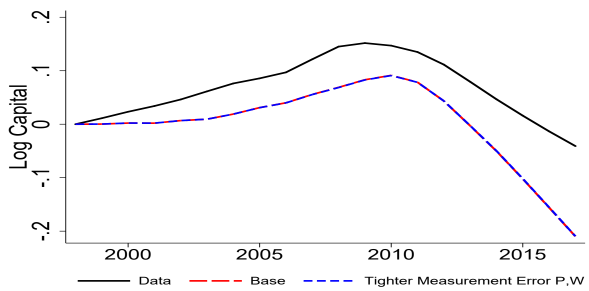
Figure C.2: Path of Variables with Tighter Measurement Error on All Variables



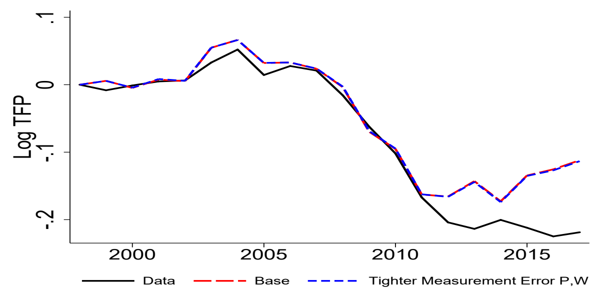
(a) Time Series of y



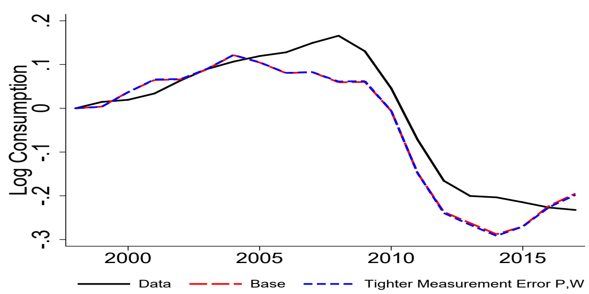
(b) Time Series of ℓ



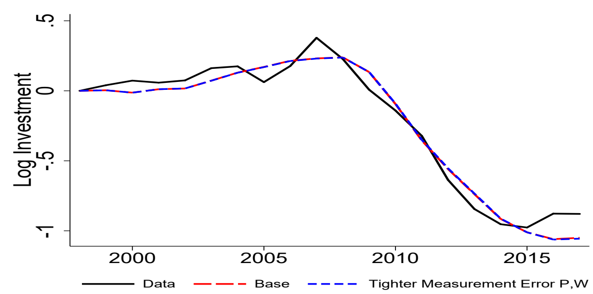
(c) Time Series of $\tilde{k}$



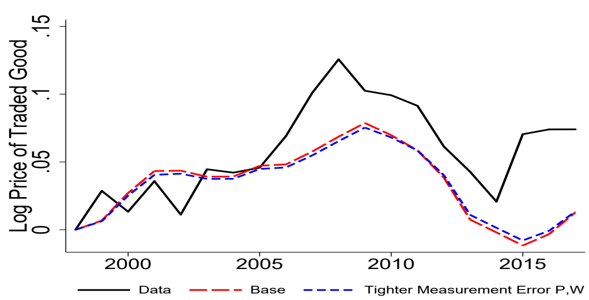
(d) Time Series of TFP



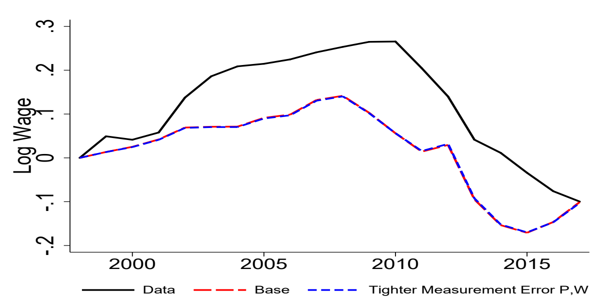
(e) Time Series of c



(f) Time Series of x

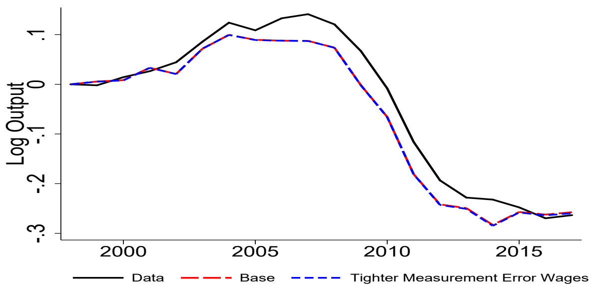


(g) Time Series of P_H

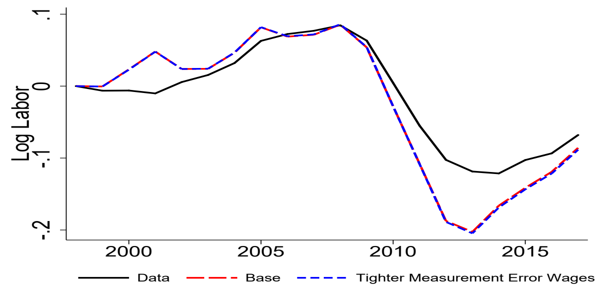


(h) Time Series of W

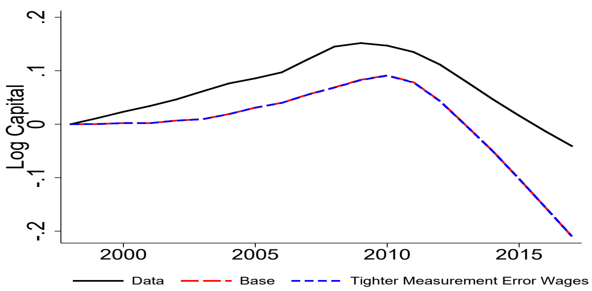
Figure C.3: Path of Variables with Tighter Measurement Error on Prices and Wages



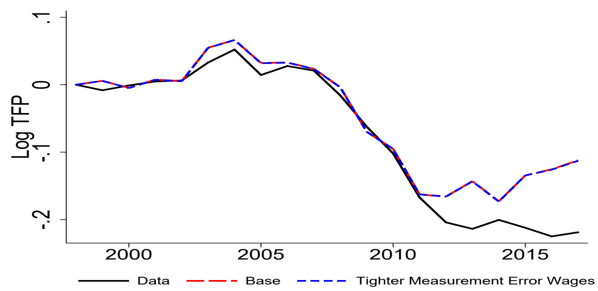
(a) Time Series of y



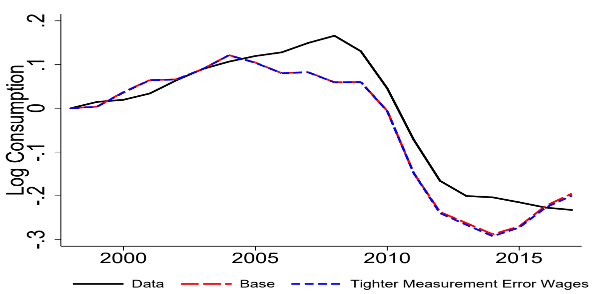
(b) Time Series of ℓ



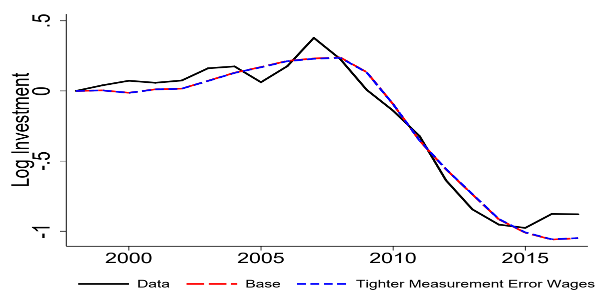
(c) Time Series of $\tilde{k}$



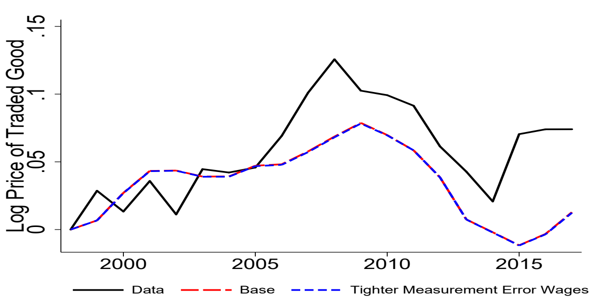
(d) Time Series of TFP



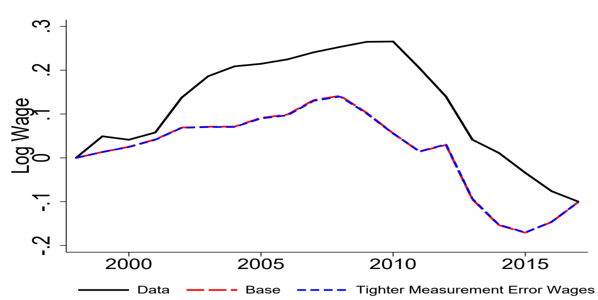
(e) Time Series of c



(f) Time Series of x



(g) Time Series of P_H

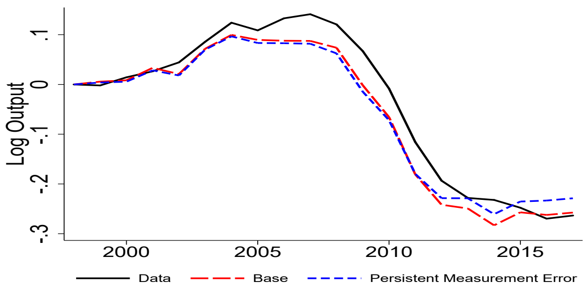


(h) Time Series of W

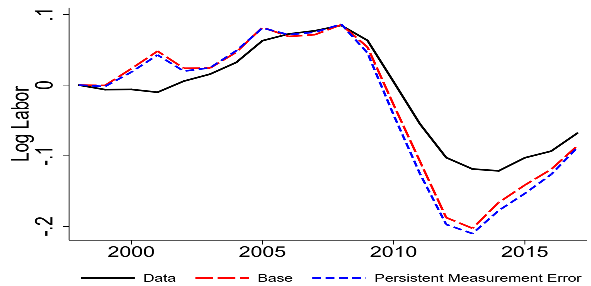
Figure C.4: Path of Variables with Tighter Measurement Error on Wages

Table C.4: Parameter Estimates with Serially Correlated Measurement Errors

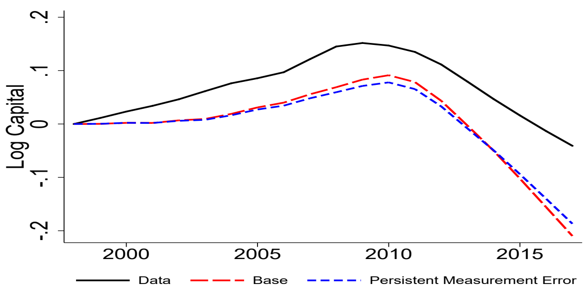
		Posterior Mean	
	Measurement Error	Baseline (i.i.d.)	Serially Correlated
ρ	intertemporal elasticity of substitution	0.97	0.90
ϕ	traded-nontraded elasticity	3.17	4.93
ϵ	frisch elasticity	1.16	1.46
κ_x	working capital, investment	0.60	0.70
κ_ℓ	working capital, labor	0.06	0.11
ζ	fraction rule-of-thumb	0.34	0.49
φ^θ	size of idiosyncratic disaster	0.16	0.16
ξ_H	utilization elasticity, traded	3.12	3.65
ξ_N	utilization elasticity, non-traded	3.75	4.15
δ_b	exit rate, bankers	0.70	0.58
ψ_π	adjustment cost, profits	0.60	0.54
ψ_x	adjustment cost, investment	6.28	6.49
ψ_ℓ	adjustment cost, labor	1.52	1.74
$\psi_{H,p}$	adjustment cost, prices traded	79.3	71.7
$\psi_{N,p}$	adjustment cost, prices non-traded	36.5	43.8
ψ_w	adjustment cost, wages	78.4	77.8



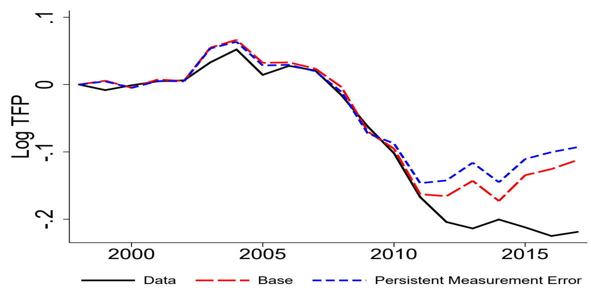
(a) Time Series of y



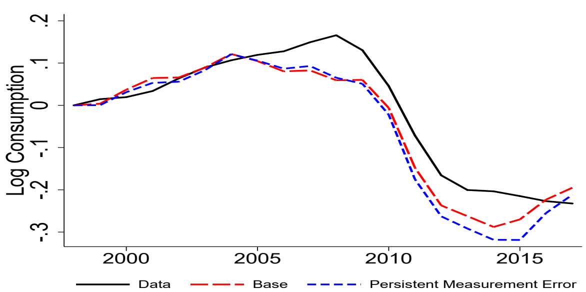
(b) Time Series of ℓ



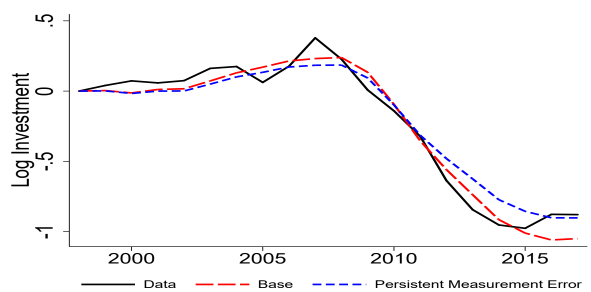
(c) Time Series of $\tilde{k}$



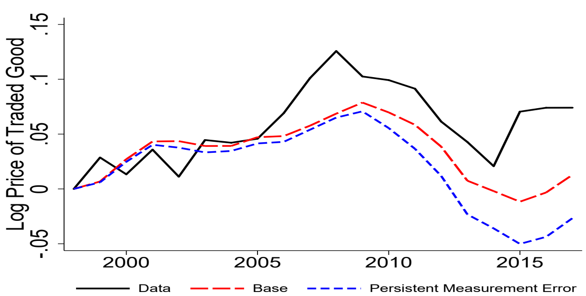
(d) Time Series of TFP



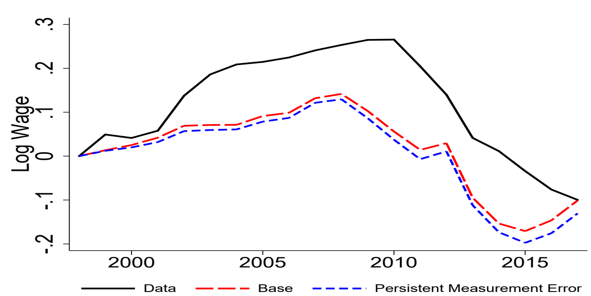
(e) Time Series of c



(f) Time Series of x



(g) Time Series of P_H



(h) Time Series of W

Figure C.5: Path of Variables with Serially Correlated Measurement Errors

Table C.5: Robustness of Sources of Macroeconomic Dynamics: Boom Period 1998-2007

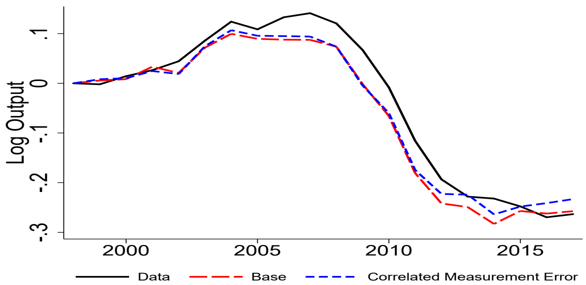
	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log \mathrm{TFP}$	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	0.14	0.08	0.12	0.02	0.15	0.10	0.18	0.24	-0.03
Model	0.08	0.07	0.05	0.02	0.09	0.05	0.08	0.12	-0.04
Productivity	0.00	0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
$\log z_H$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log z_N$	0.00	0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
External	0.04	0.03	0.02	0.01	0.04	0.04	0.05	0.07	0.00
$\log \bar{a}_T$	0.04	0.04	0.01	0.01	0.02	0.02	0.03	0.04	0.02
$\log P_F$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^g	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.01	-0.01
T^l	-0.01	-0.01	0.00	0.00	0.01	0.01	0.01	0.02	-0.01
Financial	0.00	-0.01	0.01	0.00	0.01	0.01	0.01	0.02	-0.01
$\log \bar{B}^g$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log \bar{B}^r$	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	-0.01	0.01
$\bar{r}$	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00
$\bar{i}$	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.01	-0.01
T^b_W	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^b_{Gd}	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00
T^b_{Ge}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gov Spending	0.04	0.04	0.03	0.01	0.01	0.00	0.00	0.01	-0.03
$\log g^c_T$	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	-0.01
$\log g^c_N$	0.02	0.02	0.00	0.00	-0.03	0.00	0.00	-0.01	0.00
$\log g^x_T$	0.01	0.01	0.02	0.00	0.00	-0.01	-0.01	0.00	-0.01
$\log g^x_N$	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
$\log T^r$	0.01	0.00	0.00	0.01	0.03	0.01	0.01	0.02	-0.01
Tax Policy	0.00	0.00	-0.01	0.00	0.00	-0.01	0.01	0.01	0.00
τ^c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^x	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^ℓ	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^k_H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^k_N	-0.01	0.00	-0.01	0.00	-0.01	0.00	0.01	0.00	0.00
κ_τ	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Disaster Risk	0.01	0.00	0.00	0.00	0.03	0.01	0.01	0.02	-0.01
π^θ	0.00	0.00	0.00	0.00	0.03	0.01	0.01	0.02	-0.01
π^a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table C.6: Robustness of Sources of Macroeconomic Dynamics: Bust Period 2007-2017

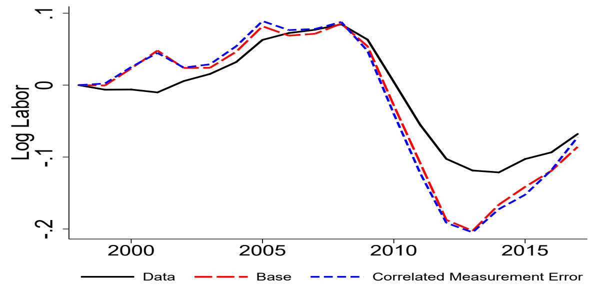
	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log \mathrm{TFP}$	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	-0.40	-0.14	-0.16	-0.24	-0.38	-0.03	-0.11	-0.34	0.11
Model	-0.31	-0.16	-0.23	-0.11	-0.30	-0.08	-0.04	-0.25	0.13
Productivity	-0.02	0.00	0.00	-0.02	-0.03	-0.01	0.03	-0.01	-0.01
$\log z_H$	0.01	0.00	0.00	0.01	0.00	-0.01	0.00	0.00	0.00
$\log z_N$	-0.03	0.01	0.00	-0.03	-0.03	0.00	0.03	-0.01	-0.01
External	-0.05	-0.04	-0.01	-0.02	-0.05	-0.05	-0.06	-0.09	0.00
$\log \bar{a}_T$	-0.05	-0.06	0.00	-0.02	-0.02	-0.03	-0.04	-0.05	-0.03
$\log P_F$	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^g	-0.01	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
T^l	0.01	0.02	-0.01	0.00	-0.02	-0.02	-0.03	-0.04	0.02
Financial	-0.01	0.02	-0.04	0.00	0.03	0.02	0.02	0.01	-0.01
$\log \bar{B}^g$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log \bar{B}^r$	0.01	0.01	-0.01	0.01	0.00	0.00	0.00	0.01	-0.01
$\bar{r}$	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	-0.01
$\bar{i}$	0.02	0.03	0.01	0.00	0.05	0.00	0.01	0.01	-0.01
T^b_W	-0.02	-0.01	-0.02	0.00	-0.02	0.00	0.00	-0.02	0.01
T^b_{Gd}	-0.04	-0.02	-0.05	0.00	-0.02	0.01	0.01	-0.02	0.01
T^b_{Ge}	0.02	0.01	0.03	0.00	0.01	-0.01	-0.01	0.01	-0.01
Gov Spending	-0.08	-0.08	-0.05	-0.02	0.01	0.00	-0.01	-0.02	0.05
$\log g^c_T$	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
$\log g^c_N$	-0.04	-0.05	0.00	-0.01	0.06	-0.01	-0.01	0.01	0.01
$\log g^x_T$	-0.02	-0.01	-0.03	0.00	-0.01	0.01	0.01	0.00	0.01
$\log g^x_N$	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	-0.01	0.00
$\log T^r$	-0.01	-0.01	0.01	-0.01	-0.05	-0.01	-0.01	-0.02	0.01
Tax Policy	-0.17	-0.12	-0.11	-0.05	-0.13	0.06	0.09	0.03	0.02
τ^c	-0.01	-0.01	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
τ^x	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
τ^ℓ	-0.03	-0.06	0.00	0.00	-0.04	0.01	0.02	0.07	0.00
τ^k_H	-0.01	0.00	0.00	-0.01	0.00	0.01	0.00	0.00	0.00
τ^k_N	-0.04	-0.01	-0.04	-0.02	-0.03	0.00	0.04	-0.01	0.00
κ_τ	-0.06	-0.04	-0.06	-0.02	-0.03	0.03	0.03	-0.03	0.02
Disaster Risk	0.01	0.06	-0.03	0.00	-0.13	-0.09	-0.10	-0.18	0.08
π^θ	0.01	0.06	-0.02	-0.01	-0.14	-0.09	-0.10	-0.18	0.08
π^a	0.00	0.00	0.00	0.00	0.01	0.00	0.00	-0.01	0.00

Table C.7: Parameter Estimates with Contemporaneously Correlated Measurement Error

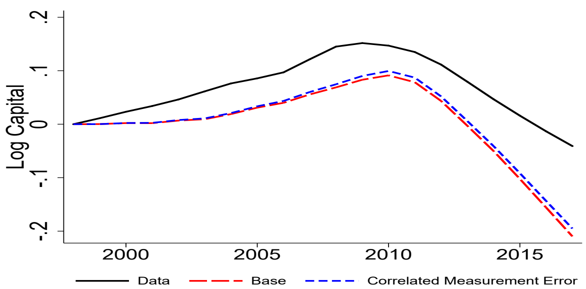
		Posterior Mean	
		Baseline	Contemporaneous Correlation
Parameters			
ρ	intertemporal elasticity of substitution	0.97	0.84
ϕ	traded-nontraded elasticity	3.17	2.02
ϵ	frisch elasticity	1.16	0.35
κ_x	working capital, investment	0.60	0.69
κ_ℓ	working capital, labor	0.06	0.09
ζ	fraction rule-of-thumb	0.34	0.46
φ^θ	size of idiosyncratic disaster	0.16	0.15
ξ_H	utilization elasticity, traded	3.12	3.33
ξ_N	utilization elasticity, non-traded	3.75	4.06
δ_b	exit rate, bankers	0.70	0.81
ψ_π	adjustment cost, profits	0.60	0.26
ψ_x	adjustment cost, investment	6.28	7.25
ψ_ℓ	adjustment cost, labor	1.52	1.74
$\psi_{H,p}$	adjustment cost, prices traded	79.3	41.7
$\psi_{N,p}$	adjustment cost, prices non-traded	36.5	22.4
ψ_w	adjustment cost, wages	78.4	210.4



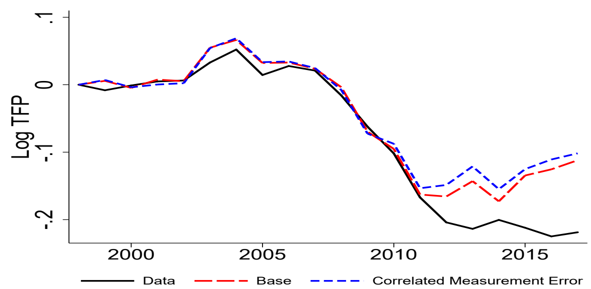
(a) Time Series of y



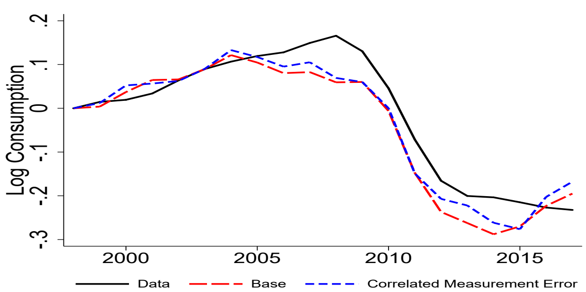
(b) Time Series of ℓ



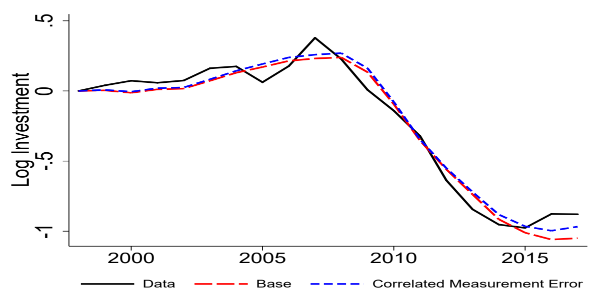
(c) Time Series of $\tilde{k}$



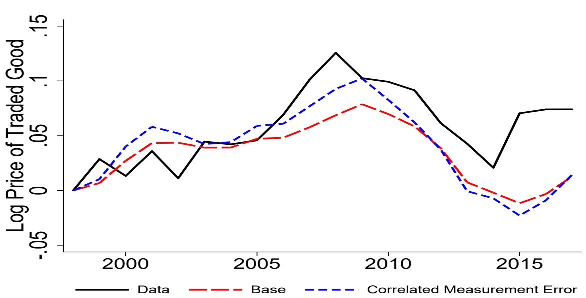
(d) Time Series of TFP



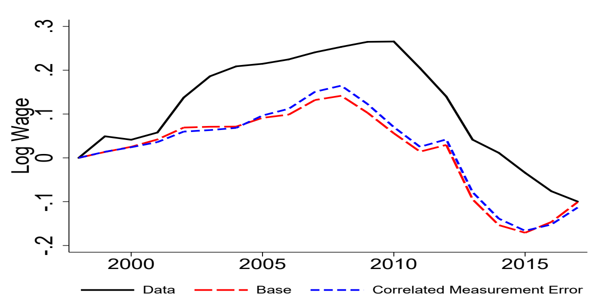
(e) Time Series of c



(f) Time Series of x



(g) Time Series of P_H



(h) Time Series of W

Figure C.6: Path of Variables with Contemporaneously Correlated Measurement Error

Table C.8: Robustness of Sources of Macroeconomic Dynamics: Boom Period 1998-2007

	$\log y$	$\log \ell$	$\log \tilde{k}$	log TFP	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	0.14	0.08	0.12	0.02	0.15	0.10	0.18	0.24	-0.03
Model	0.09	0.08	0.06	0.02	0.11	0.08	0.11	0.15	-0.04
Productivity	0.00	0.01	0.00	-0.01	0.00	0.00	0.01	0.00	0.00
$\log z_H$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log z_N$	0.00	0.01	0.00	-0.01	0.00	0.00	0.01	0.00	0.00
External	0.05	0.03	0.03	0.02	0.06	0.06	0.07	0.09	0.00
$\log \bar{a}_T$	0.04	0.04	0.02	0.02	0.02	0.03	0.04	0.06	0.02
$\log P_F$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^g	0.01	0.01	0.00	0.00	0.02	0.01	0.01	0.01	-0.01
T^l	0.00	-0.01	0.01	0.00	0.02	0.02	0.02	0.02	-0.01
Financial	0.01	0.00	0.01	0.00	0.02	0.01	0.01	0.01	-0.01
$\log \bar{B}^g$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log \bar{B}^r$	-0.01	-0.01	-0.02	0.00	0.00	0.00	0.01	-0.02	0.01
$\bar{r}$	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00
$\bar{i}$	0.01	0.00	0.02	0.00	0.01	0.00	0.00	0.02	-0.01
T^b_W	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^b_{Gd}	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00
T^b_{Ge}	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
Gov Spending	0.04	0.03	0.03	0.01	0.00	0.00	0.00	0.02	-0.03
$\log g^c_T$	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	-0.01
$\log g^c_N$	0.01	0.01	0.00	0.00	-0.04	0.01	0.01	0.00	0.00
$\log g^x_T$	0.01	0.00	0.02	0.00	0.00	-0.01	-0.01	0.00	-0.01
$\log g^x_N$	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
$\log T^r$	0.01	0.01	0.00	0.01	0.04	0.01	0.01	0.02	-0.01
Tax Policy	0.00	0.00	-0.01	0.00	0.00	0.00	0.01	0.01	0.00
τ^c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^x	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^ℓ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
τ^k_H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^k_N	-0.01	0.00	-0.01	0.00	-0.01	0.00	0.01	0.00	0.00
κ_τ	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Disaster Risk	0.01	0.00	0.00	0.00	0.02	0.01	0.01	0.01	-0.01
π^θ	0.01	0.00	0.00	0.00	0.02	0.01	0.01	0.01	-0.01
π^a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table C.9: Robustness of Sources of Macroeconomic Dynamics: Bust Period 2007-2017

	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log \mathrm{TFP}$	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	-0.40	-0.14	-0.16	-0.24	-0.38	-0.03	-0.11	-0.34	0.11
Model	-0.33	-0.15	-0.26	-0.13	-0.27	-0.06	-0.01	-0.26	0.13
Productivity	-0.02	0.01	0.00	-0.02	-0.03	-0.01	0.04	0.00	0.00
$\log z_H$	0.01	0.00	0.00	0.01	0.00	-0.01	0.00	0.00	0.00
$\log z_N$	-0.02	0.01	0.00	-0.03	-0.03	0.01	0.04	0.00	0.00
External	-0.06	-0.05	-0.01	-0.03	-0.07	-0.08	-0.09	-0.13	0.00
$\log \bar{a}_T$	-0.06	-0.06	0.00	-0.03	-0.02	-0.05	-0.06	-0.09	-0.02
$\log P_F$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^g	-0.01	-0.01	0.01	0.00	-0.01	0.00	0.00	0.00	0.00
T^l	0.00	0.01	-0.02	0.00	-0.04	-0.03	-0.03	-0.04	0.02
Financial	-0.01	0.02	-0.05	0.00	0.02	0.02	0.03	0.00	-0.01
$\log \bar{B}^g$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log \bar{B}^r$	0.01	0.02	-0.02	0.01	0.00	0.00	0.00	0.02	-0.02
$\bar{r}$	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.01	-0.01
$\bar{i}$	0.01	0.02	0.01	0.00	0.03	0.00	0.01	0.00	-0.01
T^b_W	-0.02	-0.01	-0.03	0.00	-0.02	0.00	0.00	-0.02	0.01
T^b_{Gd}	-0.04	-0.02	-0.06	0.00	-0.02	0.02	0.01	-0.03	0.02
T^b_{Ge}	0.02	0.01	0.03	0.00	0.01	-0.01	-0.01	0.02	-0.01
Gov Spending	-0.07	-0.06	-0.04	-0.02	0.02	-0.01	-0.02	-0.04	0.05
$\log g^c_T$	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
$\log g^c_N$	-0.02	-0.03	0.00	-0.01	0.08	-0.01	-0.02	-0.01	0.01
$\log g^x_T$	-0.02	-0.01	-0.04	0.00	0.00	0.01	0.01	0.00	0.01
$\log g^x_N$	-0.01	0.00	-0.02	0.00	0.00	0.00	0.00	-0.01	0.00
$\log T^r$	-0.02	-0.02	0.01	-0.02	-0.06	-0.01	-0.02	-0.02	0.01
Tax Policy	-0.15	-0.08	-0.11	-0.05	-0.09	0.08	0.11	0.03	0.03
τ^c	-0.01	-0.01	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
τ^x	-0.01	0.00	-0.01	0.00	0.00	0.01	0.01	0.00	0.00
τ^ℓ	-0.03	-0.04	0.00	0.00	-0.04	0.01	0.01	0.05	0.00
τ^k_H	-0.01	0.00	-0.01	-0.01	0.00	0.02	0.00	0.00	0.00
τ^k_N	-0.04	0.00	-0.03	-0.02	-0.02	0.02	0.06	0.01	0.00
κ_τ	-0.06	-0.02	-0.06	-0.01	-0.02	0.04	0.03	-0.03	0.02
Disaster Risk	-0.02	0.01	-0.04	-0.01	-0.12	-0.07	-0.08	-0.13	0.06
π^θ	-0.02	0.01	-0.03	-0.01	-0.13	-0.07	-0.07	-0.13	0.05
π^a	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.01	0.00

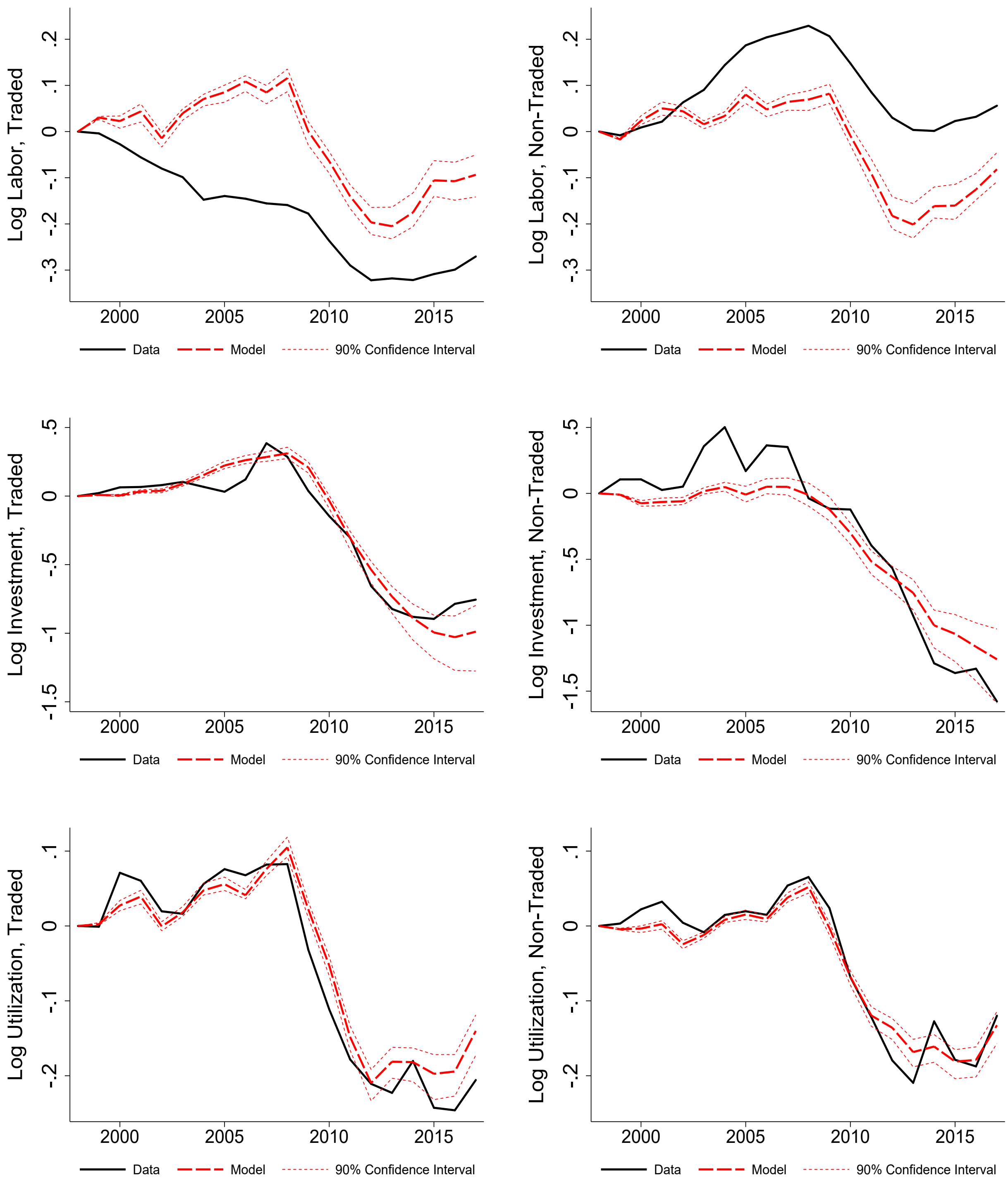
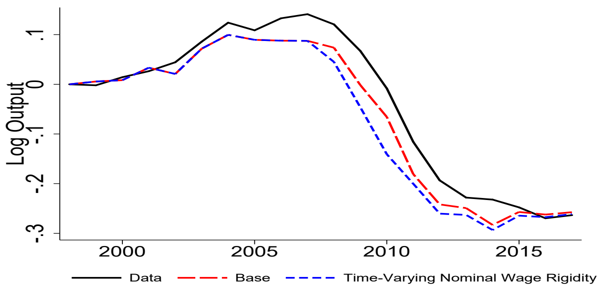
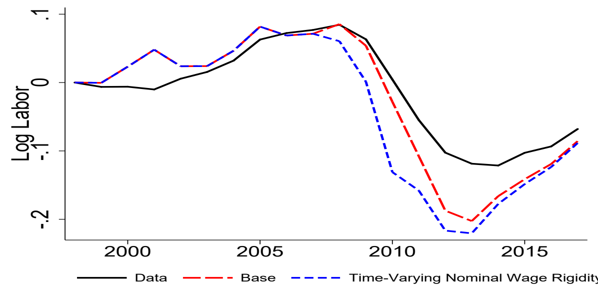


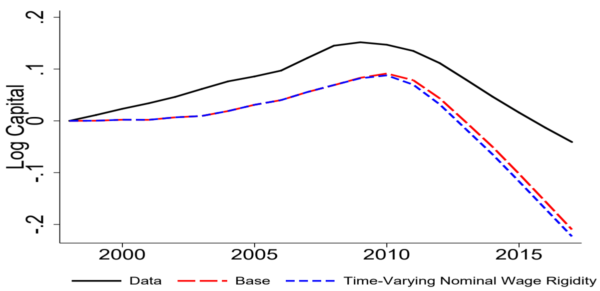
Figure C.7: Additional Sectoral Outcomes



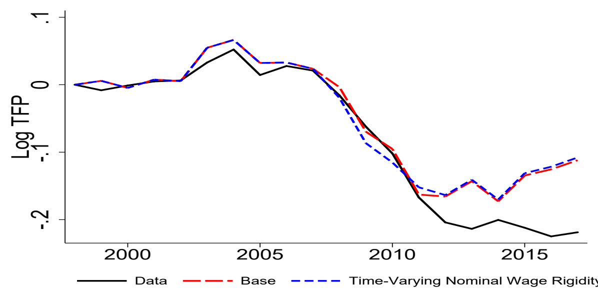
(a) Time Series of y



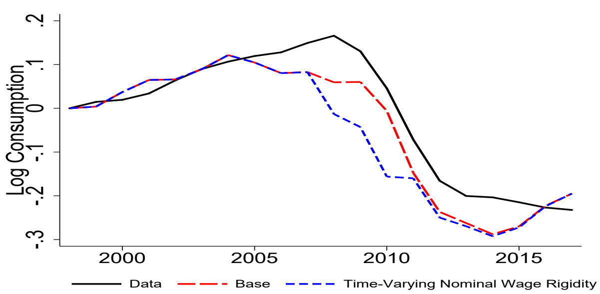
(b) Time Series of ℓ



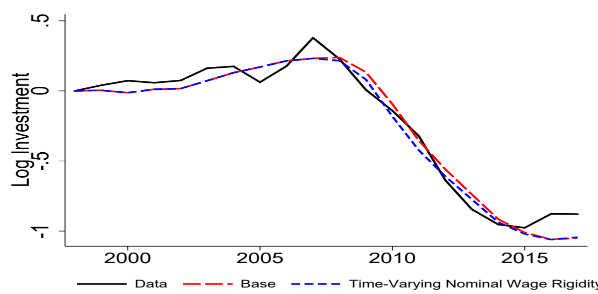
(c) Time Series of $\tilde{k}$



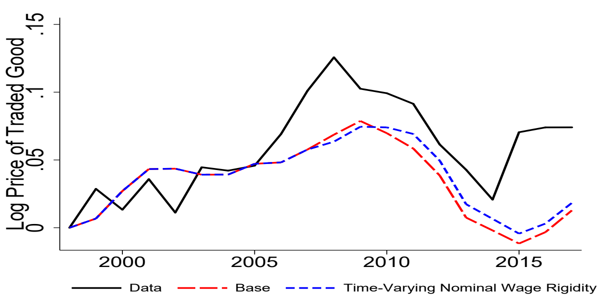
(d) Time Series of TFP



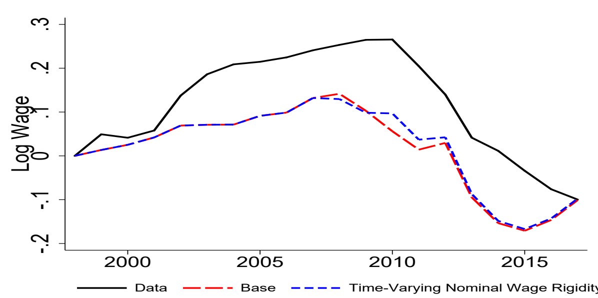
(e) Time Series of c



(f) Time Series of x



(g) Time Series of P_H



(h) Time Series of W

Figure C.8: Path of Variables with Time-Varying Nominal Wage Rigidity

Table C.10: Covariations with Variables in the Data

	Model Variable		Residual	
Data Variable	Correlation	Variance Fraction	Correlation	Variance Fraction
Output	0.98	0.97	0.22	0.05
Capital	0.86	0.73	-0.22	0.05
TFP	0.96	0.92	0.75	0.57
Consumption	0.96	0.92	0.02	0.00
Investment	0.98	0.96	-0.02	0.00
Net Exports / GDP	0.93	0.87	-0.50	0.25
Output, Traded	0.96	0.92	0.43	0.18
Output, Non-Traded	0.98	0.96	-0.04	0.00
Labor	0.96	0.92	-0.65	0.43
Prices, Traded	0.56	0.32	0.66	0.43
Prices, Non-Traded	0.59	0.34	0.87	0.76
Wages	0.86	0.73	0.60	0.36

Table C.11: Robustness of Sources of Macroeconomic Dynamics: Bust Period 2007-2017

	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log \mathrm{TFP}$	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	-0.40	-0.14	-0.16	-0.24	-0.38	-0.03	-0.11	-0.34	0.11
Model	-0.35	-0.16	-0.28	-0.13	-0.28	-0.04	0.01	-0.23	0.12
Productivity	-0.02	0.01	0.00	-0.02	-0.03	-0.01	0.03	0.00	0.00
$\log z_H$	0.01	0.00	0.00	0.01	0.00	-0.01	0.00	0.00	0.00
$\log z_N$	-0.02	0.01	0.00	-0.03	-0.03	0.00	0.03	0.00	-0.01
External	-0.06	-0.05	-0.01	-0.03	-0.05	-0.05	-0.07	-0.10	-0.01
$\log \bar{a}_T$	-0.06	-0.06	0.00	-0.03	-0.01	-0.03	-0.04	-0.06	-0.03
$\log P_F$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^g	-0.01	-0.01	0.01	0.00	-0.01	0.00	0.00	0.00	0.00
T^l	0.00	0.02	-0.02	0.00	-0.03	-0.03	-0.03	-0.04	0.02
Financial	-0.01	0.02	-0.06	0.01	0.03	0.02	0.03	0.01	-0.01
$\log \bar{B}^g$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log \bar{B}^r$	0.01	0.01	-0.02	0.01	-0.01	0.00	0.00	0.01	-0.01
$\bar{r}$	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	-0.01
$\bar{i}$	0.02	0.03	0.01	0.00	0.05	0.00	0.01	0.01	-0.01
T^b_W	-0.02	-0.01	-0.03	0.00	-0.02	0.00	0.00	-0.01	0.01
T^b_{Gd}	-0.04	-0.02	-0.06	0.00	-0.02	0.02	0.02	-0.02	0.02
T^b_{Ge}	0.02	0.01	0.03	0.00	0.01	-0.01	-0.01	0.01	-0.01
Gov Spending	-0.08	-0.07	-0.05	-0.02	0.02	0.00	0.00	-0.01	0.04
$\log g^c_T$	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01
$\log g^c_N$	-0.04	-0.05	0.00	-0.01	0.06	-0.01	-0.01	0.01	0.01
$\log g^x_T$	-0.02	-0.01	-0.03	0.00	0.00	0.01	0.01	0.00	0.01
$\log g^x_N$	-0.01	-0.01	-0.02	0.00	0.00	0.00	0.00	-0.01	0.00
$\log T^r$	-0.01	-0.01	0.01	-0.01	-0.04	-0.01	-0.01	-0.02	0.01
Tax Policy	-0.18	-0.11	-0.12	-0.06	-0.12	0.09	0.12	0.06	0.02
τ^c	-0.01	-0.01	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
τ^x	-0.01	0.00	-0.01	0.00	0.00	0.01	0.01	0.00	0.00
τ^ℓ	-0.03	-0.05	0.00	0.00	-0.03	0.01	0.02	0.07	0.00
τ^k_H	-0.01	0.00	0.00	-0.01	0.00	0.01	0.00	0.00	0.00
τ^k_N	-0.05	-0.01	-0.04	-0.02	-0.03	0.01	0.06	0.00	0.00
κ_τ	-0.07	-0.04	-0.07	-0.02	-0.02	0.04	0.04	-0.02	0.02
Disaster Risk	0.00	0.05	-0.04	-0.01	-0.14	-0.09	-0.10	-0.18	0.07
π^θ	-0.01	0.05	-0.03	-0.01	-0.14	-0.09	-0.10	-0.18	0.07
π^a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table C.12: Robustness of Sources of Macroeconomic Dynamics: Boom Period 1998-2007

	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log \mathrm{TFP}$	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	0.14	0.08	0.12	0.02	0.15	0.10	0.18	0.24	-0.03
Model	0.13	0.09	0.07	0.05	0.11	0.06	0.10	0.14	-0.06
Productivity	0.00	0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
$\log z_H$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log z_N$	0.00	0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
External	0.08	0.06	0.03	0.03	0.04	0.05	0.06	0.09	-0.01
$\log \bar{a}_T$	0.06	0.05	0.02	0.02	0.01	0.03	0.04	0.05	0.01
$\log P_F$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^g	0.02	0.02	0.00	0.01	0.02	0.01	0.01	0.02	-0.01
T^l	0.00	-0.01	0.01	0.00	0.01	0.01	0.01	0.02	-0.01
Financial	0.06	0.02	0.03	0.03	0.03	0.01	0.02	0.02	-0.03
$\log \bar{B}^g$	0.03	0.02	0.01	0.02	0.01	0.00	0.00	0.00	-0.01
$\log \bar{B}^r$	-0.02	-0.01	-0.02	0.00	0.00	0.00	0.00	-0.01	0.01
$\bar{r}$	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	-0.01
$\bar{i}$	0.01	0.00	0.03	0.00	0.00	0.00	0.00	0.02	-0.01
T^b_W	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^b_{Gd}	0.02	0.01	0.00	0.01	0.01	0.00	0.00	0.00	-0.01
T^b_{Ge}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gov Spending	-0.01	-0.01	0.01	-0.01	0.02	-0.01	-0.01	0.00	0.00
$\log g^c_T$	-0.01	0.00	-0.01	0.00	-0.01	0.00	-0.01	-0.01	0.00
$\log g^c_N$	0.00	0.01	0.00	0.00	-0.01	0.01	0.01	0.00	0.00
$\log g^x_T$	0.00	0.00	0.01	0.00	0.00	-0.01	-0.01	-0.01	0.00
$\log g^x_N$	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
$\log T^r$	-0.01	-0.01	0.00	0.00	0.03	0.00	0.00	0.01	0.00
Tax Policy	0.00	0.00	-0.01	0.00	-0.01	-0.01	0.01	0.00	0.00
τ^c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^x	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^ℓ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^k_H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^k_N	-0.01	0.00	-0.01	0.00	-0.01	0.00	0.01	0.00	0.00
κ_τ	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Disaster Risk	0.01	0.00	0.00	0.01	0.03	0.01	0.01	0.02	-0.01
π^θ	0.01	0.00	0.00	0.01	0.03	0.01	0.01	0.02	-0.01
π^a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table C.13: Robustness of Sources of Macroeconomic Dynamics: Bust Period 2007-2017

	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log \text{TFP}$	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	-0.40	-0.14	-0.16	-0.24	-0.38	-0.03	-0.11	-0.34	0.11
Model	-0.32	-0.12	-0.25	-0.14	-0.32	-0.06	-0.02	-0.25	0.12
Productivity	-0.02	0.00	-0.01	-0.02	-0.03	-0.01	0.03	-0.01	0.00
$\log z_H$	0.01	0.00	0.00	0.01	0.00	-0.01	0.00	0.00	0.00
$\log z_N$	-0.03	0.01	-0.01	-0.03	-0.03	0.00	0.03	0.00	0.00
External	-0.09	-0.08	0.00	-0.05	-0.05	-0.07	-0.09	-0.12	0.02
$\log \bar{a}_T$	-0.08	-0.08	0.00	-0.04	-0.01	-0.04	-0.05	-0.07	-0.01
$\log P_F$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^g	-0.02	-0.02	0.02	-0.02	-0.01	0.00	-0.01	0.00	0.01
T^l	0.00	0.01	-0.02	0.00	-0.03	-0.03	-0.03	-0.04	0.02
Financial	-0.02	0.02	-0.03	-0.01	0.03	0.00	0.01	0.00	0.00
$\log \bar{B}^g$	-0.01	-0.01	0.02	-0.01	0.00	-0.01	-0.01	-0.01	0.01
$\log \bar{B}^r$	0.01	0.02	-0.03	0.02	-0.01	0.01	0.01	0.02	-0.02
$\bar{r}$	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02	-0.01
$\bar{i}$	0.03	0.03	0.02	0.00	0.05	0.00	0.00	0.01	-0.01
T^b_W	-0.03	-0.02	-0.03	0.00	-0.01	0.00	0.00	-0.02	0.02
T^b_{Gd}	-0.06	-0.03	-0.05	-0.02	-0.02	0.01	0.01	-0.02	0.03
T^b_{Ge}	0.03	0.01	0.03	0.00	0.01	-0.01	-0.01	0.01	-0.01
Gov Spending	0.00	0.00	-0.05	0.02	-0.01	0.01	0.02	0.01	0.00
$\log g^c_T$	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00
$\log g^c_N$	-0.01	-0.02	0.00	0.00	0.02	-0.02	-0.02	-0.01	0.00
$\log g^x_T$	0.00	0.01	-0.02	0.01	0.00	0.02	0.02	0.02	0.00
$\log g^x_N$	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
$\log T^r$	0.00	0.01	-0.01	0.01	-0.04	0.00	0.00	-0.01	0.00
Tax Policy	-0.15	-0.09	-0.11	-0.05	-0.12	0.09	0.13	0.07	0.01
τ^c	0.00	0.00	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
τ^x	0.00	0.00	-0.01	0.00	0.00	0.01	0.01	0.00	0.00
τ^ℓ	-0.01	-0.03	0.01	0.01	-0.03	0.02	0.03	0.08	-0.02
τ^k_H	-0.01	0.00	0.00	-0.01	0.00	0.01	0.00	0.00	0.00
τ^k_N	-0.04	0.00	-0.03	-0.02	-0.04	0.01	0.05	0.00	0.00
κ_τ	-0.09	-0.05	-0.08	-0.03	-0.02	0.04	0.04	-0.02	0.03
Disaster Risk	-0.03	0.03	-0.06	-0.02	-0.14	-0.09	-0.11	-0.20	0.09
π^θ	-0.03	0.03	-0.06	-0.02	-0.14	-0.09	-0.11	-0.20	0.09
π^a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table C.14: Sources of Macroeconomic Dynamics: Bust Period 2007-2012

Process	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log$ TFP	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	-0.33	-0.18	-0.01	-0.22	-0.31	-0.04	0.03	-0.10	0.08
Model	-0.33	-0.26	-0.01	-0.19	-0.32	-0.02	-0.05	-0.10	0.09
Productivity	-0.01	-0.02	0.00	0.00	-0.01	0.01	0.00	0.00	0.00
$\log z_H$	-0.01	0.00	0.00	-0.01	0.00	0.01	0.00	0.00	0.00
$\log z_N$	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
External	-0.09	-0.08	0.02	-0.05	-0.06	-0.04	-0.06	-0.07	-0.04
$\log \bar{a}_T$	-0.07	-0.08	0.02	-0.04	-0.01	-0.02	-0.03	-0.03	-0.05
$\log P_F$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T^g	-0.01	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
T^l	0.00	0.00	0.00	0.00	-0.04	-0.02	-0.02	-0.04	0.02
Financial	-0.04	-0.03	-0.01	-0.02	-0.06	0.00	-0.01	-0.04	0.03
$\log \bar{B}^g$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log \bar{B}^r$	0.00	0.00	-0.02	0.01	0.00	0.00	0.00	0.00	0.00
$\bar{r}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\bar{i}$	0.00	0.00	0.01	0.00	-0.01	-0.01	-0.02	-0.02	0.01
T^b_W	-0.01	-0.01	0.00	-0.01	-0.01	0.00	0.00	-0.01	0.01
T^b_{Gd}	-0.04	-0.03	0.00	-0.02	-0.03	0.01	0.01	-0.02	0.02
T^b_{Ge}	0.01	0.01	0.00	0.01	0.00	0.00	-0.01	0.01	-0.01
Gov Spending	-0.05	-0.05	0.01	-0.03	0.04	0.00	0.00	0.01	0.05
$\log g^c_T$	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
$\log g^c_N$	-0.02	-0.02	0.00	-0.01	0.04	0.00	-0.01	0.00	0.00
$\log g^x_T$	-0.01	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.03
$\log g^x_N$	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\log T^r$	-0.01	-0.01	0.01	-0.01	-0.01	0.00	0.00	0.00	0.00
Tax Policy	-0.08	-0.05	-0.02	-0.04	-0.04	0.04	0.06	0.09	0.00
τ^c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^x	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^ℓ	-0.01	-0.04	0.00	0.01	-0.02	0.01	0.01	0.09	0.00
τ^k_H	-0.01	0.00	0.00	-0.01	0.00	0.01	0.01	0.00	0.00
τ^k_N	-0.02	0.00	-0.01	-0.02	-0.01	0.01	0.03	0.00	0.00
κ_τ	-0.03	-0.02	-0.01	-0.02	-0.01	0.02	0.02	-0.01	0.01
Disaster Risk	-0.06	-0.04	0.00	-0.05	-0.20	-0.03	-0.05	-0.09	0.05
π^θ	-0.06	-0.04	0.00	-0.04	-0.19	-0.03	-0.05	-0.08	0.04
π^a	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00

Table C.15: Role of Structural Elements

Boom: 1998-2007	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log \mathrm{TFP}$	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	0.14	0.08	0.12	0.02	0.15	0.10	0.18	0.24	-0.03
Baseline Model	0.09	0.07	0.06	0.02	0.08	0.06	0.09	0.13	-0.04
$\epsilon = 2$	0.09	0.08	0.06	0.02	0.08	0.05	0.08	0.12	-0.04
$\rho = 0.5$	0.10	0.08	0.05	0.03	0.12	0.06	0.09	0.14	-0.04
$\zeta = 0$	0.10	0.08	0.08	0.02	0.04	0.04	0.06	0.12	-0.04
$\eta = 0.9$	0.10	0.08	0.07	0.03	0.09	0.07	0.11	0.16	-0.04
$\eta = 2.4$	0.08	0.06	0.05	0.02	0.08	0.05	0.08	0.12	-0.04
$\psi_p = 0$	0.05	0.04	0.05	0.00	0.05	0.09	0.12	0.12	-0.05
$\psi_p = 1000$	0.15	0.13	0.07	0.05	0.14	0.03	0.04	0.17	-0.03
$\psi_w = 0$	0.08	0.04	0.06	0.03	0.07	0.07	0.10	0.19	-0.04
$\psi_w = 1000$	0.12	0.14	0.06	0.02	0.12	0.03	0.06	0.05	-0.03
$\psi_\ell = 0$	0.10	0.10	0.06	0.02	0.10	0.05	0.08	0.14	-0.04
$\psi_x = 0$	0.02	0.03	0.06	-0.03	0.07	0.06	0.09	0.11	0.03
$\phi = 0.44$	0.10	0.08	0.07	0.03	0.09	0.08	0.11	0.16	-0.03
$\kappa_x = 1$	0.08	0.07	0.05	0.02	0.08	0.06	0.09	0.13	-0.04
$\kappa_\ell = 1$	0.07	0.08	0.04	0.02	0.09	0.07	0.09	0.15	-0.03
Bust: 2007-2017	$\log y$	$\log \ell$	$\log \tilde{k}$	$\log \mathrm{TFP}$	$\log c$	$\log P_H$	$\log P_N$	$\log W$	NX/GDP
Data	-0.40	-0.14	-0.16	-0.24	-0.38	-0.03	-0.11	-0.34	0.11
Baseline Model	-0.34	-0.16	-0.27	-0.14	-0.28	-0.04	0.00	-0.23	0.13
$\epsilon = 2$	-0.36	-0.18	-0.27	-0.13	-0.28	-0.04	0.02	-0.20	0.12
$\rho = 0.5$	-0.36	-0.17	-0.28	-0.13	-0.31	-0.05	-0.01	-0.26	0.14
$\zeta = 0$	-0.38	-0.18	-0.32	-0.13	-0.21	-0.01	0.05	-0.23	0.15
$\eta = 0.9$	-0.35	-0.17	-0.25	-0.14	-0.25	-0.03	0.02	-0.21	0.11
$\eta = 2.4$	-0.33	-0.14	-0.27	-0.13	-0.29	-0.05	0.00	-0.24	0.14
$\psi_p = 0$	-0.36	-0.17	-0.27	-0.15	-0.31	-0.06	0.04	-0.22	0.12
$\psi_p = 1000$	-0.39	-0.20	-0.26	-0.16	-0.30	0.00	0.02	-0.27	0.12
$\psi_w = 0$	-0.32	-0.12	-0.26	-0.13	-0.25	-0.07	-0.02	-0.23	0.13
$\psi_w = 1000$	-0.45	-0.35	-0.27	-0.14	-0.37	0.03	0.09	-0.03	0.10
$\psi_\ell = 0$	-0.35	-0.15	-0.27	-0.14	-0.28	-0.04	0.00	-0.24	0.13
$\psi_x = 0$	-0.20	-0.07	-0.24	-0.05	-0.24	-0.06	0.00	-0.17	-0.02
$\phi = 0.44$	-0.34	-0.16	-0.25	-0.14	-0.24	-0.01	0.04	-0.19	0.11
$\kappa_x = 1$	-0.27	-0.11	-0.21	-0.11	-0.25	-0.09	-0.04	-0.21	0.10
$\kappa_\ell = 1$	-0.26	-0.16	-0.13	-0.11	-0.29	-0.09	-0.04	-0.28	0.07

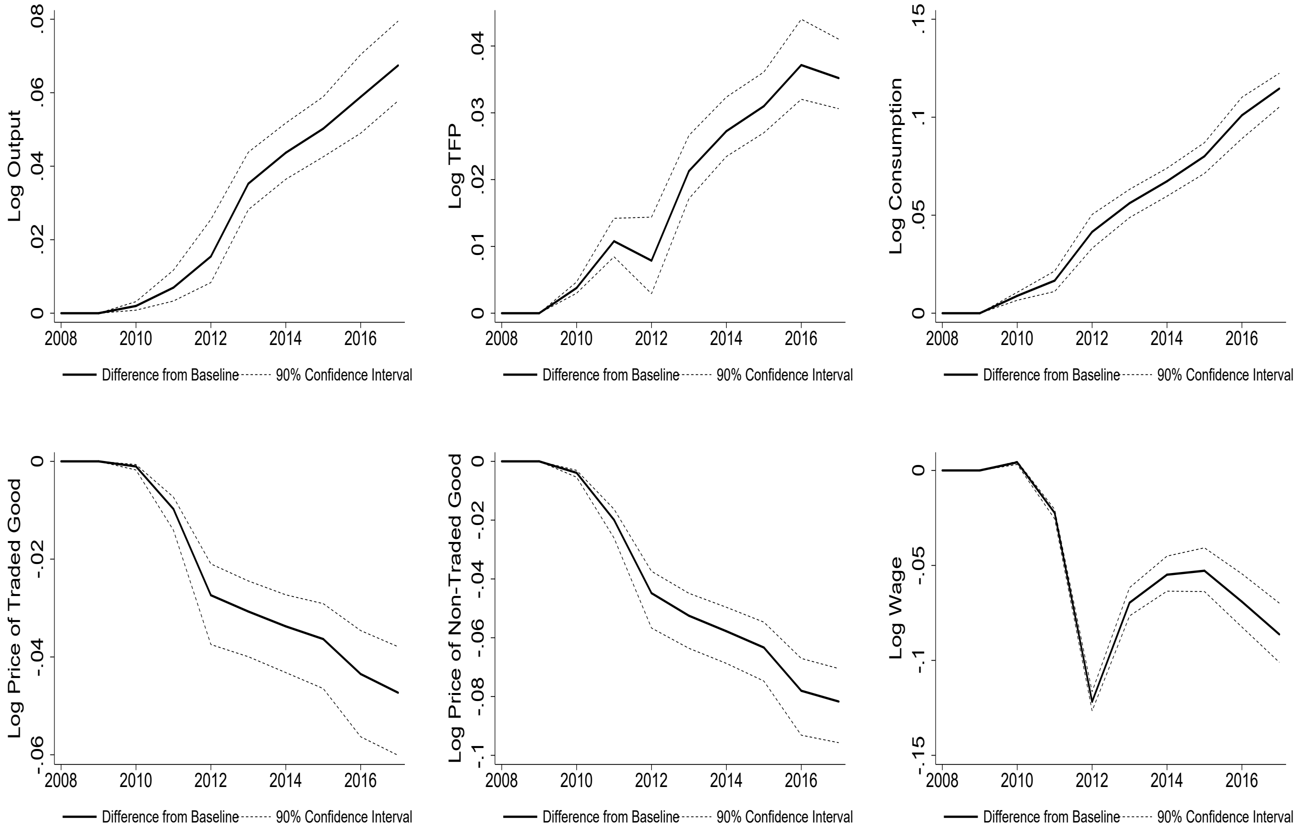


Figure C.9: Tilting Fiscal Adjustment to Spending Cuts

Table C.16: Confidence Intervals of Output and Revenue Effects of Fiscal Instruments

	Point Estimate			Lower Bound (5 percentile)			Upper Bound (95 percentile)		
	Output	Cost	Ratio	Output	Cost	Ratio	Output	Cost	Ratio
g_N^c	0.56	0.89	0.62	0.43	0.94	0.46	0.65	0.85	0.76
g_T^c	0.14	1.04	0.14	0.09	1.06	0.09	0.18	1.02	0.18
g_N^x	1.24	0.54	2.29	1.14	0.59	1.93	1.31	0.50	2.62
g_T^x	0.62	0.85	0.73	0.56	0.88	0.64	0.66	0.83	0.80
ζT^r	0.21	0.81	0.26	0.13	0.86	0.16	0.29	0.75	0.39
τ^c	-0.27	-0.38	0.72	-0.30	-0.37	0.57	-0.23	-0.40	0.81
τ^x	-0.15	-0.12	1.25	-0.17	-0.10	0.83	-0.11	-0.13	1.68
τ^ℓ	-0.38	-0.42	0.90	-0.44	-0.40	0.70	-0.31	-0.45	1.08
τ_H^k	-0.14	-0.03	4.46	-0.17	-0.02	3.38	-0.13	-0.04	6.62
τ_N^k	-0.26	-0.10	2.71	-0.31	-0.07	1.98	-0.22	-0.11	4.25

Table C.17: Output and Revenue Effects of Fiscal Instruments

	horizon $h=1$			horizon $h=7$			horizon $h=\infty$		
	Output	Cost	Ratio	Output	Cost	Ratio	Output	Cost	Ratio
g_N^c	0.49	0.94	0.52	0.56	0.89	0.62	0.62	0.90	0.69
g_T^c	0.05	1.04	0.05	0.14	1.04	0.14	0.30	1.11	0.27
g_N^x	0.93	0.68	1.38	1.24	0.54	2.29	2.33	0.32	7.23
g_T^x	0.27	0.91	0.30	0.62	0.85	0.73	1.68	0.71	2.36
ζT^r	0.32	0.80	0.40	0.21	0.81	0.26	0.22	0.86	0.25
τ^c	-0.26	-0.40	0.67	-0.27	-0.38	0.72	-0.31	-0.40	0.77
τ^x	-0.04	-0.16	0.23	-0.15	-0.12	1.25	-0.27	-0.10	2.73
τ^ℓ	-0.18	-0.50	0.35	-0.38	-0.42	0.90	-0.41	-0.40	1.04
τ_H^k	-0.07	-0.06	1.14	-0.14	-0.03	4.46	-0.18	-0.02	8.57
τ_N^k	-0.12	-0.16	0.75	-0.26	-0.10	2.71	-0.33	-0.07	4.57

Table C.18: Fiscal Multipliers

Financing and Horizon		g_N^c	g_T^c	g_N^x	g_T^x	ζT^r	τ^c	τ^x	τ^ℓ	τ_H^k	τ_N^k
T^o financed	$h=1$	0.49	0.05	0.93	0.27	0.32	-0.26	-0.04	-0.18	-0.07	-0.12
T^o financed	$h=7$	0.56	0.14	1.24	0.62	0.21	-0.27	-0.15	-0.38	-0.14	-0.26
T^o financed	$h=\infty$	0.62	0.30	2.33	1.68	0.22	-0.31	-0.27	-0.41	-0.18	-0.33
T^r, T^o financed	$h=1$	0.48	-0.06	0.83	0.15	0.23	-0.22	-0.03	-0.11	-0.06	-0.10
T^r, T^o financed	$h=7$	0.55	0.07	1.18	0.54	0.15	-0.25	-0.14	-0.34	-0.14	-0.26
T^r, T^o financed	$h=\infty$	0.62	0.24	2.25	1.59	0.15	-0.29	-0.27	-0.38	-0.18	-0.33
$\bar{B}^g, T^r, T^o$ financed	$h=1$	0.63	0.11	0.94	0.30	0.36	-0.29	-0.05	-0.19	-0.07	-0.13
$\bar{B}^g, T^r, T^o$ financed	$h=7$	0.57	0.09	1.20	0.56	0.17	-0.26	-0.14	-0.35	-0.14	-0.26
$\bar{B}^g, T^r, T^o$ financed	$h=\infty$	0.63	0.26	2.27	1.62	0.17	-0.29	-0.27	-0.39	-0.18	-0.33

Table C.19: Fiscal Multipliers: T^o financed, horizon $h = 1$

Parameters	g_N^c	g_T^c	g_N^x	g_T^x	ζT^r	τ^c	τ^x	τ^ℓ	τ_H^k	τ_N^k
Baseline Model	0.49	0.05	0.93	0.27	0.32	-0.26	-0.04	-0.18	-0.07	-0.12
$\rho_f = 0.30$	0.84	0.18	0.89	0.23	0.41	-0.31	-0.02	-0.08	-0.04	-0.07
$\rho_f = 0.75$	0.80	0.13	0.93	0.26	0.36	-0.30	-0.03	-0.15	-0.06	-0.10
$\xi_H = \xi_N = \infty$	0.36	0.05	0.59	0.17	0.19	-0.18	0.01	-0.22	-0.01	0.02
$\xi_H = \xi_N = 2.5$	0.53	0.06	0.98	0.27	0.36	-0.29	-0.07	-0.16	-0.07	-0.28
$\epsilon = 2$	0.54	0.06	0.94	0.28	0.27	-0.27	-0.04	-0.19	-0.07	-0.12
$\rho = 0.5$	0.51	0.08	1.01	0.30	0.41	-0.21	-0.05	-0.20	-0.06	-0.13
$\zeta = 0$	0.51	0.04	0.92	0.27	.	-0.26	-0.05	-0.16	-0.08	-0.14
$\zeta = 0.7$	0.48	0.07	0.97	0.28	0.42	-0.28	-0.03	-0.20	-0.06	-0.11
$\eta = 0.9$	0.51	-0.01	0.93	0.20	0.34	-0.27	0.02	-0.16	-0.05	-0.09
$\eta = 2.4$	0.47	0.08	0.92	0.30	0.31	-0.26	-0.06	-0.19	-0.09	-0.13
$\psi_p = 0$	0.25	0.10	0.55	0.31	0.13	-0.14	-0.12	-0.26	-0.19	-0.27
$\psi_p = 1000$	0.62	-0.02	1.09	0.18	0.46	-0.33	0.03	-0.07	0.00	0.01
$\psi_w = 0$	0.50	0.06	0.91	0.27	0.30	-0.26	-0.04	-0.15	-0.07	-0.12
$\psi_w = 1000$	0.48	0.01	0.97	0.27	0.37	-0.27	-0.03	-0.22	-0.07	-0.11
$\psi_\ell = 0$	0.60	0.05	1.11	0.29	0.39	-0.32	-0.02	-0.30	-0.05	-0.09
$\psi_x = 0$	0.54	0.03	1.04	0.26	0.40	-0.30	-0.05	-0.18	-0.05	-0.09
$\phi = 0.44$	0.52	0.00	0.96	0.21	0.35	-0.28	0.01	-0.15	-0.06	-0.01
$\varphi^\theta = 0$	0.49	0.05	0.93	0.27	0.32	-0.26	-0.04	-0.18	-0.07	-0.12
$\varphi^\theta = 0.3$	0.49	0.05	0.93	0.27	0.32	-0.26	-0.04	-0.18	-0.07	-0.12
$\kappa_\ell = 1$	0.54	0.07	0.98	0.29	0.32	-0.28	-0.07	-0.34	-0.09	-0.14
$\kappa_x = 1$	0.49	0.05	0.92	0.26	0.32	-0.26	-0.05	-0.18	-0.06	-0.10
$\delta_b = 0.3$	0.47	0.05	0.90	0.27	0.31	-0.26	-0.03	-0.18	-0.06	-0.10
$\delta_b = 0.9$	0.50	0.05	0.95	0.27	0.33	-0.27	-0.04	-0.18	-0.07	-0.12
No Working Capital	0.48	0.04	0.84	0.21	0.30	-0.25	-0.06	-0.19	-0.06	-0.09

Table C.20: Fiscal Multipliers: T^o financed, horizon $h = 7$

Parameters	g_N^c	g_T^c	g_N^x	g_T^x	ζT^r	τ^c	τ^x	τ^ℓ	τ_H^k	τ_N^k
Baseline Model	0.56	0.14	1.24	0.62	0.21	-0.27	-0.15	-0.38	-0.14	-0.26
$\rho_f = 0.30$	0.89	0.19	1.33	0.64	0.36	-0.33	-0.17	-0.24	-0.12	-0.25
$\rho_f = 0.75$	0.81	0.17	1.24	0.61	0.26	-0.30	-0.13	-0.35	-0.14	-0.24
$\xi_H = \xi_N = \infty$	0.47	0.13	1.06	0.60	0.10	-0.20	-0.07	-0.40	-0.05	-0.06
$\xi_H = \xi_N = 2.5$	0.61	0.16	1.26	0.57	0.27	-0.31	-0.20	-0.37	-0.15	-0.52
$\epsilon = 2$	0.63	0.17	1.28	0.64	0.17	-0.29	-0.15	-0.43	-0.15	-0.27
$\rho = 0.5$	0.61	0.17	1.34	0.65	0.28	-0.26	-0.15	-0.42	-0.14	-0.26
$\zeta = 0$	0.57	0.14	1.26	0.62	.	-0.27	-0.17	-0.35	-0.16	-0.29
$\zeta = 0.7$	0.56	0.15	1.29	0.63	0.29	-0.29	-0.14	-0.41	-0.14	-0.26
$\eta = 0.9$	0.58	0.08	1.23	0.51	0.25	-0.28	-0.11	-0.34	-0.11	-0.24
$\eta = 2.4$	0.54	0.17	1.24	0.67	0.18	-0.26	-0.16	-0.41	-0.17	-0.27
$\psi_p = 0$	0.49	0.19	1.11	0.70	0.11	-0.23	-0.18	-0.47	-0.21	-0.31
$\psi_p = 1000$	0.67	-0.02	1.34	0.32	0.44	-0.35	-0.07	-0.16	-0.04	-0.10
$\psi_w = 0$	0.57	0.18	1.18	0.62	0.14	-0.26	-0.15	-0.32	-0.14	-0.26
$\psi_w = 1000$	0.53	0.04	1.38	0.61	0.34	-0.29	-0.13	-0.52	-0.15	-0.25
$\psi_\ell = 0$	0.62	0.15	1.38	0.64	0.24	-0.31	-0.14	-0.47	-0.14	-0.25
$\psi_x = 0$	0.53	0.15	1.15	0.61	0.17	-0.25	-0.13	-0.37	-0.14	-0.25
$\phi = 0.44$	0.58	0.09	1.28	0.52	0.26	-0.29	-0.12	-0.33	-0.14	-0.17
$\varphi^\theta = 0$	0.56	0.14	1.24	0.62	0.21	-0.27	-0.15	-0.38	-0.14	-0.26
$\varphi^\theta = 0.3$	0.56	0.14	1.24	0.62	0.21	-0.27	-0.15	-0.38	-0.14	-0.26
$\kappa_\ell = 1$	0.60	0.17	1.13	0.53	0.14	-0.27	-0.23	-0.63	-0.17	-0.27
$\kappa_x = 1$	0.54	0.15	1.19	0.60	0.20	-0.26	-0.16	-0.39	-0.12	-0.19
$\delta_b = 0.3$	0.51	0.14	1.12	0.60	0.17	-0.24	-0.12	-0.38	-0.12	-0.22
$\delta_b = 0.9$	0.59	0.14	1.33	0.63	0.24	-0.29	-0.16	-0.38	-0.16	-0.28
No Working Capital	0.54	0.12	0.83	0.33	0.12	-0.22	-0.23	-0.40	-0.11	-0.19

Table C.21: Fiscal Multipliers: $\bar{B}^g, T^r, T^o$ financed, horizon $h = 1$

Parameters	g_N^c	g_T^c	g_N^x	g_T^x	ζT^r	τ^c	τ^x	τ^ℓ	τ_H^k	τ_N^k
Baseline Model	0.63	0.11	0.94	0.30	0.36	-0.29	-0.05	-0.19	-0.07	-0.13
$\rho_f = 0.30$	0.85	0.19	0.89	0.24	0.42	-0.32	-0.02	-0.09	-0.04	-0.07
$\rho_f = 0.75$	0.83	0.16	0.94	0.28	0.38	-0.31	-0.03	-0.16	-0.06	-0.10
$\xi_H = \xi_N = \infty$	0.45	0.09	0.61	0.19	0.22	-0.20	0.00	-0.24	-0.01	0.00
$\xi_H = \xi_N = 2.5$	0.67	0.11	0.99	0.30	0.39	-0.31	-0.08	-0.18	-0.07	-0.28
$\epsilon = 2$	0.65	0.11	0.95	0.30	0.30	-0.29	-0.05	-0.20	-0.07	-0.13
$\rho = 0.5$	0.67	0.15	1.02	0.33	0.45	-0.24	-0.07	-0.22	-0.06	-0.14
$\zeta = 0$	0.51	0.04	0.92	0.27	.	-0.26	-0.05	-0.16	-0.08	-0.14
$\zeta = 0.7$	0.82	0.22	1.00	0.35	0.51	-0.34	-0.07	-0.24	-0.07	-0.14
$\eta = 0.9$	0.65	0.05	0.94	0.24	0.37	-0.29	0.00	-0.17	-0.05	-0.11
$\eta = 2.4$	0.61	0.13	0.93	0.33	0.35	-0.28	-0.07	-0.21	-0.09	-0.14
$\psi_p = 0$	0.29	0.10	0.55	0.31	0.13	-0.15	-0.12	-0.26	-0.19	-0.28
$\psi_p = 1000$	0.78	0.03	1.09	0.19	0.48	-0.35	0.01	-0.08	0.00	0.00
$\psi_w = 0$	0.64	0.15	0.94	0.32	0.35	-0.29	-0.06	-0.18	-0.07	-0.14
$\psi_w = 1000$	0.61	0.05	0.97	0.28	0.39	-0.29	-0.04	-0.23	-0.07	-0.12
$\psi_\ell = 0$	0.76	0.12	1.12	0.33	0.43	-0.35	-0.04	-0.32	-0.05	-0.10
$\psi_x = 0$	0.69	0.07	1.05	0.28	0.43	-0.32	-0.07	-0.20	-0.05	-0.10
$\phi = 0.44$	0.66	0.06	0.97	0.24	0.39	-0.30	-0.01	-0.17	-0.06	-0.03
$\varphi^\theta = 0$	0.63	0.11	0.94	0.30	0.36	-0.29	-0.05	-0.19	-0.07	-0.13
$\varphi^\theta = 0.3$	0.63	0.11	0.94	0.30	0.36	-0.29	-0.05	-0.19	-0.07	-0.13
$\kappa_\ell = 1$	0.68	0.14	1.00	0.33	0.37	-0.31	-0.08	-0.35	-0.09	-0.15
$\kappa_x = 1$	0.62	0.11	0.94	0.30	0.36	-0.29	-0.06	-0.20	-0.07	-0.11
$\delta_b = 0.3$	0.61	0.11	0.92	0.30	0.35	-0.28	-0.04	-0.20	-0.06	-0.11
$\delta_b = 0.9$	0.64	0.11	0.96	0.30	0.37	-0.29	-0.06	-0.19	-0.07	-0.14
No Working Capital	0.61	0.11	0.87	0.26	0.34	-0.27	-0.07	-0.21	-0.06	-0.11

Table C.22: Fiscal Multipliers: $\bar{B}^g, T^r, T^o$ financed, horizon $h = 7$

Parameters	g_N^c	g_T^c	g_N^x	g_T^x	ζT^r	τ^c	τ^x	τ^ℓ	τ_H^k	τ_N^k
Baseline Model	0.57	0.09	1.20	0.56	0.17	-0.26	-0.14	-0.35	-0.14	-0.26
$\rho_f = 0.30$	0.84	0.12	1.28	0.57	0.31	-0.31	-0.16	-0.20	-0.12	-0.24
$\rho_f = 0.75$	0.76	0.10	1.20	0.54	0.21	-0.28	-0.12	-0.32	-0.13	-0.23
$\xi_H = \xi_N = \infty$	0.48	0.12	1.03	0.58	0.09	-0.20	-0.07	-0.39	-0.05	-0.06
$\xi_H = \xi_N = 2.5$	0.62	0.09	1.21	0.49	0.21	-0.29	-0.20	-0.33	-0.15	-0.52
$\epsilon = 2$	0.64	0.13	1.25	0.59	0.14	-0.28	-0.15	-0.40	-0.14	-0.26
$\rho = 0.5$	0.62	0.11	1.28	0.57	0.22	-0.23	-0.15	-0.39	-0.14	-0.26
$\zeta = 0$	0.57	0.14	1.26	0.62	.	-0.27	-0.17	-0.35	-0.16	-0.29
$\zeta = 0.7$	0.58	-0.01	1.15	0.44	0.16	-0.24	-0.14	-0.34	-0.13	-0.25
$\eta = 0.9$	0.59	0.01	1.17	0.44	0.19	-0.26	-0.10	-0.30	-0.10	-0.24
$\eta = 2.4$	0.55	0.14	1.20	0.63	0.15	-0.25	-0.16	-0.39	-0.17	-0.27
$\psi_p = 0$	0.50	0.16	1.09	0.67	0.08	-0.22	-0.17	-0.46	-0.21	-0.31
$\psi_p = 1000$	0.68	-0.16	1.24	0.16	0.33	-0.30	-0.06	-0.08	-0.03	-0.09
$\psi_w = 0$	0.58	0.16	1.15	0.59	0.12	-0.26	-0.15	-0.31	-0.14	-0.26
$\psi_w = 1000$	0.53	-0.06	1.30	0.50	0.26	-0.25	-0.13	-0.47	-0.14	-0.25
$\psi_\ell = 0$	0.63	0.10	1.33	0.58	0.20	-0.29	-0.14	-0.45	-0.13	-0.25
$\psi_x = 0$	0.53	0.11	1.11	0.57	0.14	-0.24	-0.13	-0.35	-0.14	-0.25
$\phi = 0.44$	0.59	0.02	1.23	0.44	0.20	-0.26	-0.11	-0.30	-0.14	-0.17
$\varphi^\theta = 0$	0.57	0.09	1.20	0.56	0.17	-0.26	-0.14	-0.35	-0.14	-0.26
$\varphi^\theta = 0.3$	0.57	0.09	1.20	0.56	0.17	-0.26	-0.14	-0.35	-0.14	-0.26
$\kappa_\ell = 1$	0.62	0.15	1.11	0.51	0.12	-0.26	-0.23	-0.62	-0.17	-0.27
$\kappa_x = 1$	0.55	0.10	1.14	0.54	0.16	-0.25	-0.16	-0.36	-0.12	-0.19
$\delta_b = 0.3$	0.52	0.11	1.08	0.55	0.13	-0.23	-0.12	-0.36	-0.12	-0.21
$\delta_b = 0.9$	0.60	0.09	1.27	0.56	0.19	-0.27	-0.16	-0.35	-0.15	-0.27
No Working Capital	0.55	0.10	0.81	0.30	0.10	-0.22	-0.23	-0.39	-0.11	-0.19

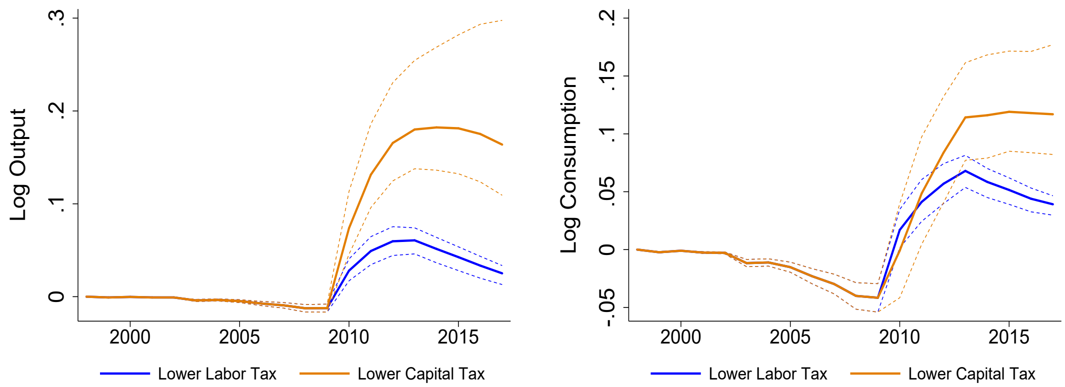


Figure C.10: Reducing Transfers in the Boom and Taxes in the Bust

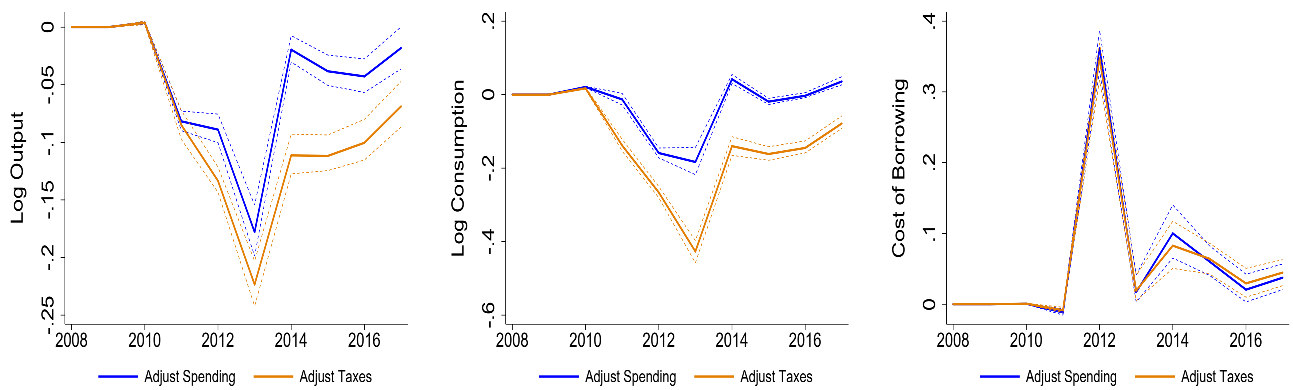


Figure C.11: External Bailout of Greek Government

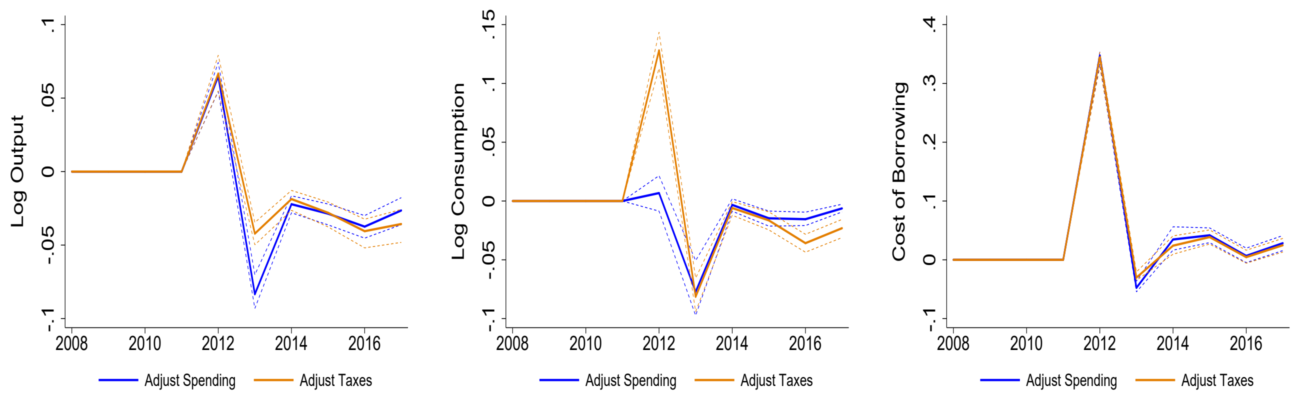


Figure C.12: Bailout of Domestic Banks