

Political Distribution Risk and Aggregate Fluctuations

Thorsten Drautzburg, Jesús Fernández-Villaverde, and Pablo Guerrón-Quintana*

September 27, 2017

Abstract

We argue that political distribution risk is an important driver of aggregate fluctuations. To that end, we document significant changes in the capital share after large political events, such as political realignments, modifications in collective bargaining rules, or the end of dictatorships, in a sample of developed and emerging economies. These policy changes are associated with significant fluctuations in output and asset prices. Using a Bayesian proxy-VAR estimated with U.S. data, we show how distribution shocks cause movements in output, unemployment, and sectoral asset prices. To quantify the importance of these political shocks for the U.S. as a whole, we extend an otherwise standard neoclassical growth model. We model political shocks as exogenous changes in the bargaining power of workers in a labor market with search and matching. We calibrate the model to the U.S. corporate non-financial business sector and we back out the evolution of the bargaining power of workers over time using a new methodological approach, the *partial filter*. We show how the estimated shocks agree with the historical narrative evidence. We document that bargaining shocks account for 34% of aggregate fluctuations and have a welfare cost of 2.7% in consumption units.

Keywords: Political redistribution risk, bargaining shocks, aggregate fluctuations, partial filter, historical narrative.

JEL classification: E32, E37, E44, J20.

*Drautzburg: Federal Reserve Bank of Philadelphia, tdrautzburg@gmail.com. Fernández-Villaverde: UPenn, je-susfv@econ.upenn.edu. Guerrón-Quintana: Boston College and ESPOL, pguerron@gmail.com. We thank participants at numerous seminars for useful comments, in particular, Pat Kehoe, John Leahy, Ben Lester, Claudio Michelacci, Dave Ratner, and Victor Ríos-Rull. The views expressed herein are our own views only. They do not necessarily reflect the views of the Federal Reserve Bank of Philadelphia, the Federal Reserve System, or its Board of Governors.

1 Introduction

The political process is an important driver of the income distribution. Collective bargaining rules, hiring and firing restrictions, overtime provisions, minimum wages, antitrust legislation, and many other policies affect the quantity and prices of labor and capital. Furthermore, these regulations change over time, often suddenly and unexpectedly. For instance, a common event after coups, democratic transitions, or party system realignments is a thorough modification in labor market regulations and fast changes in the capital income share. The U.S. 2016 primary and presidential campaigns illustrate the political viability of candidates with widely different agendas regarding how labor and goods markets should be organized. In summary, political distribution creates considerable income risk for workers and owners of capital.

We argue that this political distribution risk is a quantitatively relevant source of aggregate fluctuations and asset prices. To do so, we first document the existence of the political distribution risk through three empirical exercises. The first exercise is a collection of six case studies of countries that undertook significant political events over the last few decades (France, West Germany, Spain, Portugal, Argentina, and Chile). We show how these events were associated with considerable changes in how income was divided between capital and labor and variations in stock market valuation. The second exercise compiles international evidence on political events and factor income distribution in 117 countries from 1970-2013. The third exercise analyzes the consequences for distribution of the adoption of right-to-work legislation by several U.S. states. As an example of the findings we uncover, the introduction of right-to-work legislation in a state is followed, on average, by increases in the state capital share of 1.5-1.6 percentage points (pp.) relative to the U.S. five years after adoption.

Next, we focus on U.S. aggregate fluctuations by estimating a Bayesian proxy-vector autoregression (VAR) for the U.S. economy. We proxy the redistributive shock by legislated changes in the federal and state-level minimum wages. In different specifications, we document the significant effects of redistribution shocks on output, factor shares, labor markets, and asset prices.

This evidence motivates a straightforward quantitative exercise. We augment a standard stochastic neoclassical growth model with labor search and matching à la [Shimer \(2010\)](#) with shocks to the bargaining power of workers. These shocks are a simple way to capture a central mechanism through which political distribution risk operates. Formally, political risk can be interpreted as arising from political influences on the protocol of an underlying dynamic bargaining game ([Binmore et al., 1986](#)). In our model, this risk is separate from distributional changes due to endogenous movements in the bargaining position of workers and firms since those movements are reflected in the outside values of the agents.

We identify our model by exploiting the differences in responses of output and wages to shocks to productivity and the bargaining power of workers. After both a positive shock to productivity and a shock that lowers the bargaining power of workers, output grows. However, wages rise if the former shock occurs, but fall if the latter shock hits the economy. Hence, looking at the comovements of output and wages disentangles one shock from another.

With this identification, we calibrate our model to quarterly observations of the U.S. non-financial corporate business sector and the labor market. As a baseline, we look at long-lived bargaining shocks with a half-life of 34 quarters. Thus, our approach deals not only with standard business cycles, but also with medium-term aggregate fluctuations. The half-life of 34 quarters is based on our reading of the changes in political climate regarding the bargaining power of workers in the post-war U.S. and matches the average duration of control of the different branches of the federal government by each party after World War II. As a robustness check, we explore the behavior of the model with even more persistent bargaining shocks (half-life of 80 quarters) and with less persistent ones (half-life of 14 quarters, a standard business cycle persistence). The qualitative dynamic properties of the model are not substantially affected by this persistence.

We solve our model using a third-order perturbation since we document how the non-linear features of the solution can be significant. For example, distribution shocks in favor of labor are more important when the bargaining power is already biased against capital. These non-linearities also mean that we must calibrate the model to match the moments of its ergodic distribution and not its steady-state properties. To assess the properties of our economy, we compare it with a version of the model without bargaining shocks, with a benchmark real business cycle (RBC) model with productivity shocks, and with an RBC model augmented with factor share shocks in the production function (as in [Ríos-Rull and Santaella-Llopis, 2010](#), and [Lansing, 2015](#)).

A central part of our investigation is to use U.S. data to back out the bargaining shocks implied by our quantitative model. We do so by proposing a *partial filter*, a new methodological contribution of broad applicability. The central idea of the partial filter is to take one of the key optimality conditions of the model (in our case, the wage-setting equation), substitute the different conditional expectations of a product of variables by their conditional covariance plus the product of conditional expectations of single variables, and approximate those conditional covariances and expectations of single variables from a Bayesian VAR (BVAR). The procedure can be implemented with a Gibbs sampler and it is much less involved than a sequential Monte Carlo filter such as those in [Fernández-Villaverde et al. \(2016\)](#). The backed-out shocks agree with our detailed historical narrative evidence, with peaks at moments of large labor union victories (e.g., the 1970 GM strike) and troughs at moments of weakness of unions (e.g., the early 2000s).

Other significant findings of the paper are as follows. First, our model replicates the near acyclicity of wages highlighted by [Lucas \(1977\)](#) as an obstacle for equilibrium business cycle models that want to rely on movements on real wages as a source of fluctuations. In our economy, output can increase either because productivity grows, which raises wages, or bargaining power shifts toward capital, which lowers wages. As we mentioned before, we use these two opposite forces to identify and calibrate our model. Hence, this result, although interesting insofar as it shows the doors that our model opens to understand aggregate fluctuations, cannot be used to assess the validity of the model. But this finding allows us to discriminate between models. An RBC model with factor share shocks yields wages that are too pro-cyclical: a shock toward labor makes it more productive and, thus, raises wages.

More relevant for assessing the model is our second finding: the model accounts very well for the pro-cyclicality of the capital share and reasonably well for the pro-cyclicality of the net capital share (i.e., after depreciation). This stands in stark contrast to the version of the model without bargaining shocks and the RBC models (with and without factor share shocks). This result is robust to changes in the elasticity of substitution between capital and labor in the production function. When we impose a low elasticity of substitution of 0.75, consistent with U.S. manufacturing estimates (Oberfield and Raval, 2014), or a high elasticity of 1.25, consistent with cross-country estimates (Karabarbounis and Neiman, 2014), our model still replicates the cyclicity of the capital and net capital shares, while the other models do not.

Our third finding is that the bargaining shocks account for around 34% of the volatility of output and nearly all of the model-generated volatility of capital shares (which is, itself, around 40% of the observed one). When the model is calibrated to match observations from the U.S. labor market, the surplus of the labor relation is small. Minor variations in how this surplus is allocated induce substantial changes in the number of recruiters that firms employ to hire new workers. This leads to lower output and employment, but also to higher wages. We illustrate this point with a parallel experiment. The U.S. has benefited from a more stable capital share than other industrialized countries. For example, the overall volatility of the capital share is about 40% lower than in the U.K. If increased redistribution risk would cause the capital share to become 40% more volatile, our model predicts output and consumption volatility that is 20% higher. The welfare cost of bargaining shocks is a sizable 2.7% of consumption, much larger than in Lucas (1991).

Finally, we look at the dynamic effects of a bargaining power shock, and we perform a battery of robustness exercises. We document, for example, how after a bargaining shock that redistributes in favor of workers, output, employment, and firm valuation drop and how trying to endogenize the bargaining shocks to make them dependent on the business cycle does not affect our main results. But perhaps most interestingly, bargaining shocks have larger output effects in a polarized environment. When the share of the surplus going, for instance, to capital is already low, further redistribution in favor of workers has a deeper impact as it makes even small amounts of recruiting effort by the firm unprofitable.

Our paper builds on a large previous literature. The recent evolution of the capital share has commanded much attention (e.g., Autor et al., 2017; Barkai, 2017; De Loecker and Eeckhout, 2017; Elsby et al., 2013; Karabarbounis and Neiman, 2014; Koh et al., 2015; Oberfield and Raval, 2014). Some of the proposed explanations highlight technological change, the fall in the relative price of capital, increases in firm concentration, globalization, or the role of intellectual property products. For our investigation, we can remain agnostic about these mechanisms. Our point is not that all sources of fluctuations in the capital share have a political origin: we only claim that part of them do. Furthermore, we will focus more on short- and medium-term fluctuations around a trend than on the trend (although we perform some high-persistence exercises). One should expect that the effects of technological change or structural transformation on factor shares would manifest themselves more clearly in the trend than in middle- and high-frequency movements.

Previous work has also focused on how changes in the bargaining power affect factor shares. Examples include [Blanchard \(1997\)](#), [Caballero and Hammour \(1998\)](#), [Blanchard and Giavazzi \(2003\)](#), and [Kumhof et al. \(2012\)](#). The first three papers above are concerned with the trend decline in the labor share in Europe, whereas we focus on aggregate fluctuations. Unlike our work, [Kumhof et al. \(2012\)](#) link shocks to bargaining power to changes in income inequality. [Gertler et al. \(2008\)](#) and [Liu et al. \(2013\)](#) also allow, in passing, for time-varying bargaining power, but they do not study its implications in full. [Ravenna and Walsh \(2011\)](#) relate bargaining shocks to the design of optimal monetary policy. Contemporaneous with us, [Feroni et al. \(2017\)](#) have presented VAR evidence of the importance of bargaining supply shocks in employment fluctuations. [Ríos-Rull and Santaeulàlia-Llopis \(2010\)](#) interpret redistribution shocks as technological shocks to the production function. As we will see later, our model outperforms an RBC model with factor share shocks in terms of matching important aggregate fluctuation statistics.

Our bargaining shocks resemble wage markup shocks such as those in [Galí et al. \(2012\)](#). There are some important differences, though. First, our model endogenously generates the equivalent to state-dependent markups over disutility from labor because the surplus of the match is time-varying. Second, we document the importance of higher-order effects related to labor market tightness. These effects are absent in models with markup shocks. Third, and most important, we link our shocks to a precise historical narrative. For instance, our partial filter points out that, from 1950 to the late 1970s, the evolution of bargaining power mostly followed the fate of unions (except for the Kennedy-Johnson wage-posting guidelines). After 1980, changes such as Reagan’s regulation, Clinton’s welfare reform, immigration, and labor market policies such as minimum wages and unemployment extension played a bigger role.

We also link with papers dealing with wage bargaining and aggregate fluctuations. This literature is too large to do justice to it in a few lines, but we can highlight the textbook treatment in [Shimer \(2010\)](#) (with all the references therein), and the influential contributions of [Hall \(2005\)](#), [Hall and Milgrom \(2008\)](#), [Gertler and Trigari \(2009\)](#), and [Christiano et al. \(2016\)](#). Interestingly, [Shimer \(2005\)](#) pointed out the potential of bargaining power shocks for resolving the unemployment volatility puzzle, but emphasized the need for clear identification. Our paper focuses much attention on identification and on the close link between historical evidence and bargaining power shocks.

More broadly, our paper relates to the literature on the asset pricing implications of macro models with production. Our work is closer to [Danthine et al. \(2008\)](#), [Lansing \(2015\)](#), and [Greenwald et al. \(2014\)](#). These authors argue that distribution risk can be important for explaining asset prices. But it remains unclear, in these papers, what is driving the fluctuations in the factor shares. We provide evidence and a model that allows us to quantify both the endogenous and exogenous factors behind the changing capital share.

The rest of the paper is organized as follows. Section 2 reviews the historical evidence documenting how political interventions affect factor shares. Section 3 systematizes the data using a Bayesian proxy-VAR estimated with U.S. data. In Section 4, we present and compute our model,

and we take it to the data in Section 5. Section 6 explains our partial filter and the backed-out evolution of bargaining power in the U.S. Section 7 presents the quantitative results and Section 8 reports the dynamic effects of bargaining power shocks. Section 9 concludes. An appendix discusses further details of the data, empirical exercises, model, computation, and results.

2 Factor shares: Historical evidence

In this section, we present historical evidence regarding the evolution of factor shares across many countries and the role that political interventions may have in them. In the next section, we will focus our investigation on U.S. data using structural VARs. We start, however, with a brief discussion about measurement and stylized facts.

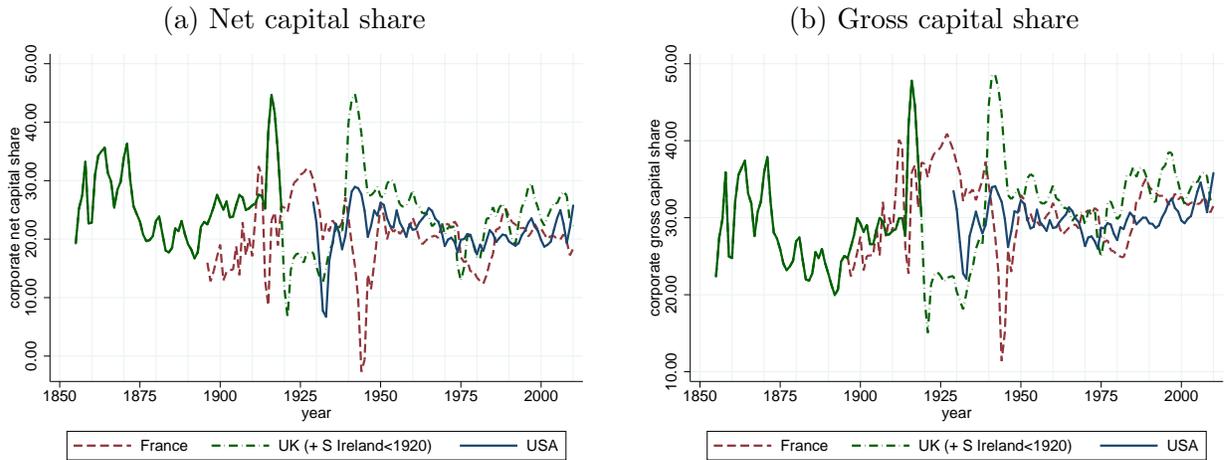
2.1 Measurement and basic facts

How does the capital share of income evolve over time? While the definition of this share is conceptually straightforward, its measurement presents challenges. For instance, we need to allocate ambiguous sources of income such as copyright payments, deferred compensation, or proprietors' income between labor and capital. Also, we must make a decision about how to impute indirect taxes. Finally, to go from the gross to the net share, we need to take a stand on depreciation rates. [Gomme and Rupert \(2004, 2007\)](#) discuss the measurement issues in the U.S. and [Gollin \(2002\)](#) analyzes proprietors' income in a cross-section of countries.

In Appendix A, we give an overview of different measurements of the capital income share in the U.S. economy. Suffice it to say that these alternative calculations agree among themselves regarding the behavior of capital income share over middle and business cycle frequencies (see Figure A.2 in the Appendix). Thus, for many of our purposes, picking one measure or another in the U.S. case is inconsequential (a similar point is made by [Muck et al., 2015b](#)). On the other hand, across countries, our empirical statements may depend on available data.

Figure 1(a) shows annual data, taken from [Piketty and Zucman \(2014\)](#), over long horizons for the net corporate capital share for France, the U.K., and the U.S. The net corporate capital share moves in parallel with the gross capital share in panel (b). The former is particularly informative about the incentives faced by investors: since it eliminates depreciation, it uncovers the compensation for intertemporal substitution, precautionary motives, and risk-taking. The data reveal three facts. First, when we concentrate on the corporate sector of the economy –the object of interest in our model– in none of the three countries does the capital share display an apparent trend, although one can see some increase at the end of the sample.¹ Second, there has been, nevertheless, significant movement in the capital share over time, including larger movements before WWII and a recent increase in the capital share. Third, the U.S. has exhibited the least volatile capital share among the three countries, 30% less volatile than in France and 40% less than in the U.K.

¹[Rognlie \(2015\)](#) has documented that the recent increase in the capital income share in the *overall* U.S. economy was driven by the housing sector and not by the corporate sector. Nevertheless, our model later in the paper can



The data on the U.K. include Ireland prior to its independence. Source: [Piketty and Zucman \(2014\)](#).

Figure 1: Net and gross corporate capital shares in the long run: U.K., France, and the U.S.

Table 1: Changes in the gross labor share volatility across time and countries

(a) Historic and cross-country comparison of volatility of the gross labor share

Country	Raw			HP-filtered		
	1929–1949	1950–2010	Difference	1929–1949	1950–2010	Difference
USA	3.28	1.86	1.42	1.79	0.81	0.98
France	7.14	2.50	4.63	2.73	0.75	1.98
UK	10.16	2.72	7.44	2.44	1.14	1.30
Diff.: France – USA	3.85	0.64		0.94	-0.07	
Diff.: UK – USA	6.88	0.86		0.65	0.32	

(b) Within-industry volatility of the gross labor share

Country	Raw		HP-filtered	
	Mean	SE	Mean	SE
USA	4.54	0.52	1.60	0.23
Difference: France – USA	2.78	1.00	-0.06	0.34
Difference: UK – USA	3.77	0.99	0.95	0.37

The data for panel (a) come from [Piketty and Zucman \(2014\)](#) and for panel (b) from the EU KLEMS database and exclude agriculture, mining, and finance. Standard errors in panel (b) clustered by industry and country. HP-filtered with $\lambda = 6.25$.

The top panel of Table 1 lists the raw and HP-filtered volatility of the gross capital shares for our three countries. The bottom panel shows that income shares are much more volatile in the U.K. than in the U.S. even after controlling for industry composition (and, hence, reducing the effect of structural transformations and technological change). For France, the same is true only in the raw data, but not after detrending. Lastly, while the standard deviation of the capital share of income fell in the U.S. in the post-WWII period by around 43%, it decreased around 65% in the U.K. and 73% in France.

2.2 Factor shares and policy changes: International evidence

We will argue now that the timing of policy changes and subsequent swings in the capital share of income across many countries suggest that the latter can be partially accounted for by the former. We will complete this section by focusing on data from the U.S.

To investigate the effect of policy changes, we use three panel data sets on factor shares. Our baseline is the OECD Business Sector Data Base underlying Blanchard (1997).² These data are available over longer horizons and at a higher frequency than the measures in the Penn World Table (Feenstra et al., 2013) and Karabarbounis and Neiman (2014). The OECD Business Sector Data Base provides information on the gross capital share in the business sector, independent of whether businesses are private or public, or whether they are incorporated. The second data source covers the annual net capital share in Latin America and the Caribbean and is compiled by the Economic Commission for Latin America and the Caribbean (ECLAC). This data set includes all sectors of the economy. Our third data source covers the gross capital shares in all private industries in U.S. states after 1963. We define the capital share as the reciprocal of the labor share of income.

2.2.1 Case studies

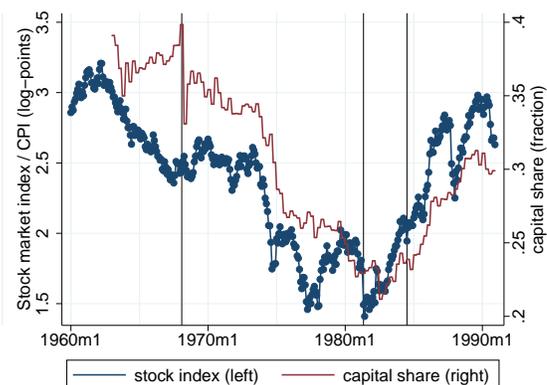
As a first exercise, Figure 2 summarizes six case studies. In each of them, momentous political changes were accompanied by significant movements in factor shares. While the panels in Figure 2 are not a formal econometric assessment (we avoid such an exercise due to data and identification limitations), all six cases are suggestive that economic policy can have a material effect on income distribution between labor and capital. To show that this phenomenon affects countries with different levels of income per capita, we selected two rich economies (France and West Germany), two upper-middle-income economies (Spain and Portugal), and two lower-middle-income economies (Argentina and Chile).

Our first case study, in panel (a), is France. After the big strikes of 1968 (first vertical line), successive French governments introduced ambitious pro-labor measures (see Caballero and Hammour, 1998, for a detailed list of these policy changes in favor of labor approved between 1968 and 1983). The capital income share declined continuously during this period. This process culminated

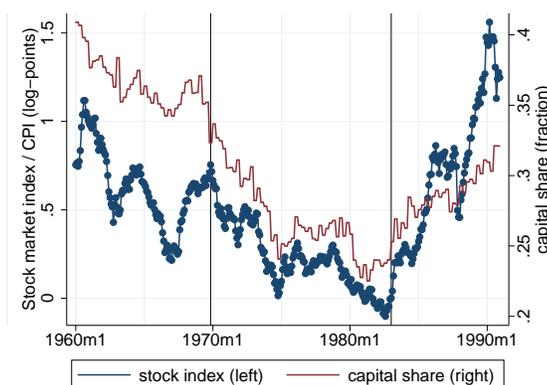
handle long-lived increases in capital shares (in one calibration, with half-lives up to 80 quarters).

²This database is no longer maintained by the OECD. We obtained a copy from <http://fmwww.bc.edu/ec-p/data/oecd/oecd.bsdb.html>.

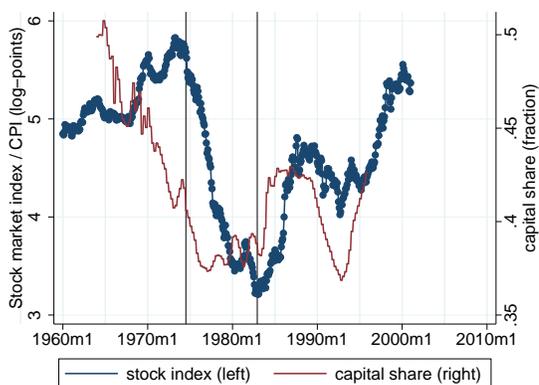
(a) France: Mitterrand's election and turn



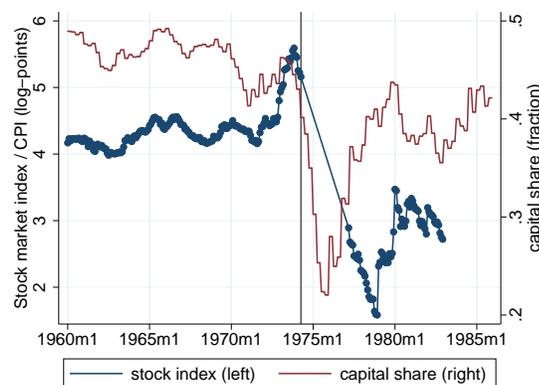
(b) West Germany: Brandt and Kohl



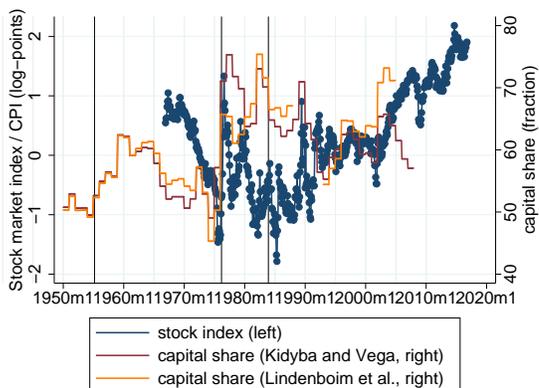
(c) Spain: Franco's illness and González's government



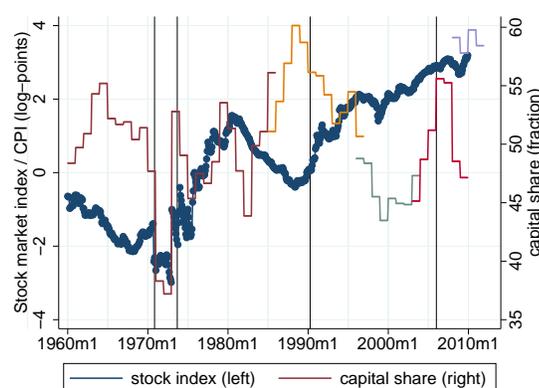
(d) Portugal: Carnation Revolution



e) Argentina: Coups vs. Juan & Isabel Perón, democracy



f) Chile: Allende, Pinochet, democracy



The graphs show the gross capital share and stock market indices for France, West Germany, Spain, Portugal, Argentina, and Chile. The data are at lower frequencies for capital shares. Overlain are black vertical lines that indicate major political events as described in the main text. The capital share data for Argentina come from [Lindenboim et al. \(2005\)](#) and [Kidyba and Vega \(2015\)](#). No continuous time series on the capital share is available for Chile, so we show the spells of available data. Stock market indices are broad indices, except for Chile, where we use the financial stock index. The indices are deflated by consumer prices.

Figure 2: Capital share, stock market indices, and major government changes

in 1982 when Mitterrand was elected as the first socialist president of the Fifth Republic on a left-wing platform (second vertical line). We see the capital share fall slightly after his election. The worsening economic conditions forced Mitterrand to appoint Laurent Fabius as his new prime minister in July 1984 (third vertical line), to drop his alliance with the French Communist Party, and to inaugurate an era of more market-friendly policies, a focus on price stability, and wage moderation. After that change, the capital share of income started growing.

Panel (b) shows the case of West Germany. The appointment of Willy Brandt as the first Social Democratic chancellor since 1930 correlated with a sharp drop in the capital share. A famous example of the changes introduced by the Social Democrat-led government was the strengthening of the role of workers' councils in its 1972 reform of the *Betriebsverfassungsgesetz* (the legal framework for worker co-determination within firms). Later, under Helmut Schmidt, co-determination was extended to all companies with at least 2,000 employees, rather than just the steel and coal industry. The increase in unions' power was halted and partly reversed when the Christian Democrats returned to power in October 1982 (second vertical line). For instance, in 1986, the Christian Democratic-led government changed the *Arbeitsförderungsgesetz* (the Employment Promotion Act) to limit the strike tactics of unions. This policy reversal coincided with an increase in the capital share.

Our third case study is Spain (panel (c)). The last years of Franco's dictatorship were associated with increasing labor unrest, the breakdown of the system of government-controlled corporatist unions ("Organización Sindical Española") that had repressed wage growth, and a profound economic crisis. The capital share of income and the stock market plummeted. Only after 1982, with the election of the surprisingly pro-market Felipe González's government and the implementation of a wage restraint policy, did the capital share of income recover.³

Our fourth case study is Portugal. Panel (d) documents how, after the Carnation Revolution on April 25, 1974, the capital share fell precipitously. The *Processo Revolucionário em Curso* opened by the sudden change of political regime saw widespread nationalizations, an aggressive land reform, and a new collective bargaining environment tilted in favor of workers. After the failed pro-communist coup of November 25, 1975, and the return to more market-friendly policies that followed the democratic normalization, the capital income share quickly recovered but without ever reaching the levels seen during the authoritarian *Estado Novo*.

Argentina is our fifth case (panel (e)). In this country, the principal political events were the coups against Juan and Isabel Perón on September 16, 1955 (the so-called *revolución libertadora*) and on March 24, 1976, and the beginning of the current democratic era in 1983. Juan Perón, according to the "Marcha Peronista," knew how to win over the people by fighting capital.⁴ In contrast, both coups brought considerably more business-friendly governments to power and vir-

³In fact, González's economic team was keen on engineering a recovery of the profit rates of firms to help investment. See Solchaga (1997, pp. 198-199).

⁴The Spanish lyrics refer to Juan Perón as follows: "¡Viva Perón! ¡Viva Perón! / Por ese gran argentino / que se supo conquistar / a la gran masa del pueblo / combatiendo al capital" or "Hurrah! Hurrah for Perón!, Hurrah for a great Argentinian who knew how to conquer the great mass of the people by fighting against capital!"

ulent anti-labor-union policies. Panel (e) shows the subsequent increases in the capital share of income. After losing the Falklands War, the military called for general elections that led to the presidency of Raúl Alfonsín on December 10, 1983, and a subsequent drop in the capital share.

Our final case is Chile. Panel (f) plots the behavior of the capital income share and an index of the stock market in Chile throughout four periods: the *Unidad Popular* government of Allende (the area between the first two vertical lines), Pinochet’s dictatorship (the area between the second and third vertical lines), the governments of Aylwin, Frei, and Lagos -the moderate left-wing first three democratic presidents after Pinochet (the area between the third and fourth vertical lines), and, finally, the more left-wing first presidency of Bachelet (the area to the right of the fourth vertical line). While we do not have a continuous time series, Panel (f) shows a sharp drop in the capital income share around the time of the election of Allende, a socialist candidate who supported a vigorous pro-labor agenda. The capital share recovers quickly around Pinochet’s coup, with its violent policy against workers’ unions, and falls after the transition to democracy and the return of a friendlier environment for workers’ political action.

Figure 2 shows that stock markets tend to move with the capital share. Appendix C.1 formalizes this notion and also considers employment changes (output effects are harder to measure because of trends). We show that stock markets and the employment-to-population ratio tend to move in the same direction as the capital share around the above events. Specifically, the two-year changes in capital shares show a moderate to strong correlation with changes in the employment-to-population ratio and the real stock index over the same period, with an R^2 between 0.25 and 0.33.

2.2.2 Labor regulation and capital shares

The previous case studies suggest that political changes are often followed by redistribution of income between capital and labor. But how do political events affect the capital share? And how general are our case studies? While one could think about different mechanisms linking policy and income distribution (fiscal and monetary policy, competition policy, etc.), a channel that directly impacts on income shares is variations in labor regulation. Thus, we employ data on labor regulation, capital shares, and the timing of coups or democratic transitions to econometrically assess the link between policy changes and income shares.

Our data on labor regulation come from Adams et al. (2016). This group of legal scholars maintains an annual data set that quantifies labor regulations in 117 countries from 1970–2013. It contains 40 separate indicators that cover five areas: (1) the definition of employment, (2) working time, (3) dismissals, (4) employee representation, and (5) collective action. Each indicator measures the degree of worker protection from $[0, 1]$ – a mix of binary, ordinal, and cardinal measures. The measure is designed to cover both statutory and case law.⁵ We use an equal-weighted average of the available indicators as our measure of labor regulation.

⁵It is possible that the data set is imperfect in its coverage of case law. For instance, in the U.S., it records only one change from 1970 to 2013, the 1987 WARN Act. However, Budd (2012) characterizes the recent history of U.S. labor law as “static” statutes and “dynamic and voluminous” case law. Incomplete coverage or miscoding resembles classical measurement and biases our results toward zero and, therefore, *against* our hypothesis.

Because labor regulation could evolve in response to changes in the state of the economy, we also look at large political events that are often dictated by exogenous shocks such as wars, internal conflicts, or deaths of political leaders: successful coups and democratic transitions. We define a successful coup as Powell and Thyne (2011) do and a democratic election as a legislative election in a parliamentary system or a presidential election in a semi-parliamentary or presidential system according to Bormann and Golder (2013). We then look at changes between a coup-regime and a democratic regime. Our prior is that democratic changes tend to favor labor (as most voters are wage-income earners) and assign these changes a value of +1, whereas coups receive a -1. Table 2 reports the political events as computed by our algorithm for the OECD and Latin American countries for which we have good data both on income shares and labor regulations.⁶

Country	Pro capital	Pro labor
Argentina	1976	1973, 1983
Chile	1973	1993
Ecuador		1979
Greece		1974
Honduras	1972	1971, 1985, 2009
South Korea		1992
Panama		1989
Paraguay		1989
Portugal		1974 (1976)
Turkey	1980	1973, 1983
Uruguay	1973	
Number of events	5	14

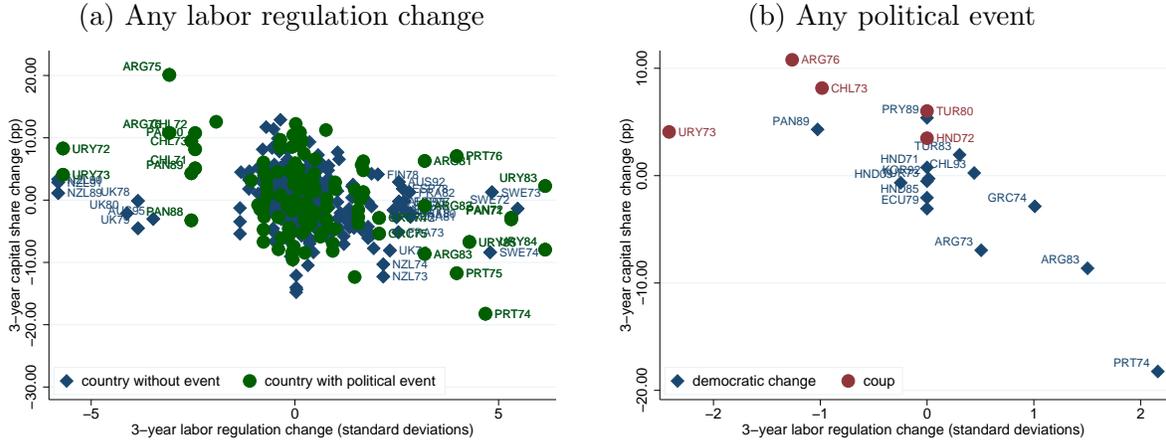
Table 2: Political events used as predictors for labor regulation changes

Figure 3 shows the change in labor regulation and its correlation with changes in the capital share. We focus on cumulative three-year changes and standardize the data to ease interpretation. The left panel shows a negative correlation between capital share changes and labor regulation changes that favor workers (leaving out periods of no variation in regulation). The sparser right panel conditions on political transitions. Labor regulation weakly falls in all coups (red circles). In turn, democratic transitions (blue diamonds) mostly correlate with higher worker protection and declines in capital shares. Uruguay is a clarifying example of how we separate observations. In the left panel we see observations for this country for 1972 and 1973. In 1972, Juan María Bordaberry became president and initiated an aggressive conservative policy. However, Bordaberry’s accession to power was democratic. In comparison, on June 27, 1973, Bordaberry closed the parliament and inaugurated a civic-military dictatorship that repressed trade unions and jailed many of their leaders. We code 1973 as a coup.

We now formalize the associations in Figure 3 with a regression design. Figure 4 shows the results when we look at cumulative three-year changes since a political event.⁷ The left panel

⁶Although a coup could be pro-workers, none of those appear in our sample. In particular the *Carnation Revolution* in Portugal did not overthrow a democratic government and, thus, our algorithm does not code it as a coup. Instead, the algorithm codes the election in 1976 as the democratic transition, even if history suggests that the actual event was the army rising up against the dictatorship in 1974. We use 1974 for our benchmark results.

⁷We take the capital shares from various sources, but only one per country to avoid splicing the data. Because



Panel (a) conditions on a non-zero change in labor regulation and highlights countries with political events as green circles. Panel (b) conditions on a political event in the base year. The labor regulation changes are standardized to have zero mean and unit standard deviation within each sample.

Figure 3: Capital share changes and labor regulation changes

shows that for coups, worker protection via labor regulation is eased, whereas the opposite is true after democratic events. A democratic transition tends to raise worker protection by one-third of a standard deviation. The t -statistic of 2.3 corresponds to an F -statistic of 5.2 and cannot fully dispel weak instrument concerns. The middle panel shows how this predicted change in labor regulation is associated, on average with a large 6.9 pp. drop in the capital share following tighter regulation. Given that a regime switch induces a change of one-third of a standard deviation, a political regime switch is associated with a change in the capital share of about 2.3 pp. OLS, run on the same sample around political events only, produces a slightly smaller estimate of 5.2 pp.

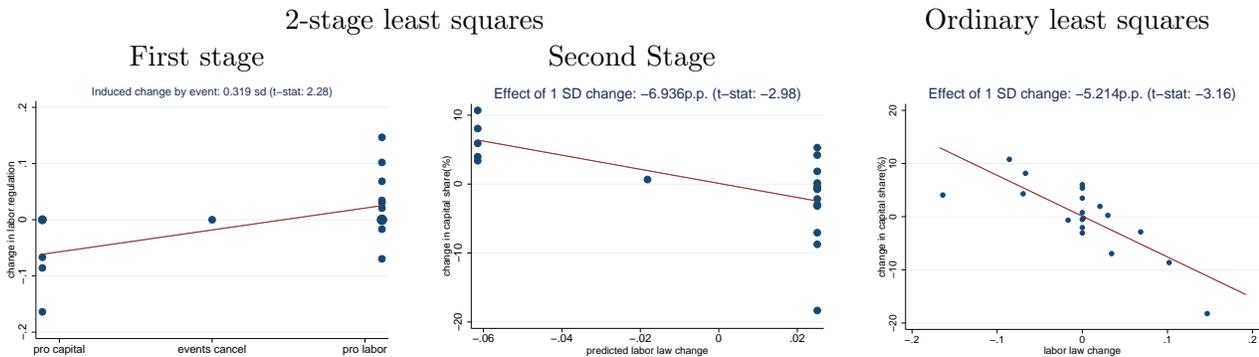


Figure 4: Political events and labor regulation changes

To show that the 19 political events our algorithm identifies are not spuriously correlated with large changes in the labor share, we compute placebo effects. For each country, we randomly pick dates for coups and democratizations with equal probability, respecting their alternating order. We

of the varying data quality and possible residual correlation within countries, we cluster standard errors by country.

code the first event date with equal probability as a coup or democratization. Each subsequent event, if any, is then coded as the other type. Thus, we have the same number of event dates per country as in our actual sample, and we can apply the same IV analysis as in our benchmark case. We repeat this process 1,000 times and show the distribution of placebo and actual t -statistics. Figure 5 shows that the probability of finding second-stage t -statistics is below 1% independent of using all countries with events, only event episodes, and whether, for Portugal, we use 1976 (as suggested by our coding algorithm) as the event year instead of 1974 (as suggested by our reading of history; see the Portugal row in Table 2).

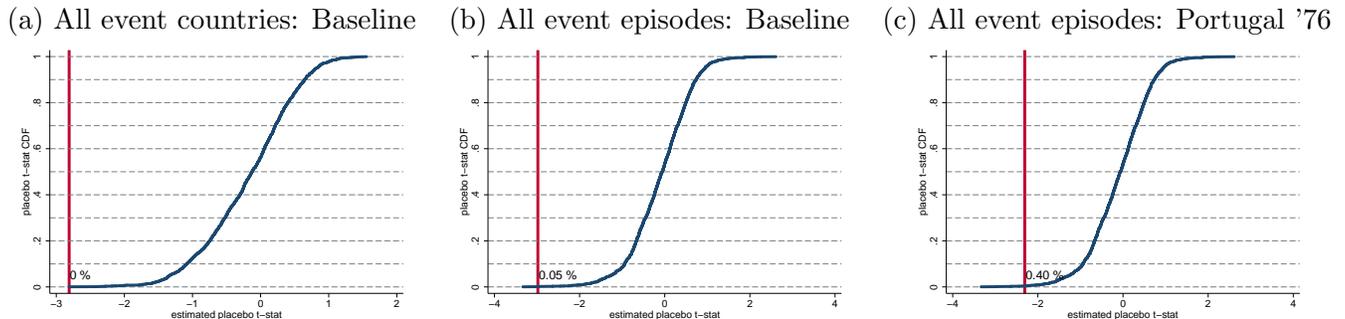


Figure 5: Placebo test: Political events, labor regulation, and capital share changes

Our finding that politics affects the labor share through labor regulation is also robust to various specifications; see Table 3. Importantly, the results change little if we condition on the capital share and per capita GDP growth prior to the political event. The capital share change is, thus, driven by neither reversion to the mean nor cyclical factors. Allowing for common factors across countries matters little. Broadening our sample to include all countries with political events weakens the estimated effect of a one standard deviation change in labor regulations, so that a one standard deviation change in labor regulation leads to a considerable decline in the capital share of 4 pp. While all the OLS estimates point in the same direction as the IV estimates, they are smaller when using all available years for countries with political events. If labor regulation is tightened when the economy is expanding, the pro-cyclicality of the capital share could explain this attenuation. Classical measurement error would have the same effect.

Tables C.2 and C.3 in the Appendix report how the results hold for additional specifications: following our algorithm blindly by assigning 1976 as the democratization date for Portugal, examining only changes within the year of the political event or labor-regulation change, and using all countries for which we have labor share and capital share data with OLS. As one would have expected, the effects over three-year periods are stronger than over one-year periods.

Table 3: Effects of changes in labor regulation on capital shares: Regression estimates

Specification	5y FE	Initial conditions	Effect on		
			capital share	t-stat	1-stage t-stat
Event countries: OLS	–	–	-1.49	-3.47	.
	y	–	-1.56	-3.72	.
	–	y	-1.40	-3.13	.
	y	y	-1.49	-3.41	.
Event countries: IV	–	–	-4.58	-3.21	2.09
	y	–	-4.06	-2.81	3.00
	–	y	-4.06	-2.55	2.01
	y	y	-4.17	-2.90	2.96
Event episodes: OLS	–	–	-5.21	-3.16	.
	y	–	-6.21	-2.86	.
	–	y	-5.43	-2.48	.
	y	y	-5.22	-2.40	.
Event episodes: IV	–	–	-6.94	-2.98	2.28
	y	–	-8.39	-3.62	2.62
	–	y	-7.94	-2.18	1.72
	y	y	-8.94	-2.90	1.85

“5y FE” refers to a fixed effect for the five-year period surrounding the event. “Initial conditions” are the level of capital share and real per capita GDP growth in the year prior to the estimation period. In the baseline IV regressions, we only include countries with political events, as defined in the main text. Alternatively, we also include all observations for the countries with political events. Standard errors are clustered at the country level and the state-country level when estimated with fixed effects.

2.3 Factor shares and policy changes: U.S. evidence

The U.S. has had the good fortune of avoiding the radical political events we used to identify exogenous drivers of labor regulation in our international analysis. At the level of U.S. states, however, there is direct evidence of the effect of policy changes on the labor share. Right-to-work legislation was aimed at limiting the bargaining power of unions by allowing employees to opt out of union membership. Did it succeed?

We use data on states that were late to adopt right-to-work legislation to analyze its effects on the capital share. While most right-to-work states enacted the underlying laws in the first decade after 1945, six states (Idaho, Louisiana, Oklahoma, Wyoming, Indiana, and Michigan) adopted this legislation between 1963 and 2012, the period for which we have data on their private-industry labor share. Among these, Indiana and Michigan were the most recent adopters in 2012.

The data from Idaho, Louisiana, Oklahoma, and Wyoming indicate increases in the capital share after right-to-work legislation was passed, but with different dynamics. However, three to five years after the adoption of right-to-work legislation the capital share in all four states has risen relative to that in the U.S. (see Figure 6; capital shares are computed as one minus the share of employees’ compensation in state GDP net of taxes and subsidies). For Indiana and Michigan, their capital share increased in 2013 and 2014, both in absolute terms and relative to that in the

U.S. as a whole, but with only two observations, we must be cautious. Also, we cannot generally control for pre-trends in all states because of data limitations.

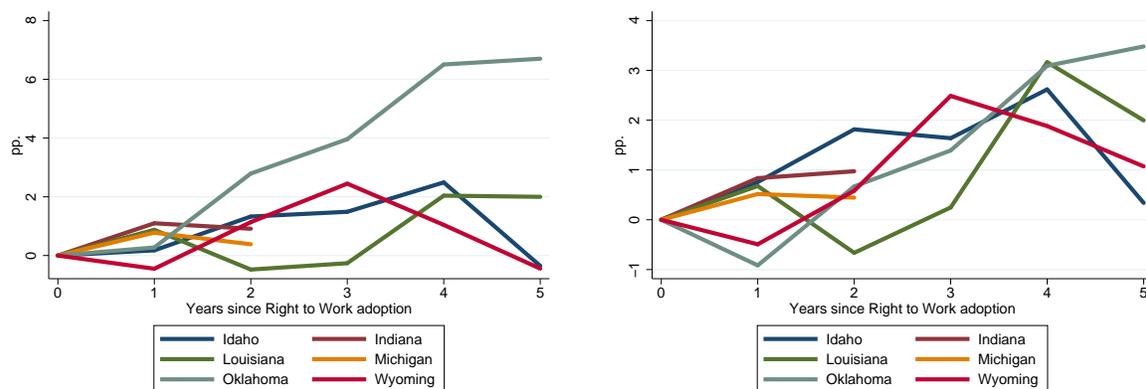


Figure 6: Change in state private industry capital shares after right-to-work adoption: Cumulative change (left panel) and change relative to U.S. (right panel).

To gauge the statistical significance of the previous numbers, we also use industry-level variation from these states. We find that in most specifications, the increase in the capital share following right-to-work legislation is positive, with two-sided p -values below 0.1 after five years. We can reject the null of decreases in the capital share after right-to-work legislation in most cases. The exception is when we satiate the regression with state, year, and industry fixed effects. Slightly less demanding regressions robustly confirm the increase in the capital share. Note that the permanent effect of the right-to-work legislation is ambiguous – potentially because eventually labor-intensive industries disproportionately flock to right-to-work states.

We also look at the effects of right-to-work legislation on economic activity. While the evidence on differences in private-sector real GDP growth is less pronounced, GDP growth weakly increases three to five years after a state adopts right-to-work legislation (see Figure D.7 and Table D.4 in the Appendix). This finding is consistent with Holmes (1998) and Alder et al. (2014). These papers analyze the effects of right-to-work legislation on the location of manufacturing and find positive effects on manufacturing activity. To provide more detail on the economic dynamics following a redistribution shock, we now turn to a VAR estimated for the U.S. economy.

Table 4: State-Industry panel regression: Right-to-work laws and gross capital share

Controlling for census region FE, year FE, and industry FE						
	Level	1y change	2y change	3y change	4y change	5y change
Right to Work	1.38 (0.00)					
Change in RtW		0.77 (0.48)	0.88 (0.34)	1.04 (0.22)	1.35 (0.12)	1.53 (0.07)
Controlling for state FE, and industry FE						
	Level	1y change	2y change	3y change	4y change	5y change
Right to Work	-0.20 (0.85)					
Change in RtW		0.61 (0.59)	1.24 (0.19)	1.86 (0.04)	1.78 (0.04)	1.64 (0.06)
Controlling for state FE, quadratic trend, and industry FE						
	Level	1y change	2y change	3y change	4y change	5y change
Right to Work	-1.55 (0.14)					
Change in RtW		0.17 (0.88)	0.71 (0.45)	1.29 (0.14)	1.62 (0.07)	1.58 (0.07)
Controlling for state FE, year FE, and industry FE						
	Level	1y change	2y change	3y change	4y change	5y change
Right to Work	-1.86 (0.08)					
Change in RtW		0.51 (0.65)	0.59 (0.54)	0.78 (0.39)	0.95 (0.31)	0.85 (0.34)

Before 1997: Private SIC industries. From 1997: Private NAICS industries. Standard errors are clustered by state and industry. Two-sided p -values are in parentheses.

3 Factor shares: VAR evidence

Besides changing the bargaining power of workers, the government can directly affect how the surplus is split between firms and workers by mandating a minimum wage. As [Flinn \(2006, p. 1014\)](#) points out: “Increases in the minimum wage can be viewed as a way to increase their [i.e., workers’] “effective” bargaining power.” Even though less than 10% of hours worked in the U.S. are paid at or below minimum wage ([Autor et al., 2016](#)), increases in statutory minimum wages often spill over to higher wage groups due to indexing or tournament wage structures. For the U.S., [Lee \(1999\)](#) estimates that the spillovers are big enough to account for more than 100% of the change in the ratio of the 50th to the 10th wage percentile after a decline in the real minimum wage. More recently, [Autor et al. \(2016\)](#) finds smaller spillovers of 30-40%. Similar findings are reported by [Kearney and Harris \(2014\)](#), who argue that the “ripple effects” of an increase in the minimum wage will raise the wages of nearly 30% of the workforce.

Motivated by these results, we analyze how changes in the statutory federal minimum wage impact the capital income share. In [Figure 7](#), we show how the corporate non-financial capital share changed relative to the real change in the statutory minimum wage.⁸ Once we exclude the

⁸We focus on the original federal minimum wage that covered only employees engaged in interstate commerce.

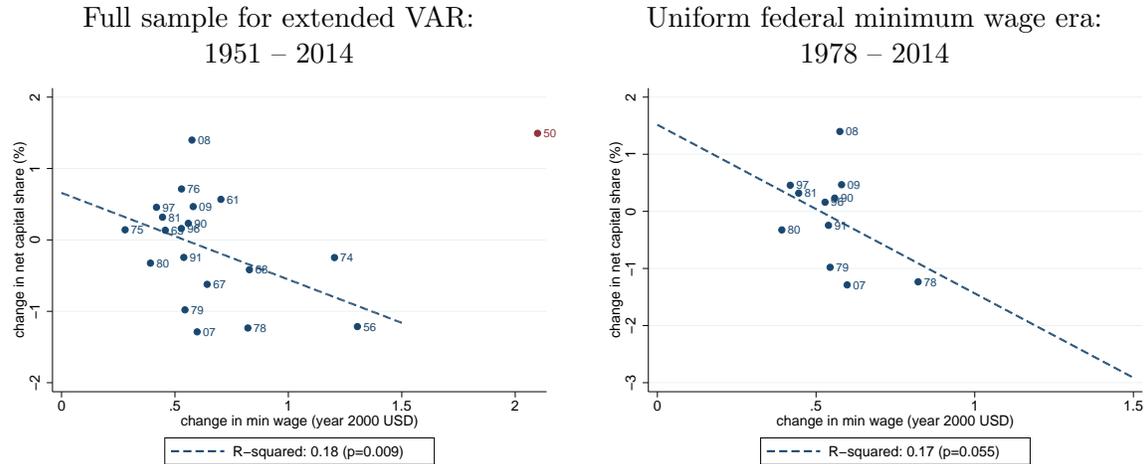


Figure 7: Change in the corporate capital share and real change in the statutory federal minimum wage.

outlier in 1950, we find a robust negative relationship between changes in the statutory minimum wage and the capital share that explains about 18% of the variation in the observed capital share (reported p -values are based on White robust standard errors).⁹

To move from these simple scatter plots to a formal estimation, we use a proxy-VAR. Our proxy for the redistributive shock is the legislated change in the federal minimum wage, converted to constant year 2000 USD - similar to the instrumental variables strategy in Autor et al. (2016). Under the assumption that the federal minimum wage legislation is uncorrelated with other shocks, this procedure identifies the response of the economy.

The assumption that statutory minimum wage changes are uncorrelated with other shocks allows us to identify a redistribution shock without any additional restrictions, such as zero restrictions on impulse response functions (IRFs) common in the VAR literature. Technically, our proxy-VAR is a Bayesian version of the original frequentist approach in Stock and Watson (2012) and Mertens and Ravn (2013). We use the Bayesian implementation in Drautzburg (2016) with a flat prior. Under the assumption that the proxy is a valid instrument, the proxy-VAR identifies the IRFs from the covariance of forecast errors and the proxy. The algorithm also allows us to purge the proxy from other predictors, which we exploit in robustness checks.

We estimate a small VAR that captures the labor market, the goods market, and the capital share. The VAR has four variables: (1) the real minimum wage, (2) the unemployment rate, (3) the net capital share in the non-financial corporate business sector, and (4) gross value added (GVA)

From 1961 onward, other federal minimum wage rates were introduced. These were lower until 1978, when they were replaced by a single minimum wage. See <https://www.dol.gov/whd/minwage/chart.pdf>. To convert the statutory change to 2000 USD, we divide the change by the level of the PCE deflator relative to the year 2000.

⁹On January 25, 1950, the minimum wage increased from \$0.40/hour to \$0.75. However, given the limited coverage of minimum wage at the time (it only covered workers employed by firms engaged in interstate commerce) and the prevailing wages in the industry for low-skill workers (well above \$0.40/hour), the real effects of this sharp increase in the minimum wage were likely limited. Furthermore, using a robust regression that drops any observation with Cook's distance greater than 1 (a standard choice in the literature), only the 1950 observation is eliminated.

in the overall non-farm business sector. Our data are quarterly and we include four lags. We begin our estimation in 1951, excluding the apparent outlier in 1950 and allowing us to keep the sample constant when we later extend the VAR. In the main text, we focus on specifications without any trend. Figure E.8 in the Appendix shows that our results change little with a deterministic quadratic trend.

Figure 8(a) shows the IRFs to a 10% minimum wage increase in the full sample, a typical increase in the postwar period. Both for the full sample (top row of panels) and for the post-Volcker era (middle row), statutory minimum wage increases cause the real minimum wage to rise persistently, a redistribution effect. The capital share falls significantly on impact in the full sample by between 0.1 and 0.7 pp. with 68% posterior probability. Unemployment increases with a delay and peaks 0.3 to 0.9 pp. higher after about one year. Gross value added falls by 2% one year after the shock. In the post-Volcker era, the effects are similar for the unemployment rate and value added, with a more pronounced effect on the capital share that is delayed by one quarter and also peaks within one year. Except for the insignificant value-added response, the results are stronger for the post-Volcker sample. The lower share of hours worked at or below the federal minimum wage rate – a peak of 9% in 1980–81 and a low of 3% in 2002–06 (Autor et al., 2016, Table 1B) – may explain the delayed effect on the capital share as indirect equilibrium effects become more important than direct effects. In the post-Volcker sample, there is also some predictability in statutory minimum wage changes that are our shock proxy and that is not captured by the small-scale VAR. Controlling for the level and the square of the capital share, the minimum wage, and the unemployment rate (Figure 8(c)), the IRFs show a shorter, more plausible shape (see the next paragraph for further motivation for these controls).

One concern about our identification procedure could be that Congress increases minimum wages when the labor share is too low or the economy is performing well. However, if the information set in the VAR is rich enough to capture the state of the economy well, our results cannot be explained by current economic conditions. To see this, note that the estimation in Drautzburg (2016) is based on the covariance between the proxy, here the statutory minimum wage changes, and the VAR forecast errors. Because the forecast errors are orthogonal to the state of the economy as captured by the VAR, our results would not change if we further controlled for any linear combination of the lagged VAR variables in the proxy variable itself. Only variables outside our VAR or non-linear combinations of VAR variables could change our results. In this four-variable VAR, our information set may be small. Hence, we consider additional non-linear controls to purge our proxy variable. Specifically, we only use the variation in statutory minimum wage changes that is orthogonal both to the level and the squared values of the real minimum wage, the capital share, and the unemployment rate. For the full sample, the differences are minimal. For the post-Volcker sample, purging the proxy of these past predictors makes the identified shock more transient, but otherwise changes little; see Figure 8(c). Another approach to making sure our results are not driven by predictable variation in the proxy variable is to enlarge the information set in the VAR. To check this, we estimate a 10-variable VAR in Appendix F. We also estimate versions of the

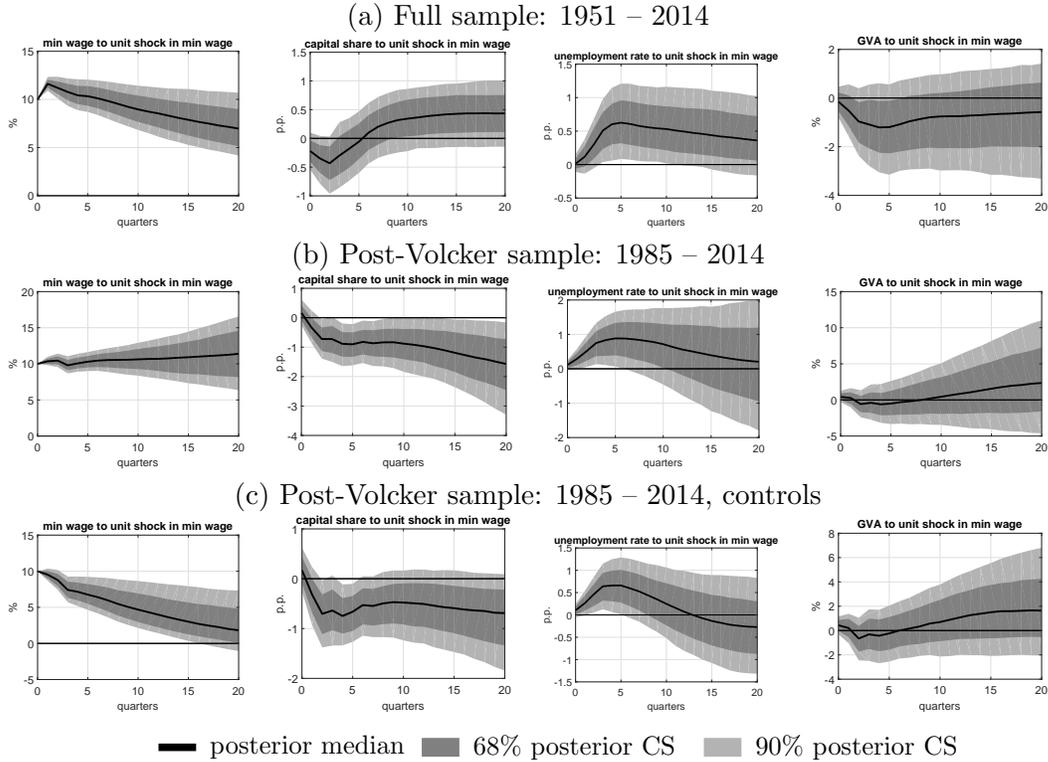


Figure 8: Responses to a 10% real minimum wage shock in VAR.

VAR that incorporate information on changes in state-level minimum wages and with different trends/subsamples. Our results are basically unchanged.

4 Model

In the previous two sections we have presented evidence on various legal ways that politics influences labor shares in the data. We now present a parsimonious model of such measures as determinants of the wage bargaining process. More concretely, we propose a quantitative, discrete-time stochastic neoclassical growth model with labor search and matching in the tradition of [Andolfatto \(1996\)](#), [Merz \(1995\)](#), and [Shimer \(2010\)](#). In the model, there is a representative household, a final good producer, and a government. Markets are complete. To make the model closer to the data along important dimensions for our exercise, we add taxes on labor income and net corporate profits, adjustment costs in capital, and variable capacity utilization.

We postulate political shocks to factor income shares as innovations to the bargaining power of workers. As [Binmore et al. \(1986\)](#) show, variations in the bargaining power can arise from changes in the bargaining procedure. These changes correspond in the data with innovations in labor law, judicial decisions, and, more generally, the political climate regarding collective bargaining. As we will see, the capital income share in the steady state is mostly pinned down by deep parameters other than the bargaining power. In contrast, shocks to the bargaining power will have significant

transient effects. In the next subsections, we present the key model ingredients, while we relegate to Appendix G the full description of the model.

4.1 Households

There is a representative household formed by a continuum of individuals of measure 1. Individuals can be either employed or unemployed, but they are otherwise identical in terms of preferences. The household perfectly insures its members against idiosyncratic risk by equating marginal utilities. Under this perfect insurance assumption, the household problem can be recast in terms of the following lifetime utility function:

$$U_0 = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma} (1 + (\sigma - 1)\gamma n_{t-1})^\sigma - 1}{1 - \sigma}, \quad (4.1)$$

and budget constraint:

$$a_0 = \mathbb{E}_0 \sum_{t=0}^{\infty} \left(\prod_{s=0}^t m_t \right) (c_t - (1 - \tau_n)w_t n_{t-1} - T_t). \quad (4.2)$$

In the utility function, β is the discount factor, c_t is the average consumption, and $n_{t-1} \in [0, 1]$ is the fraction of household members who are employed at time t , a fraction that, as we will explain below, was determined in the previous period (and hence the subindex $t - 1$). The parameter σ controls the relative risk aversion and γ the disutility of working.

In the budget constraint, a_0 is the household net worth at time 0 and m_t is the stochastic discount factor that transforms net income in each period into present valuations (with $m_0 = 1$). Net expenditures are given by consumption less after-tax labor income and T_t , the lump-sum transfers from the government and the net profits from the ownership of firms (capital is owned directly by the firm; under complete markets, this is equivalent to capital being owned by the household, but more convenient algebraically). Labor income is determined by the wage w_t and it is taxed at a rate τ_n .

When making its decisions, the household considers that workers lose their jobs at rate x and find new jobs at rate $f(\theta_t)$, where θ_t is the recruiter-unemployment ratio that the representative household takes as given. Thus, the fraction of household members employed next period will be:

$$n_t = (1 - x)n_{t-1} + f(\theta_t)(1 - n_{t-1}). \quad (4.3)$$

The job finding rate, $f(\theta_t)$, is given by $f(\theta_t) = \xi \theta_t^\eta$, with matching efficiency ξ and elasticity η .

4.2 Firms

There is a representative firm that allocates the matched workers n_{t-1} between recruiting (a fraction ν_t) and producing the final good (the remaining fraction $1 - \nu_t$). The latter are combined with the

capital owned by the firm, k_{t-1} , to produce a homogeneous final good with the technology:

$$y_t = \left(\alpha^{\frac{1}{\varepsilon}} (u_t k_{t-1})^{1-\frac{1}{\varepsilon}} + (1-\alpha)^{\frac{1}{\varepsilon}} (e^{g_z t} z_t (1-\nu_t) n_{t-1})^{1-\frac{1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}}, \quad (4.4)$$

where ε is the elasticity of substitution between capital and labor. For $\varepsilon \rightarrow 1$, we obtain a Cobb-Douglas production function with capital share α . A labor-augmenting trend productivity growth is given by g_z and a productivity shock by z_t . Finally, u_t is capital capacity utilization.

For an investment i_t , capital k_t evolves as:

$$k_t = (1 - \delta(u_t)) k_{t-1} + \left(1 - \frac{1}{2} \kappa \left(\frac{i_t}{k_{t-1}} - \tilde{\delta} \right)^2 \right) i_t, \quad (4.5)$$

where $\tilde{\delta} \equiv g_z^{\frac{1}{1-\alpha}} - (1 - \delta(\bar{u}))$ depends on g_z , the growth rate of z_t . The utilization cost is:

$$\delta(u) = \delta_0 + \delta_1(u - 1) + \frac{1}{2} \delta_2(u - 1)^2. \quad (4.6)$$

The firm's value is determined by the discounted flow of post-tax revenue less investment and labor payments:

$$J_0 = \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \left(\prod_{s=1}^t m_t \right) \left((1 - \tau_k)(y_t - w_t n_t) - i_t + \tau_k \delta(\bar{u}) \bar{q} k_{t-1} \right) \right]$$

where τ_k is the tax on corporate profits net of a depreciation allowance. Production and capital follow from (4.4) and (4.5) and employment growth at the firm level satisfies:

$$n_t = (\nu_t \mu(\theta_t) + 1 - x) n_{t-1}, \quad (4.7)$$

where $\mu(\theta_t) = f(\theta_t)/\theta_t$ is the hiring probability per recruiter.¹⁰

4.3 Wage determination

Households and firms determine the wage under generalized Nash bargaining. Workers have bargaining power ϕ_t . As mentioned before, we view exogenous shifts in ϕ_t as capturing political and legal shocks (e.g., an administration that appoints more union-friendly board members at the NLRB or a major decision regarding labor relations by the Supreme Court of the United States), as well as potentially other shocks (for example, a structural change in the economy such as a move from manufacturing factories to decentralized services that make it difficult for workers to take collective

¹⁰We could easily augment the model with endogenous separations and firing costs, such as those existing in Europe. Since we will calibrate the model to the U.S. economy, where these costs are small, we can ignore them with little loss of empirical relevance. We could also include a time-varying unemployment insurance, but we prefer to keep the model parsimonious and focus on shocks to the Nash bargaining in the next subsection.

action).¹¹

The equilibrium wage, thus, solves the following problem:

$$w_t = \arg \max_{\tilde{w}_t} \tilde{V}_{n,t}(\tilde{w}_t)^{\phi_t} \tilde{J}_{n,t}(\tilde{w}_t)^{1-\phi_t},$$

where $\tilde{V}_{n,t}$ and $\tilde{J}_{n,t}$ are, respectively, the marginal values of employment for the worker and the firm given an arbitrary wage \tilde{w}_t for the current period and w_t thereafter. In equilibrium, of course, $\tilde{w}_t = w_t$. We derive $\tilde{V}_{n,t}$ and $\tilde{J}_{n,t}$ in the Appendix from the recursive formulation of the household and firm problems.

4.4 Exogenous processes

In our economy, two variables evolve exogenously: labor productivity z_t and the bargaining power ϕ_t . Labor productivity follows:

$$\ln z_t = \rho_z \ln z_{t-1} + \omega_z \epsilon_{z,t}$$

where $|\rho_z| < 1$ and $\epsilon_{z,t}$ is a normalized Gaussian shock. In the Appendix, we allow for $\rho_z = 1$ (i.e., permanent shocks to labor productivity). The bargaining power follows:

$$\ln \frac{\phi_t}{1-\phi_t} = (1-\rho_\phi) \ln \frac{\bar{\phi}}{1-\bar{\phi}} + \rho_\phi \ln \frac{\phi_{t-1}}{1-\phi_{t-1}} + \omega_\phi \epsilon_{\phi,t}$$

where the transformation $\ln \frac{\phi_t}{1-\phi_t}$ maps the level of the bargaining power from $[0, 1]$ to $(-\infty, \infty)$ and $\bar{\phi}$ is the average value of the process. Again, $|\rho_\phi| < 1$ and $\epsilon_{\phi,t}$ is a normalized Gaussian shock.

In contrast to other papers, we hold the matching efficiency ξ constant to isolate more transparently the effects of innovations to bargaining power.

4.5 Market clearing and equilibrium

Aggregate employment must follow the law of motion for the representative household (4.3), where the recruiter-unemployment ratio satisfies:

$$\theta_t = \frac{n_{t-1}}{1-n_{t-1}} \nu_t. \quad (4.8)$$

The resource constraint in this economy is standard: the production of the final good equals aggregate consumption and investment.

$$y_t = c_t + i_t. \quad (4.9)$$

Finally, aggregate capital has to satisfy the capital law of motion for the representative firm (4.5).

¹¹Binmore et al. (1986) show that the static bargaining problem is the limit point of a sequential strategic bargaining model. In such a sequential bargaining model, ϕ_t reflects asymmetries in the bargaining procedure or beliefs about the likelihood of a breakdown of negotiations. Their model, therefore, provides a micro-foundation for how policies that change the bargaining procedure induce changes in ϕ_t if the parties to the bargain are impatient.

The equilibrium stochastic discount factor, which follows from household optimization and market completeness, is:

$$m_{t+1} = \beta_t \frac{c_{t+1}^{-\sigma} (1 + (\sigma - 1)\gamma n_t)^\sigma}{c_t^{-\sigma} (1 + (\sigma - 1)\gamma n_{t-1})^\sigma}. \quad (4.10)$$

In the Appendix, we derive a more general discount factor that allows for external habit formation.

In equilibrium, households choose consumption and employment optimally, taking the process for the wage rate, the real interest rate, and labor market tightness as given. Similarly, firms choose investment, utilization, capital, production, and recruiting optimally, taking the process for the wage rate, the stochastic discount factor, and labor market tightness as given. The goods market also clears at the equilibrium choices.

In the spirit of [Hosios \(1990\)](#), Appendix G.5 shows that allocations along the balanced growth path are constrained efficient if $\phi = 1 - \eta$ and $\tau_n = \tau_k$. If workers' bargaining power or the corporate tax rate is too high, the value of employment to firms and recruitment are too low.

4.6 Mapping theory into data

There are two sources of value added in our model: final goods production and matching workers and firms. Thus, we define real output yr_t to be the sum of final goods production and the cost of recruiting:

$$yr_t \equiv y_t + \nu_t n_{t-1} w_t. \quad (4.11)$$

The cost of recruiting is not accounted for in the National Income and Product Accounts (NIPA) as an intermediate output, but as added value, since it corresponds to wages paid to workers hired to undertake this task.

The capital share is defined relative to this measure of output. Specifically, we use the following measures of the gross and net capital share in our economy:

$$cs_t \equiv 1 - \frac{n_{t-1} w_t}{yr_t}, \quad (4.12a)$$

$$ncs_t \equiv 1 - \frac{n_{t-1} w_t}{yr_t} - \delta \frac{k_{t-1}}{yr_t}. \quad (4.12b)$$

In the model, depreciation changes with the endogenous utilization decisions. In comparison, the depreciation rate in NIPA varies over time only because the capital stock changes its composition. Because we have a single good in our economy, we choose to measure the NIPA equivalent of the net capital share using the steady-state depreciation rate. This computes the net capital share under the assumption of a constant service life of an asset.¹²

¹²Per capita consumption is defined as the sum of real consumer non-durables and consumer services. Per capita investment is defined as real gross domestic private investment plus real durable consumption. Because only nominal or quantity indices are available for private consumption expenditures, we compute real consumption expenditures in 2009 dollars as the product of the per capita quantity index times their average 2009 nominal expenditures. Per capita GDP is defined as real per capita investment plus consumption. For variable mnemonics and exact series definitions, see Appendices A and G.8.

Finally, measured total factor productivity (TFP; hereafter we will omit “measured,” but TFP should always be understood as such) is equal to

$$TFP = GDP_t - cs_t k_{t-1} - (1 - cs_t)n_{t-1}. \quad (4.13)$$

Before solving our model, we HP-detrend all variables as needed. To compute business cycle statistics in the following sections, we compute quarterly averages and add the trend to all trending variables before HP-filtering. In the model, labor productivity, capital, consumption, investment, the marginal value of employment, the marginal product of labor, and wages grow at the common rate g_z , while all other variables are stationary.

4.7 Solution

We use a third-order perturbation to solve for the equilibrium of the detrended economy. This approach allows us to analyze some non-linear dynamics of interest and delivers higher accuracy. For example, the mean Euler equation errors are below 0.5% of consumption and the 99th percentile of Euler errors is around 1.5% (see Appendix G.11).¹³ To ensure stability, we apply the pruning method developed by [Andreasen et al. \(2017\)](#).

In the neighborhood of the calibrated, detrended steady state (see Section 5), the capital share is almost invariant to the bargaining power. In the long run, the capital share is overwhelmingly determined by technology and preferences. In our baseline calibration, 31 out of the 31.2 pp. of the gross capital share are compensation for depreciation, impatience, and growth. Instead, employment moves to equate the marginal product of labor to the varying wage rate (adjusted for recruiting costs). For the same reason, the rental rate of capital and the marginal product of capital are also nearly invariant to the bargaining power for a wide range of calibrations.¹⁴

5 Taking the model to the data: Identification and calibration

We calibrate our model at a monthly frequency to U.S. data. As described in [Andreasen et al. \(2017\)](#), we will match moments in the data to the corresponding moments of the model’s ergodic distribution, and not to their steady-state values. We do so because, under a non-linear solution, the latter may not summarize well the properties of ergodic distributions.

¹³[Petrosky-Nadeau and Zhang \(2013\)](#) argue that a partial equilibrium search-and-matching model close to ours exhibits non-linearities that a second-order perturbation does not capture adequately. But their model has an occasionally-binding inequality constraint on posting vacancies that complicates the computation of the solution. The analog in our model is the fraction of recruiters, ν_t . In general equilibrium, ν_t does not get to zero: because of the concavity of the recruiting technology, firms always want to have at least a small positive fraction of recruiters. Thus, our solution is much easier to compute.

¹⁴When we re-calibrate the disutility of working to keep employment constant, the capital shares are independent of $\bar{\phi}$. The matching efficiency ξ is calibrated for any given average employment level \bar{n} to ensure that the balanced-growth path recruiter-employment ratio $\bar{\theta}$ is constant across parameterizations. Then, the optimality for recruiting and the production function imply that the wage, GDP, final output, the number of recruiters, and the capital along the balanced-growth path are constant as well.

5.1 Technology and preferences

We start by selecting a Cobb-Douglas production function, with $\varepsilon = 1$, as in [Cooley and Prescott \(1995\)](#) and many others. Alternatively, we will consider values of $\varepsilon = 1 \pm 0.25$, reflecting the recent work of [Karabarbounis and Neiman \(2014\)](#) and [Oberfield and Raval \(2014\)](#). The former estimate the elasticity of substitution of 1.25 using long-run differences across countries. The latter estimate a macro-elasticity of substitution for the manufacturing sector of 0.7 based on a weighted average of micro-elasticities of substitution and demand. Also, after [Cooley and Prescott \(1995\)](#), we select g_z to be 1.6% per year.

We choose the discount factor β , the share of capital in production α , and the depreciation rate δ to match three properties of the non-financial corporate business sector: (1) the gross capital share of 31.2%, (2) the ratio of depreciation to gross value added of 12.7%, and (3) the (annualized) ratio of capital to gross value added of 2.3. We calibrate the average corporate tax rate to 30%, the average observed in the data. Given our choice of g_z , the implied annual depreciation rate is 5.5% and the annualized discount rate is 0.976. The corresponding capital share α depends on the elasticity of substitution, but is simply 0.31 in the Cobb-Douglas case.¹⁵

Next, we calibrate the labor market following [Shimer \(2010, p. 80f.\)](#). The exogenous separation rate x is 3.3% per month, the average unemployment rate is 5%, and the matching efficiency ξ is such that one recruiter hires, on average, 25 employees per quarter. We set the matching elasticity η and the average bargaining power $\bar{\phi}$ to 0.5. As in [Prescott \(2004\)](#), a labor income tax rate of 40% combines the consumption taxes and the actual labor tax rate. Choosing a conventional value of $\sigma = 2$ implies that consumption complements labor moderately and that the employed consume 30% more than the unemployed.

5.2 Stochastic processes

The stochastic processes for z_t and ϕ_t are indexed by their persistences, ρ_i , and standard deviations, ω_i , for $i \in \{z, \phi\}$. Following [Cooley and Prescott \(1995\)](#), we set $\rho_z = 0.95^{1/3}$, a standard value. This leaves us three parameters to determine: ρ_ϕ , ω_z , and ω_ϕ . Given that we do not have direct observations of the bargaining shocks, we will proceed in two steps. First, we will describe the source of variation in the data that will give us identification of ω_z and ω_ϕ given ρ_ϕ . Second, we will explain how we explore a wide range of values of ρ_ϕ to capture different views on the persistence of bargaining shocks.

The first step is illustrated by [Figure 9](#), where we show the response of the fraction of recruiters, unemployment rate, and wages to shocks to the bargaining power and labor productivity.¹⁶ In the top panels, we see that, after innovations to the shocks that deliver either higher bargaining power

¹⁵While the calibration of the model is not fully recursive, in practice it is nearly so (i.e., we can calibrate one block of parameters, move to calibrate another one, and so on, and only have to do minor readjustments at the end). Thus, to simplify the exposition, we discuss separately in the text the different blocks of parameters.

¹⁶To plot the four panels, we assume permanent shocks, keep consumption constant after each shock, and use our baseline calibration in [Table 5](#). With the full transient dynamics, the panels would be harder to read. However, the intuition of the identification result remains fully unchanged.

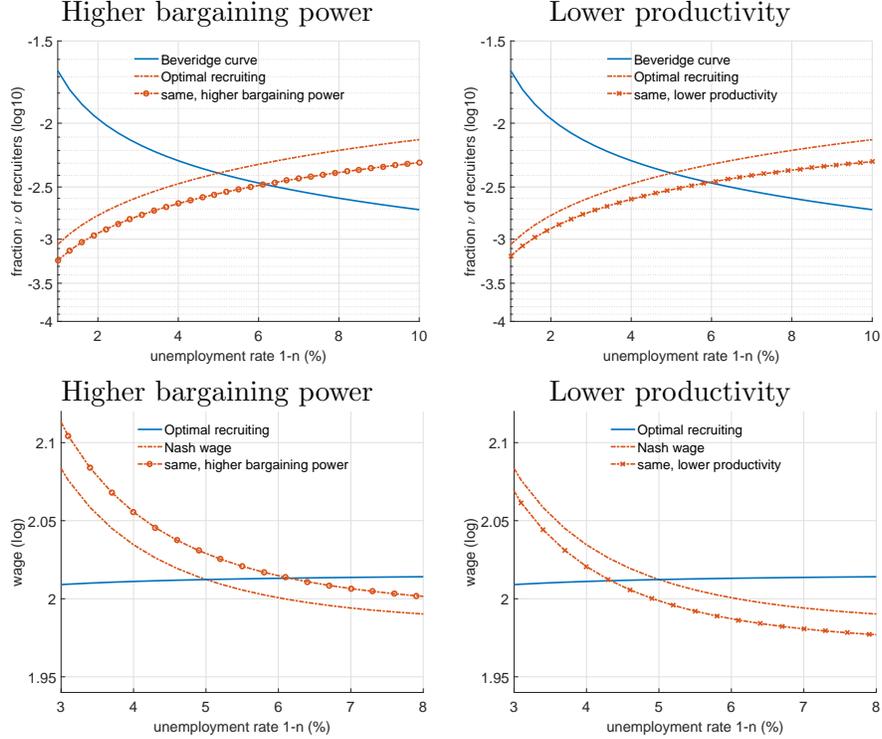


Figure 9: Steady-state response to shocks.

for workers, ϕ_t , or lower productivity, z_t , the optimal recruiting decision for the firm that relates the unemployment rate, $1 - n_t$, and the fraction of recruiters, ν_t , moves to the right. In both cases, the firm finds it less profitable to recruit new workers: either the firm appropriates a smaller share of the match surplus or workers are less productive. Thus, $1 - n_t$ increases (and output falls) and ν_t falls after both innovations. The bottom panels of Figure 9 document that, in comparison, wages increase after an increase in bargaining power, but fall after a decrease in productivity. Higher bargaining power for workers lowers output and the match surplus, but because their share in the surplus rises enough, workers still take home a higher wage. In summary: higher worker bargaining power and lower productivity lower output, but have an opposite impact on wages.

Thus, we can exploit observations on wages, output, and TFP to pin down the size of bargaining power shocks and productivity shocks. More concretely, given ρ_ϕ , we pick ω_z and ω_ϕ to match the observed correlation of wages with GDP and –recall equation (4.13)– the volatility of TFP.¹⁷ Given ω_z , a higher ω_ϕ lowers the correlation of wages and GDP. This trade-off is illustrated by the left panel in Figure 10. The green horizontal line gives us the observed correlation of wages and GDP and the decreasing curves the model-implied correlation for different values of ω_ϕ (with κ that matches the volatility of investment at the preferred calibration).

Note, however, that we plot three different lines, each corresponding to a different value of

¹⁷At a quarterly frequency, Cooley and Prescott (1995) find an autocorrelation of 0.95 and a standard deviation of 0.73% for TFP. Averaging monthly observations within quarters, their values correspond to a monthly autocorrelation of $0.95^{1/3}$ and a standard deviation of TFP productivity of 0.73%. We find a value of 0.76%.

ω_z (and, as before, conditional on ρ_ϕ). We can improve the sharpness of the identification if we simultaneously calibrate the standard deviation of productivity shocks, ω_z , to match the volatility of TFP (middle panel of Figure 10), and the investment adjustment cost, κ/δ_0^2 to match the relative volatility of investment (right panel). The horizontal lines in the figure indicate HP-filtered data moments.¹⁸ Intuitively, the larger the standard deviation of productivity, the larger the standard deviation of the bargaining shocks that matches the cyclicity of wages. Fortunately, productivity shocks are the main driver of TFP and, thus, we can easily identify these parameters together. Last, the relative volatility of investment to GDP pins down the investment adjustment cost. While changing this parameter has next to no impact on the cyclicity of wages, it has a large impact on investment. We match the relative volatility of investment, because recruitment is also a quasi-investment activity that we want to discipline indirectly by getting capital investment right. Figure G.14 plots the additional bivariate relation among these three parameters and documents why we can ignore, for calibration purposes, the omitted plots.

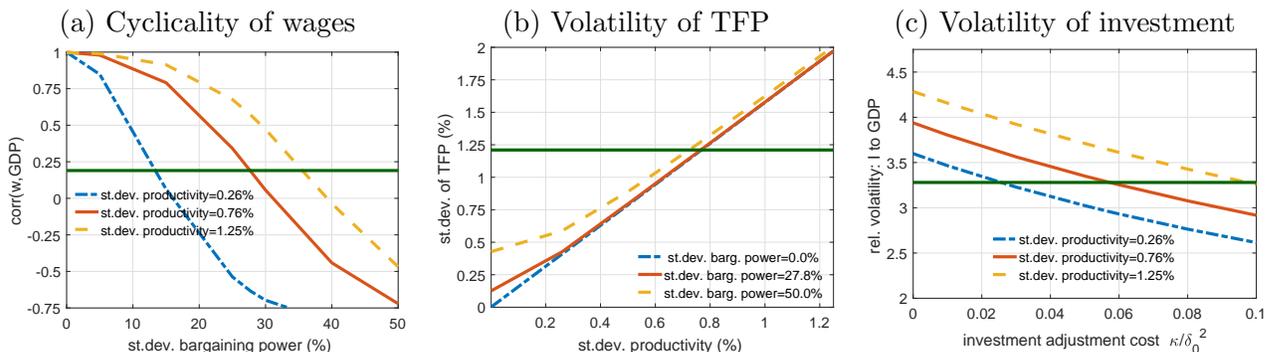


Figure 10: Identifying ω_z , ω_ϕ , and κ/δ_0^2 .

Thus, it only remains to pick the persistence of the bargaining shock, ρ_ϕ . Since we are agnostic about how persistent this shock is in the data, we will select three cases. As a baseline medium-term case, we set $\rho_\phi = 0.98^{1/3}$. This value implies a half-life of the shock of 34 quarters.¹⁹ From 1948 to 2016, the average duration of a party's control of the presidency has been 30.2 quarters, of the Senate 38.9 quarters, and of the House of Representatives 24.7 quarters (the Democrats started 1948 already in control of the presidency and the current Republican control of the Senate and the House is ongoing, so our numbers are slightly biased downward).²⁰ Given that the changes in party control that resulted in small changes in policy (Truman followed by Eisenhower, the first Bush followed by Clinton) have been roughly the same as the changes that resulted in more substantial policy shifts (Carter by Reagan, the second Bush by Obama), 34 quarters is a reasonable duration

¹⁸We also set the elasticity of utilization with respect to the marginal product of capital to $\frac{1}{2}$ (i.e., $\delta_2 = 2\delta_1$).

¹⁹Note that 34 quarters is above the conventional 32-quarters cut-off of business cycle frequencies. Thus, we are dealing with a shock that generates medium-term business cycles as in Comin and Gertler (2006). In the interest of space and to allow an easy comparison with the literature, most of our quantitative results will focus more on business cycle fluctuations. We will make some references, however, to the longer-lived effects of the shock.

²⁰Coding the control of the Supreme Court is harder, as justices drift across time (John Paul Stevens started in 1975 as a Republican and ended in 2010 as a solid liberal) and across cases (think of Anthony Kennedy's pivots).

for the half-life of the middle-run political cycle in the U.S. after WWII. Given this $\rho_\phi = 0.98^{1/3}$, the monthly standard deviation of the bargaining power shock of 6.9 pp. and $\kappa = 0.075/\delta_0^2$. In addition, $\rho_\phi = 0.98^{1/3}$ approximately coincides with the features of the U.S. labor income share's medium-term dynamics documented by [Muck et al. \(2015a\)](#). Table 5 summarizes this baseline calibration.

Parameter	Value
Risk aversion σ	2
Discount factor β	$0.976^{1/12}$
Disutility of working γ	such that $\bar{n} := 0.95$
Capital share α	0.31
Elasticity of substitution ε	1
Depreciation δ_0	0.055/12
Avg. efficiency of investment $\bar{\chi}$	1
Avg. detrended \tilde{z}	1
Trend productivity growth g_z	$1.016^{1/12}$
Investment adjustment cost κ	$0.0575 \times (\delta_0)^{-2}$
Capacity utilization cost δ_1	such that $\bar{u} = 1$
Capacity utilization cost δ_2	$2\delta_1$ (BGP ela. w.r.t. $\frac{mpk_t}{u_t}$ of $\frac{1}{2}$)
Separation rate x	0.033
Bargaining power $\bar{\phi}$	0.5
Matching elasticity η	0.5
Matching efficiency ξ	2.3
Labor income tax rate τ_n	0.4
Corporate tax rate τ_k	0.3
Productivity shock persistence ρ_z	$0.95^{1/3}$
Bargaining shock persistence ρ_ϕ	$0.98^{1/3}$
Bargaining power s.d. ω_ϕ	27.75%
Labor productivity s.d. ω_z	0.76%
Implied gross capital share $\bar{c}\bar{s}$	31.2%
Implied net capital share $\bar{n}\bar{c}\bar{s}$	16.9%

Table 5: Parameter values for the baseline persistence of bargaining shock.

Second, as a high-persistence scenario, we choose $\rho_\phi = 0.9914^{1/3}$. This value gives a half-life of the bargaining shock of 80 quarters, which corresponds to long-run movements in the political climate related to party realignments, demographic changes, etc., like those documented in our six case studies of Section 2. We recalibrate all other parameters of the model accordingly.

Third, as a low-persistence scenario, we set $\rho_\phi = 0.95^{1/3}$, which yields a half-life of around 14 quarters. This low-persistence case matches the same persistence for the bargaining shock as for the productivity shock, and thus it embodies a degree of parsimony and “standard” business cycle properties. For this persistence, we also recalibrate all other parameter values.

5.3 An RBC model calibration

For comparison purposes in the results section, we formulate an RBC model *à la* Hansen-Rogerson where we eliminate the search and matching frictions. We calibrate the model using the same targets as for our baseline economy to pin down the ω_z and κ (given the known properties of this model, we need to give up on matching the cyclical behavior of wages). In that way, we can benchmark our model against the behavior of a well-understood environment. For better comparison, labor supply is determined one period in advance, but wages are set on the spot market. The counterpart model is described in detail in Appendix G.14 and its quantitative properties are reported in the rows labeled “RBC model” in Table 7. As an additional exercise, in Subsection 7.1, we will calibrate a version of this RBC model where we add exogenous shocks to the factor shares in the production function (as in Ríos-Rull and Santaeulàlia-Llopis, 2010, and Lansing, 2015).

6 Quantitative results I: Historical bargaining power

Do the data, analyzed through the lenses of our model, support our calibration of the bargaining power process? Is the process we calibrate consistent with the historical evidence? In this section, we argue that the data broadly confirm our empirical approach. We document, first, that the implied bargaining power process covaries meaningfully with historical U.S. events. Second, we show that the statistical properties of the bargaining power process closely match our model.

We use a new methodology, which we call the *partial filter*, to back out the bargaining power process from the data because a full-information particle filter is hard to implement. First, our model is a simple two-shock economy without the bells and whistles present in many New Keynesian models designed to account for many observables. Second, our pruned solution features a large number of state variables and non-linearities that would require a high-dimensional particle filter. Our filtering strategy, instead, exploits the structure of the key equations of our economy to deliver a simple statistical model that recovers the bargaining power. Indeed, we call our filter *partial* because, importantly, we do not have to filter all the states and it uses only some of the equilibrium conditions of the model. Methodologically, the central insight of our proposal is to move from unobserved expectations in the equilibrium conditions to conditional first and second moments that can be described using (potentially time-varying) VARs. Hence, our partial filter can be potentially applied to many contexts, including non-linear Phillips curve models and others.

6.1 The partial filter

Bargaining power enters into our model only through the wage-setting equation (G.25) (see Appendix G for the tedious, but straightforward derivation of this equation). Hence, it is natural to use the wage-setting equation to recover the historical bargaining power implied by the theory and data. The challenge is, however, that this equation features firms’ expectations. Specifically, we need to model the expectation of the discounted future value of employment to firms times their relative bargaining power. A full-information approach would rely on a non-linear filter, such as

a sequential Monte Carlo filter (Fernández-Villaverde et al., 2016), to filter all the states of our non-linear model and back out the relevant expectation.

Instead, we use an auxiliary statistical model and firms' optimality conditions to model the expectations. To do so, we take advantage of two results. First, for any two random variables (x_t, y_t) , we have that $\mathbb{E}_t[x_{t+1}y_{t+1}] = \text{Cov}_t[x_{t+1}, y_{t+1}] + \mathbb{E}_t[x_{t+1}]\mathbb{E}_t[y_{t+1}]$. Second, firms' equilibrium conditions allow us to write the product of the conditional expectations in terms of time t observables. This leaves only the unknown covariance of the random variables, which we estimate with a statistical model. Conditional on an estimate, the bargaining power is the value that makes the wage-setting equation hold.

Specifically, Appendix G.12 shows that we can re-write the wage-setting equation as:

$$\begin{aligned} & e^{\ln \frac{\phi_t}{1-\phi_t}} \left(\left(mpl_t \left(1 + \frac{1-x}{\mu(\theta_t)} \right) - w_t \right) - (1-x-f_t(\theta_t)) e^{\kappa_\phi + (\rho_\phi - 1) \ln \frac{\phi_t}{1-\phi_t} + \frac{1}{2} \omega_\phi^2} \left(\text{Cov}_t[\circ] + \frac{mpl_t}{\mu(\theta_t)} \right) \right) \\ = & w_t - \frac{1}{1-\tau_n} \left(\frac{c_t}{1 + (\sigma-1)\gamma n_{t-1}} \right) \gamma \sigma, \end{aligned} \quad (6.1)$$

where mpl_t is the marginal product of labor, κ_ϕ is a constant, and

$$\text{Cov}_t[\circ] = \text{Cov}_t \left[\ln \frac{\phi_{t+1}}{1-\phi_{t+1}}, m_{t+1} \left(mpl_{t+1} \left(1 + \frac{1-x}{\mu(\theta_{t+1})} \right) - w_{t+1} \right) \right].$$

Intuitively, $\frac{\phi_t}{1-\phi_t}$ multiplies the static and future match-surplus to the firm on the left-hand side of equation (6.1). The right-hand side is simply the static surplus to the household.

To take equation (6.1) to the data, we exploit that, in our baseline Cobb-Douglas calibration, mpl_t is proportional to the average product $\frac{y_t}{n_t}$. We use real gross value added in the non-farm business sector to compute $\frac{y_t}{n_t}$. Employment n_t is one minus the unemployment rate.²¹ The wage rate w_t is the real hourly compensation in the same sector. Consumption c_t equals real per capita expenditures on non-durables and services. The stochastic discount factor m_t is a function of consumption and employment. Labor market tightness θ_t is the ratio of vacancies to the unemployed. We then use a simple Bayesian VAR that includes the discounted match surplus and the implied bargaining power to estimate this covariance term.

A Gibbs sampler solves the difficulty that we need the bargaining power process to estimate the covariances and the covariances to back out bargaining power. The sampler starts with an arbitrary guess of the covariances and allows us to address the estimation uncertainty. More concretely, for $d = 1, \dots, D$, we iterate on the following steps:

1. Given the previous draw of the bargaining power sequence, draw parameters:

- (a) Draw the covariance term $\text{Cov}_t[\circ]^{(d)}$ from the posterior for a VAR in $\ln \left(\frac{\phi_{t+1}}{1-\phi_{t+1}} \right)^{(d-1)}$, $m_{t+1} \left(mpl_{t+1} \left(1 + \frac{1-x}{\mu(\theta_{t+1})} \right) - w_{t+1} \right)$, mpl_t , θ_t , w_t , and c_t .

²¹The unemployment rate in our model is $1 - n_t$. Note that in the model y_t excludes recruiting activities, whereas value added does not. This discrepancy is, however, tiny.

- (b) Draw $\rho_\phi^{(d)}, \omega_\phi^{(d)}$ from the posterior for the AR(1) process for $\ln\left(\frac{\phi_t}{1-\phi_t}\right)^{(d-1)}$.
2. Given observables, $\text{Cov}_t[\circ]^{(d)}, \rho_\phi^{(d)}$ and $\omega_\phi^{(d)}$, solve (6.1) period by period for $\left(\frac{\phi_t}{1-\phi_t}\right)^{(d)}$.

For details, see Appendix G.12.²² There we describe how we scale the observed variables to match the steady state of our model. By construction, we match the positive steady-state surplus to households and firms in our model, but these match surpluses would turn negative in some periods. We guarantee that the discounted match surplus is positive by first adjusting mpl_t so that it lies weakly above the real wage. We then lower the average disutility of working, such that the implied bargaining power averages 0.5 in our sample when the covariance terms are set to zero.²³ Last, we adjust the frequency of the model to quarterly data. We use a flat prior in the estimation.

6.2 Results

The blue solid line charted against the left axis in Figure 11 shows the implied path of the bargaining power process. We focus, first, on the medium-term fluctuations. Our sample starts at the time of a large victory for labor, the so-called “Reuther’s Treaty of Detroit,” a 5-year contract between General Motors (GM) and the United Automobile Workers (UAW) and named after the UAW’s president, Walter Reuther. As one astute contemporary economist observed: “The inclusion of the modified union shop in a five-year contract and the conciliatory approach of the corporation in bargaining have finally convinced the union leadership, it appears, that GM has accepted the UAW on a realistic and permanent basis” (Harbison, 1950, p. 404). The Treaty of Detroit opened two decades of gains for workers across many industries and sectors in the U.S. economy (Levy and Temin, 2007). Even Eisenhower appointed Martin P. Durkin, a former union leader, as his first Secretary of Labor and his second Secretary of Labor, James P. Mitchell, has been inducted into the Labor Hall of Honor. Proposed right-to-work laws were defeated in California, Ohio, Colorado, Idaho, and Washington (Dubofsky and Dulles, 2017, loc. 7891). In line with these events, our bargaining power increases from 0.5 to levels close to 1 by the end of the 1950s.

However, the end of this decade saw, as documented by Figure 11, the start of a relative decline in workers’ power. Several factors contributed to it. First, the American Federation of Labor (AFL) and the Congress of Industrial Organizations (CIO) merged in 1955. The merger led, after a few years, to a more moderate attitude by the unions formerly associated with the CIO and a smaller effort in increasing unionization rates. Richard Lester, a prominent Princeton labor economist at the time, labeled the new AFL-CIO a “sleepy monopoly.” Also, the merger of the two organizations facilitated the purge of the few remaining communist sympathizers at the CIO. Second, many firms, worried by increasing foreign competition and rising costs, adopted the

²²We initialize the process at our calibrated parameters and discard draws from a burn-in period. A time-varying VAR would yield a time-varying sequence of covariances that would match our non-linear model more closely. We abstract from this non-linearity because the covariance terms are small and the posterior uncertainty about the in-sample bargaining power is negligible.

²³Adjusting mpl_t instead does not allow us to match the average bargaining power without turning the firms’ match surplus negative for some periods.

so-called “hard-line” position of 1958, which, after several years of industrial conflict (as in the steel industry in 1959), led to some victories for management. Third, the Landrum-Griffin Act of 1959, a response to corruption and racketeering in the labor movement, imposed additional guarantees regarding the internal behavior of unions and tightened the rules regulating secondary boycotts, “hot cargo” agreements, and recognitional picketing. These measures curbed the tactics of some unions, which called for many fewer strikes in the early 1960s than in the late 1950s. As Walter Reuther put it in 1960: “We are going backward.”

The decline in workers’ bargaining power continued until the mid-1960s when it was back at around 0.5. This trend was helped by the wage-price guideposts started by Walter Heller at the Council of Economic Advisors in 1962 and pushed by Johnson as an essential tool of the economic policy of his administration. Although often remembered because of the fight between Kennedy and the steel industry in 1962, the wage-price guideposts probably slowed down wage increases relative to productivity growth (see the narrative in [Slesinger, 1967](#)).

The late 1960s saw, in comparison, lower unemployment, an economy running at high utilization rates (although those factors are endogenous in our model), and the renewed strength of unions, often led by a younger, more militant generation that had experienced the civil rights struggles, the anti-war movement, and the radicalizing influence of the New Left. One of these new union leaders, Leonard Woodcock (the successor of Walter Reuther as president of the UAW after Reuther’s untimely death), organized the nationwide UAW strike against GM in September 1970, which lasted for 67 days. This strike was one of the biggest victories of the post-WWII labor movement: UAW members received complete cost-of-living wage adjustments and a “30-and-out” retirement plan (i.e., full pension after 30 years of work regardless of age). Our partial filter identifies as one of its local peaks 1970.Q4.

The early 1970s were an Indian summer for U.S. unions and industrial workers (see, again, [Levy and Temin, 2007](#)). But the effect of the oil shocks and a changing political climate eroded the bargaining power of workers by the late 1970s, perhaps best represented by the failure of the 1978 proposed reform of labor law, an endeavor in which the AFL-CIO had invested considerable political capital, and the peak in unionization coverage and membership percentages in 1979 ([Hirsch and Macpherson, 2003](#)).

This process sharply accelerated with Reagan’s arrival at the White House and his notorious firing of striking air-traffic controllers in 1981.Q3 (the repercussions of which were only felt in the second half of the 1980s). For the next two decades, our backed-out bargaining power series nearly uninterruptedly drops to well below 0.5. Reagan was followed by the first Bush and Clinton, a pro-business Democrat who signed the welfare reform act in 1996.Q3, lowering many workers’ outside option at the time of bargaining. Simultaneously, the significant immigration of the 1980s-2000s (spurred by the somewhat delayed effects of the 1965 Hart-Celler Act) created many service-sector workers with fewer historical links to the labor movement.²⁴

²⁴For immigration data, see <https://www.dhs.gov/immigration-statistics/yearbook>.

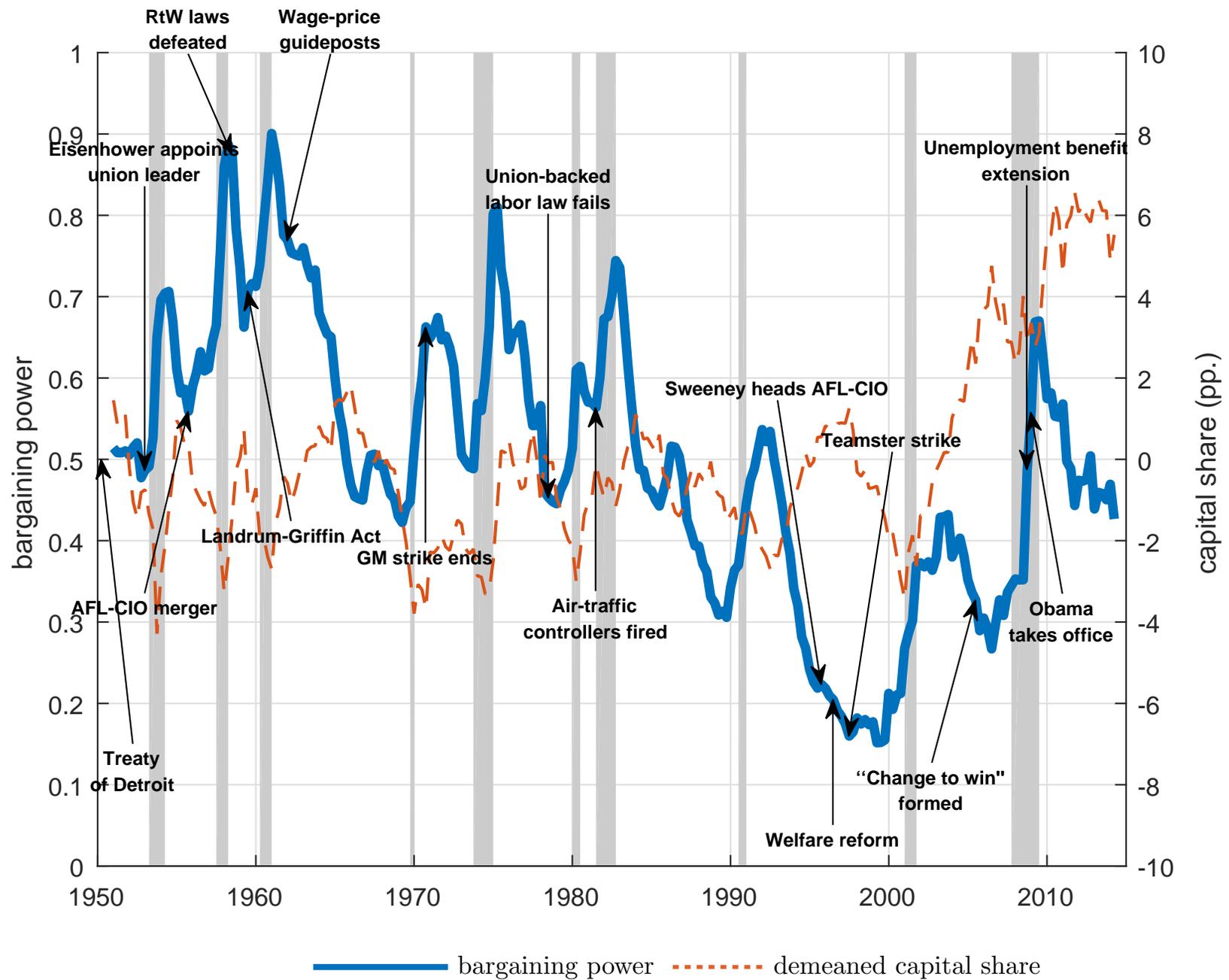


Figure 11: Bargaining power process implied by the baseline calibration

The late 1990s and early 2000s saw, according to our partial filter, a stop in the negative trend of workers’ bargaining power. The 1997 Teamsters strike, the arrival of John Sweeney to the leadership of the AFL-CIO, and the creation of the Change to Win Federation in 2005 did not return organized labor to its former glory, but, at least, stabilized bargaining power somewhat below 0.5. The bargaining power partially recovered in 2008.Q4, when the unemployment benefit extensions raised the outside option of many workers,²⁵ with the electoral victory of Obama –the most pro-union president in a generation– and later with some early successes of the “fight for \$15” and the slowdown in immigration.

While our stylized two-shocks economy cannot hope to match all the richness of the data, our comparison of Figure 11 with the historical narrative above demonstrates a surprising level of agreement. In Appendix G.12, we compare our results with an alternative bargaining power index proposed by Levy and Temin (2007). The fact that both indexes display a considerable degree of comovement reinforces our positive assessment of our partial filtering exercise.

Of course, there are aspects that we miss. For example, our filter shows increases in workers’ bargaining power during recessions (shaded lines in Figure 11). Our model requires such counter-cyclical bargaining power to account for the fluctuations in the data. Even if the model is consistent with the observations, we acknowledge that we may miss additional aspects such as unemployment benefits with endogenous duration that, in a richer model, would affect the outside option, but not necessarily bargaining power. We view this parsimony as a positive feature of our investigation, but we also consider the role of endogenous bargaining power below by introducing a reduced-form policy rule, which will not change the main thrust of our results.²⁶

Table 6: Implied bargaining power process moments
Productivity based on complement of the unemployment rate, no detrending

	Median	5th percentile	95th percentile
In-sample autocorrelation	0.9747	0.9747	0.9748
Posterior autocorrelation	0.9741	0.9511	0.9957
In-sample AR(1) st.dev.	0.1728	0.1727	0.1730
Posterior AR(1) st.dev.	0.1720	0.1611	0.1851
In-sample $\text{Cov}_t[o]$	0.0018	0.0018	0.0018
Posterior $\text{Cov}_t[o]$	0.0020	0.0009	0.0032
In-sample average bargaining power	0.4993	0.4992	0.4995

Besides the previous narrative, the statistical properties of the bargaining power process are very close to the model; see Table 6. With a flat prior, the median posterior persistence is 0.9741 per quarter with a 90% credible set of (0.9511, 0.9957). The posterior for the conditional standard deviation is 0.1720 (0.1611, 0.1851). These values come close to our calibration of $\rho_\phi = 0.9800$ and $\omega_\phi = 0.2775$. The posterior for the covariance is close to zero with a 90% credible set of

²⁵These benefits peaked in mid-2010; see Figure A-4 in Hagedorn et al., 2013

²⁶Other alternatives could include a richer heterogeneity, with job ladders or learning-on-the-job, that vary across the cycle and affect wages, and that our model may miss. An interpretation of our results in Figure 11 would be the “aggregate” bargaining power that such models with heterogeneous workers should be able to match.

(0.0008, 0.0030). Appendix G.12 shows that when we use the wage of new hires, an alternative measure of labor productivity or the employment-to-population ratio, and detrend non-stationary variables before filtering, we find only small changes in our results. The same appendix also computes a counterfactual unemployment generated by our filtered bargaining shock and discusses the positive correlation of our bargaining power index with the federal minimum wage, in agreement with our VAR exercise in Section 3.

7 Quantitative results II: Business cycle statistics

We move now to assess the business cycle properties of the model. Table 7 compares U.S. business cycle statistics to those of our search and matching (S&M) model (with and without bargaining shocks) and its RBC counterpart. We focus on statistics that describe the volatility, persistence, and cyclicity of aggregate variables. All business cycle statistics are based on HP-filtered quarterly variables, averaged across 3 months in the model simulations. We take logs of level variables before filtering, but filter variables that are ratios as such. We construct GDP per capita as the sum of real per capita consumption and investment to match the data with our model.

In the data, the volatility of (log) GDP is slightly less than 2.0% per quarter. Investment is 3.28 times as volatile as GDP, whereas consumption is only 0.58 times as volatile. With correlations of 0.91 and 0.84, both investment and consumption are highly pro-cyclical. Similarly, both the gross and the net capital share are pro-cyclical (with a correlation of 0.57 and 0.36 respectively), but less so than consumption and investment. All variables are very persistent, with quarterly autocorrelations of 0.67 to 0.90.

How does our model compare to the data? Recall that we calibrated the standard deviation of the capital adjustment cost to match the volatility of TFP (1.21%) and the relative volatility of investment (3.28) and consumption (0.58). Thus, it is not surprising that this calibration delivers nearly the exact level of GDP volatility (2.01). If we eliminate the bargaining shock (but keep all the other parameters, including adjustment costs, at their baseline value), the volatility of output drops 34% to 1.31; compare the row “S&M model: baseline” with “S&M model: No bargaining shocks” in Table 7). Without bargaining shocks, the performance of the model in terms of the relative volatility of investment and consumption is still satisfactory.²⁷

The model with “no bargaining shock” fails, however, to generate any meaningful fluctuations in the gross capital share and only around 17% of the fluctuations in the net capital share. Instead, our baseline model with bargaining shocks can account for slightly less than 20% of the volatility of the gross and 34% of the volatility of the net capital share in the data.

The baseline model also captures the cyclicity and persistence of the capital shares well. With respect to cyclicity, the model overstates a bit the cyclicity of the net capital share and

²⁷As a robustness check, we tried an alternative exercise where we calibrated the model with productivity shocks, but without bargaining shocks. Then we measured the effects of introducing bargaining shocks while keeping all the other parameters constant. The results were nearly identical. In particular, the difference in the explained share of GDP fluctuations by bargaining shocks was within 1 pp.

Table 7: Business cycle statistics: 1947Q1–2015Q2

	Volatility							
	Y [%]	$\frac{\text{std}(I)}{\text{std}(Y)}$	$\frac{\text{std}(C)}{\text{std}(Y)}$	std(ncs) [pp.]	std(cs) [pp.]	std(w) [%]	std(u) [%]	std(TFP) [%]
U.S. data	1.99	3.28	0.58	1.07	0.86	0.95	0.83	1.21
	Models							
S&M model: baseline	2.01	3.28	0.59	0.36	0.17	1.31	1.86	1.21
S&M model: no bargaining shock	1.31	3.73	0.49	0.18	0.02	1.14	0.15	1.20
RBC model: baseline	1.89	3.28	0.60	0.25	0.00	0.92	1.04	1.21
RBC model with factor share shock	1.58	3.28	0.60	0.36	0.16	0.83	0.55	1.21
	Cyclicalities							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	1.00	0.91	0.84	0.57	0.36	0.19	-0.76	0.78
	Models							
S&M model: baseline	1.00	0.96	0.98	0.87	0.33	0.19	-0.76	0.71
S&M model: no bargaining shock	1.00	0.99	0.99	0.97	0.89	1.00	-0.96	1.00
RBC model: baseline	1.00	0.98	0.99	0.98	NaN	0.96	-0.95	0.99
RBC model with factor share shock	1.00	0.98	0.99	0.99	0.99	0.98	-0.94	0.99
	Persistence							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	0.87	0.82	0.78	0.76	0.74	0.67	0.90	0.78
	Models							
S&M model: baseline	0.83	0.79	0.85	0.78	0.66	0.79	0.81	0.78
S&M model: no bargaining shock	0.79	0.80	0.80	0.78	0.60	0.78	0.82	0.78
RBC model: baseline	0.80	0.80	0.80	0.81	NaN	0.76	0.79	0.78
RBC model with factor share shock	0.79	0.79	0.80	0.80	0.78	0.77	0.77	0.78

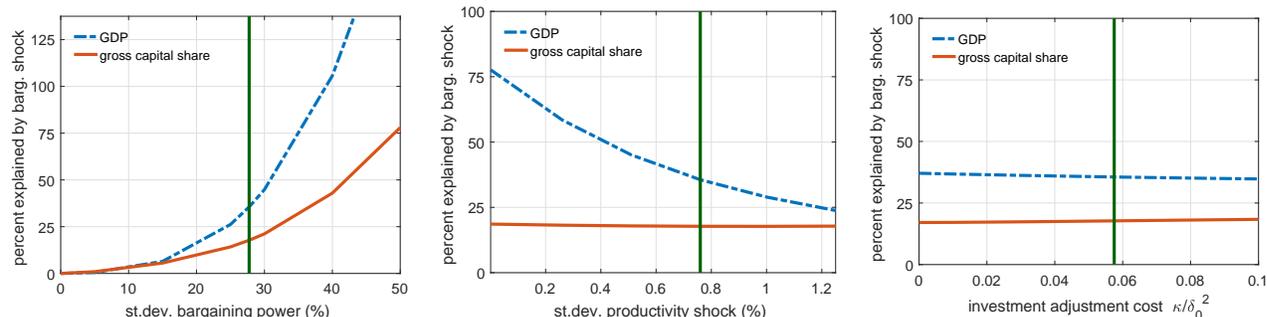
Note: Quarterly data, HP-filtered with smoothing parameter $\lambda = 1,600$. We average the monthly model-generated data first within quarters before HP-filtering.

understates that of the gross capital share. In comparison, the model with “no bargaining shock” does considerably worse regarding correlations of the gross and net capital shares, with correlations counterfactually close to 1. Without bargaining shocks, the only moves in these shares come from changes in capital and the outside value in the bargaining protocol and both mechanisms are weak. With respect to the autocorrelation, the model with bargaining shocks matches the autocorrelation of the net capital share in the data of 0.76 almost exactly and, with a value of 0.66, understates the empirical autocorrelation of the gross capital share of 0.74 only slightly. The model with “no bargaining shock” does somewhat worse matching these autocorrelations.

By construction, our baseline model generates a nearly acyclical wage: the correlation of output and wages is 0.19 both in the model and in the data. The procyclicality of wages in productivity-driven models (higher productivity increases the marginal productivity of labor and, with it, wages) is compensated by the bargaining shocks. A shock that lowers wages is also expansionary (it increases the returns to capital and, thus, investment in physical capital and recruiting and, with

them, output in the following periods). This mechanism is sufficiently strong to nearly wipe out any correlation between wages and output.

The three panels in Figure 12 complete this discussion by showing the explained standard deviation of GDP and the gross capital share as a function of the standard deviation of the bargaining and productivity shocks and the investment adjustment. Only the size of the bargaining shocks has noticeable effects on the volatility of the capital share.



Note: The vertical lines indicate HP-filtered data moments.

Figure 12: Explained standard deviation as a function of calibrated parameters.

7.1 Comparison with an RBC model

Could a standard RBC model account for the same features of the data as our search and matching model with bargaining shocks? To answer this question, we report in the rows “RBC model” in Table 7 the quantitative properties of the RBC model à la Hansen-Rogerson introduced in Subsection 5.3 (see, also, Figure G.27 for the full set of impulse response functions with unitary elasticity of substitution and Figures G.28 and G.29 for the corresponding figures with elasticities of $\varepsilon = 1 \pm 0.25$.)

The RBC model fails to account for labor market statistics (the cyclical nature of wages and unemployment) and for the fluctuations of the net capital share induced by changes in depreciation (by construction, this RBC model cannot generate any volatility in the gross capital share when $\varepsilon = 1$; we will relax this assumption below).

One could follow [Ríos-Rull and Santaeulària-Llopis \(2010\)](#) and [Lansing \(2015\)](#) and introduce shocks to the factor shares in production within the RBC model. However, these shocks move real wages in the same direction as output: A negative shock to the factor share of capital lowers the productivity of capital and, via the marginal product of labor, also the real wage. Thus, the real wage remains perfectly procyclical even with the additional shock.

To illustrate this point, we calibrate a version of the RBC model with factor share shocks to generate the same volatility of TFP and relative volatility of investment as our baseline model (see rows “RBC model with factor share shocks” in Table 7). Because both factor share shocks and productivity shocks generate pro-cyclical wages and highly volatile TFP, their volatility is not identified by our calibration strategy. We thus set the volatility of productivity to 0.05% and

calibrate the volatility of the factor share to match the volatility of TFP. Note that the correlation of the real wage is unchanged after such a shock relative to the standard RBC model. Figure G.30 shows that the real wage remains pro-cyclical in response to factor share shocks.

7.2 Extensions and alternative calibrations

We next analyze how our results change with several model extensions and alternative calibrations. In each version of the model, we recalibrate the model to hit our target moments. Figure 13 provides an overview. It decomposes the standard deviation of GDP, the gross capital share, and the net capital share into the contribution from productivity only and the additional contribution due to bargaining power shocks. The contribution to GDP of bargaining power shocks varies from 8% to 69%, while the contribution to the gross capital share varies from 6% to 29%, compared with our baseline result of 34% and 17%, respectively. Most model variants roughly match the overall volatility of output but explain only up to 40% of the volatility of gross capital share. In the next subsections, we discuss in detail each of the columns in Figure 13.

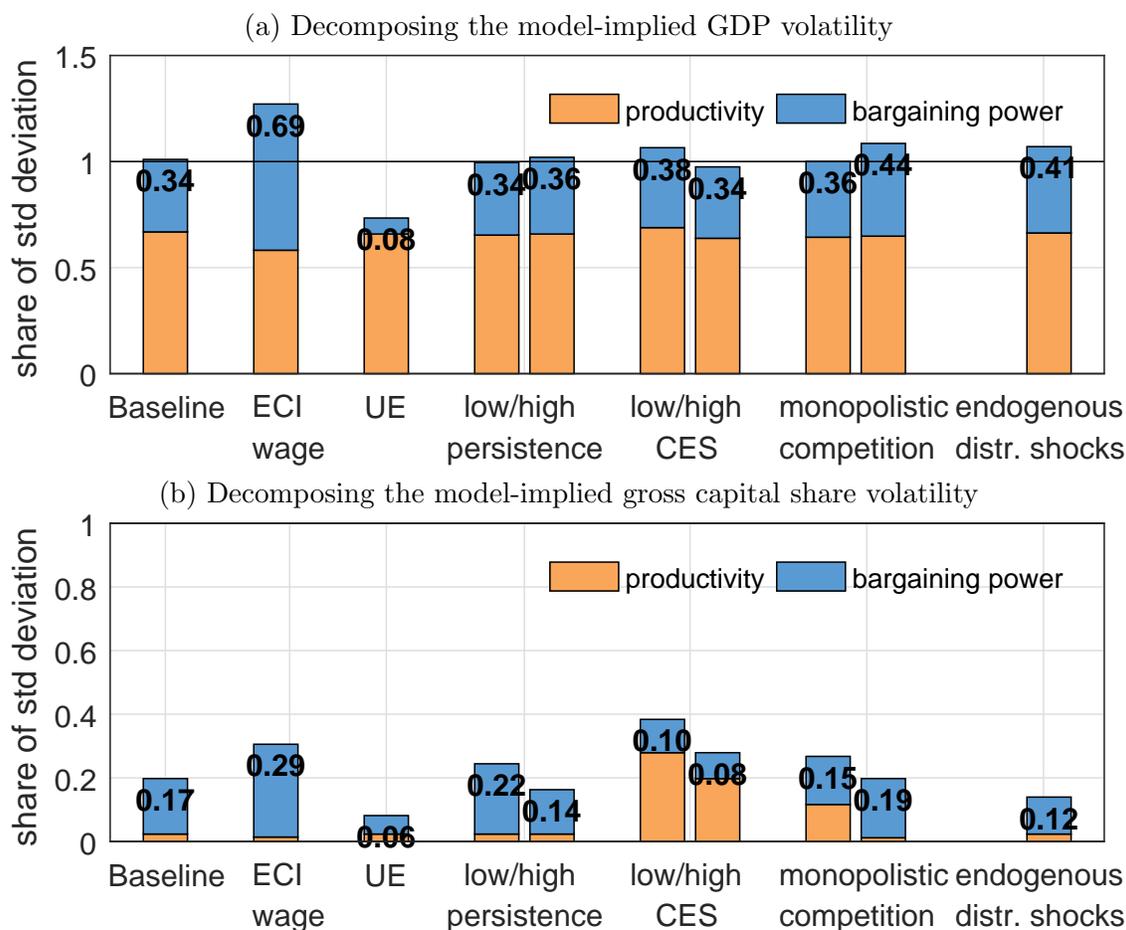


Figure 13: Decomposing GDP and capital share volatility across model variations and calibrations.

7.2.1 The role of the elasticity of substitution

Our first exercise varies the elasticities of substitution between capital and labor to $\varepsilon = 1 \pm 0.25$. This range includes both the estimates in Oberfield and Raval (2014) and Karabarbounis and Neiman (2014) that we described in Section 5. Table 8 summarizes the results.

When we depart from $\varepsilon = 1$, the RBC model produces fluctuations in the capital share, but it cannot match the low but positive cyclicalities of the gross capital share. For example, with a low elasticity $\varepsilon = 0.75$, the RBC model generates a correlation of the gross capital share with output of -0.95 vs. 0.36 in the data. For a high elasticity $\varepsilon = 1.25$, the same correlation is 0.98 . Similarly, the search and matching model with “no bargaining shocks” can produce sizable fluctuations in the gross capital share, but it fails to account for the cyclicalities of capital shares, either getting the sign wrong ($\varepsilon = 0.75$) or considerably overstating it ($\varepsilon = 1.25$).

In comparison, our baseline model with $\varepsilon = 0.75$ matches well the net capital share (0.58 vs. 0.57 in the data), but it misses the gross share (-0.02 vs. 0.36). With $\varepsilon = 1.25$, the result flips, the model can match the gross capital share (0.42 vs. 0.36 in the data), but not the net share (0.84 vs. 0.57 in the data). In both cases the bargaining shock accounts for between 34% and 38% of fluctuations. See Table G.9 for the implied autocorrelations.

7.2.2 The role of persistence

If redistribution shocks are short-lived, firms and households face little incentive to adjust their investment decisions to the realizations of the shock. Thus, when we calibrate shocks to be less persistent, there is a larger price effect (wages and the capital share become more volatile), but a smaller quantity effect. Recall that we consider two alternative calibrations. In one, the redistribution shock is a business cycle shock with a half-life of 3.5 years. In the other, it has a half-life of 20 years. Both are within the 90% credible set implied by our filtering of U.S. data. We find that, when we re-calibrate the model, the differences with our baseline calibration are minor. Both the baseline calibration and the business cycle calibration explain 34% of the variation in GDP, compared to 36% with the long-run calibration. The business cycle shock explains 22% of the gross capital share, compared with 17% in the baseline and 14% in the long-run calibration. See Table G.8.

7.2.3 The role of market power

In our baseline model, the profits largely go to physical capital. Market power introduces another source of profits: markups. Therefore, we augment our model to encompass market power; see Appendix G.9 for details. If these markups represent pure profits due to inelastic demand in a model of monopolistic competition, our analysis is essentially unchanged. If these markups compensate for the fixed cost of operating, we find a more volatile capital share. Re-calibrating the extended model, we set the elasticity of substitution between varieties to 10, corresponding to an 11% markup. We find that without fixed costs, the bargaining power shock now explains 20%

Table 8: Elasticity of substitution and business cycle statistics: 1947Q1-2015Q2.

	Volatility							
	Y [%]	$\frac{\text{std}(I)}{\text{std}(Y)}$	$\frac{\text{std}(C)}{\text{std}(Y)}$	std(ncs) [pp.]	std(cs) [pp.]	std(w) [%]	std(u) [%]	std(TFP) [%]
U.S. data	1.99	3.28	0.58	1.07	0.86	0.95	0.83	1.21
				$\varepsilon = .75$				
S&M model: baseline	2.12	3.28	0.58	0.35	0.33	1.67	1.92	1.21
S&M model: no bargaining shock	1.37	3.68	0.50	0.15	0.24	1.47	0.27	1.20
RBC model: baseline	2.22	3.28	0.61	0.07	0.18	1.04	2.41	1.21
				$\varepsilon = 1.25$				
S&M model: baseline	1.94	3.28	0.59	0.41	0.24	1.08	1.81	1.21
S&M model: no bargaining shock	1.27	3.76	0.48	0.33	0.17	0.93	0.09	1.20
RBC model: baseline	1.62	3.28	0.59	0.35	0.14	0.83	0.63	1.21
	Cyclicalities							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	1.00	0.91	0.84	0.57	0.36	0.19	-0.76	0.78
				$\varepsilon = 0.75$				
S&M model: baseline	1.00	0.97	0.98	0.61	-0.02	0.19	-0.79	0.72
S&M model: no bargaining shock	1.00	0.99	0.99	-0.79	-0.99	1.00	-0.95	0.99
RBC model: baseline	1.00	0.97	0.99	0.80	-0.95	0.95	-0.77	0.99
				$\varepsilon = 1.25$				
S&M model: baseline	1.00	0.96	0.97	0.84	0.42	0.19	-0.75	0.70
S&M model: no bargaining shock	1.00	0.99	0.99	0.99	1.00	1.00	-0.96	1.00
RBC model: baseline	1.00	0.99	0.99	0.99	0.98	0.98	-0.93	0.99

Note: Quarterly data, HP-filtered with smoothing parameter $\lambda = 1,600$. We average the monthly model-generated data first within quarters before HP-filtering.

of the variation in the capital share and 36% of the variation in output, slightly more than in our baseline. With fixed costs, the bargaining power shock explains 19% of the variation in the capital share and 44% of the variation in output.

Given that markups are constant, the RBC model cannot generate fluctuations in the capital share, unless there are fixed costs. With fixed costs, the RBC model accounts for 15% of the variation in the capital share, compared to 27% for the corresponding search and matching model with both shocks and 10% for the search and matching model just with TFP shocks. See Table G.10.

7.2.4 The role of exogenous redistribution shocks

In our model, we take the political shifts that drive bargaining power variations as given. However, periods of high unemployment may induce political changes. If this political change led to redistribution toward capital, this would strengthen our results because it would make wages more procyclical and, thus, require larger bargaining shocks. Therefore, we concentrate on the opposite possibility and recalibrate our model assuming that in periods of sustained unemployment, redistribution shocks favoring workers are more likely. Specifically, for every 1 pp. of unemployment

above its mean, the target bargaining power is one standard deviation higher. Formally, the shock process becomes:

$$\ln \frac{\phi_t}{1 - \phi_t} = (1 - \rho_\phi) \left(\ln \frac{\bar{\phi}}{1 - \bar{\phi}} - \omega_\phi \frac{n_{t-1} - \bar{n}}{0.01} \right) + \rho_\phi \ln \frac{\phi_{t-1}}{1 - \phi_{t-1}} + \omega_\phi \epsilon_{\phi,t}.$$

This strong endogenous component changes our results slightly: The contribution to GDP becomes 7 pp. bigger, to 41%, while the contribution to the capital share shrinks 5 pp., to 12%. Intuitively, redistributing toward workers when unemployment is high endogenously makes wages more countercyclical, and our calibration finds a smaller standard deviation of bargaining shocks. See Table G.11.

7.2.5 Alternative calibration: Employment cost index

We calibrate our baseline model to the relative cyclicity of the real compensation per hour in the non-farm business sector for the post-war sample. Alternatively, we can calibrate the model to the occupation and industry-adjusted wage rate from the employment cost index, deflated by the PCE deflator. To form the longest possible sample, we splice together the SIC-based measure for wages and salaries and the NAICS-based measure for total compensation. The resultant sample covers 1980 to 2014, and we recompute the target moments: First, wages are now moderately countercyclical, with a correlation of -0.25 instead of +0.19. (For the baseline measure, the cyclicity is -0.02 for the sub-sample.) Second, investment is smoother, with a relative volatility of 3.06 instead of 3.28. Third, the average tax rate is lower (20% rather than 30%). Fourth, the share of depreciation is slightly higher (13.6% rather than 12.7%). Last, the volatility of TFP is 20% lower over the sub-sample. Hence, we recalibrate the model using the same strategy as before. Intuitively, we find that bargaining shocks are more important because wages are now more countercyclical. Bargaining shocks account for 69% of the volatility of GDP and 29% of the volatility of the gross capital share. See Table G.12 for details.

7.2.6 Alternative calibration: Matching unemployment volatility

Interestingly, our baseline model yields excess volatility of unemployment. The HP-filtered average quarterly unemployment rate has a standard deviation of 0.83% in the data, but of 1.86% in our calibration. This excess volatility is in stark contrast to the basic search model with only productivity shocks, which is well-known for failing to replicate the volatility of unemployment (Shimer, 2005). Cutting the volatility of the bargaining power shock by about 40%, however, matches the volatility of the unemployment rate. Therefore, bargaining power shocks can be a simple and empirically relevant way to reconcile search and matching dynamic macro models with the data. But as Table G.13 shows, in this case, our model explains only 6% of the volatility of the gross capital share, almost entirely because of bargaining power shocks. Only 8% of output volatility is due to bargaining shocks, but more than 80% of employment fluctuations are due to bargaining power shocks. Moreover, this calibration implies wages that are too pro-cyclical.

7.3 Increased volatility

Within countries over time and across countries, we observe large differences in the volatility of the capital share. For example, the volatility of the HP-filtered gross capital share has fallen from 1.79% per year from 1929 to 1949 to 0.81% per year from 1950 to 2010 in the U.S., a drop to less than half. The U.K. and France have seen even larger reductions in volatility. At the same time, the U.K. has a much more volatile capital share than the U.S. post-1950; its HP-filtered capital share has been about 40% (0.31/0.81) higher than that in the U.S. (Table 1(a)). Controlling for industry composition, this difference amounts to 60% (Table 1(b)). What would the consequences be if the U.S. capital share became more volatile due to more political redistribution?

If political redistribution risk increased enough to raise the volatility by 40%, U.S. output would become 20% more volatile. Consumption volatility would increase as much as output volatility. Given that households prefer smooth consumption, the increased volatility reduces welfare. In addition, we find that more volatile bargaining power shocks also lower welfare, mostly by lowering the ergodic mean of consumption.

Table 9: Welfare effects of increased or reduced political distribution risk

Specification	std(Y) [%]	$\frac{\text{Std}(C)}{\text{Std}Y}$	Std(cs) [%]	Std(n) [%]	Welfare: Δ baseline Consumption units
Baseline	2.01	0.59	0.17	1.86	0
40% higher capital share volatility	2.43	0.60	0.24	2.50	-0.9%
100% higher capital share volatility	3.11	0.60	0.34	3.48	-2.1%
No redistribution risk	1.31	0.49	0.02	0.15	+2.7%

Table 9 reports the consequential welfare effects of redistribution risk, much larger than conventional measures of the welfare cost of the business cycle (Lucas, 1991). Welfare, expressed in consumption units, drops by 0.9% when we increase the volatility of political redistribution risk to make the capital share 40% more volatile. To compute consumption equivalents, we hold employment fixed at its ergodic mean. Doubling the volatility of the capital share through increased political risk, thus undoing the decline we saw in the U.S. post-1950, leads to a welfare loss of 2.1% of consumption. Eliminating all redistribution risk would increase the welfare of the representative household by 2.7% of consumption.

Appendix G.15.6 reports a set of robustness checks, in terms of the cyclical properties of the model and welfare, when we modify how far away the calibration of the model is from satisfying the Hosios rule. Appendix G.15.6 documents that the main factor behind the welfare losses is the persistence of the shock and not the steady-state deviations of the model with respect to the Hosios rule.

8 Quantitative results III: The dynamic effects of a bargaining power shock

In the previous section, we reported the unconditional properties of the model. In this section, we document the conditional responses to a bargaining shock. Figure 14 shows the response to a bargaining shock that strengthens workers' bargaining power. In particular, we plot generalized impulse responses based on a third-order perturbation following the procedure outlined in [Andreasen et al. \(2017\)](#).

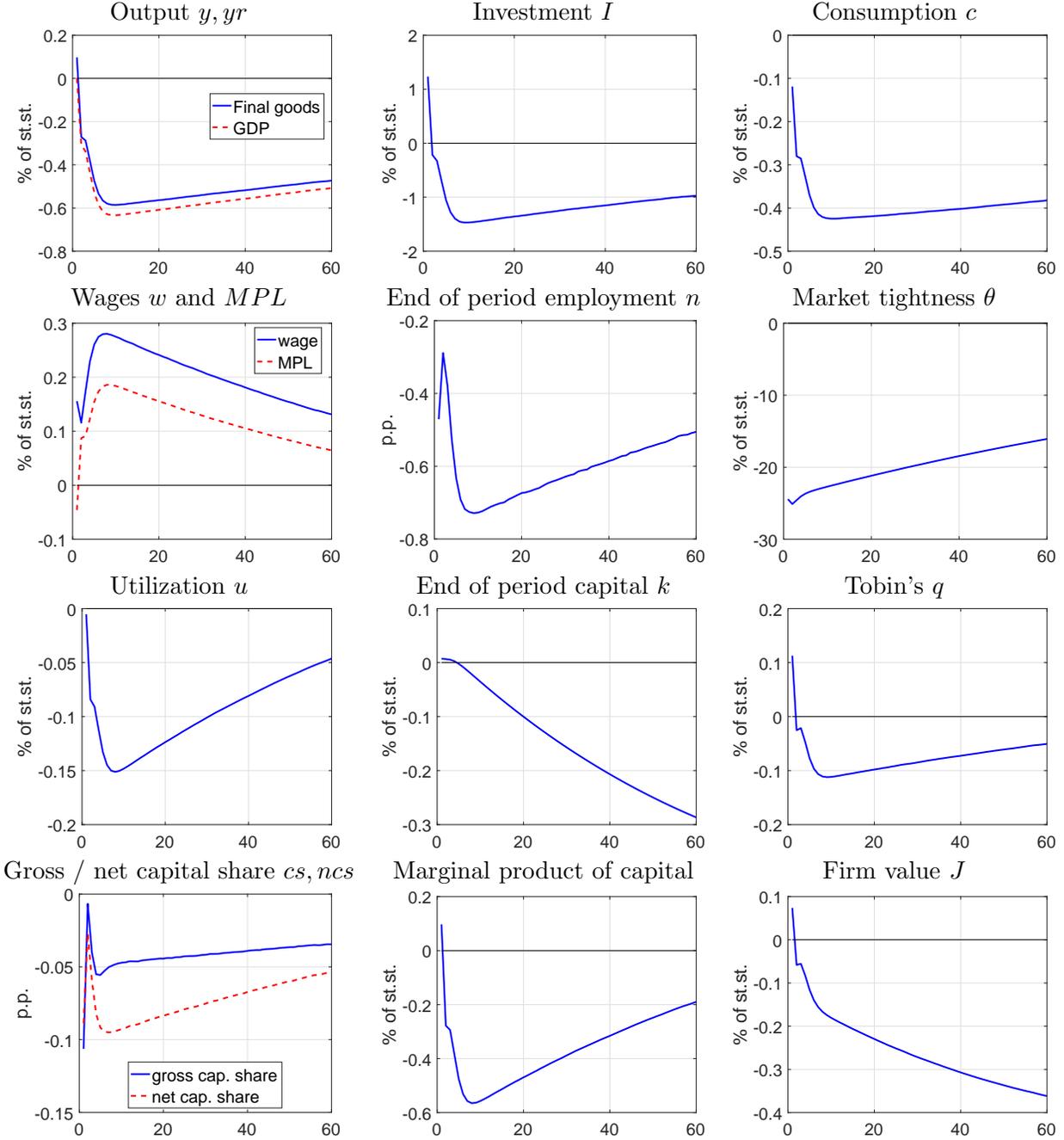
First, after this shock, the capital share falls, irrespective of whether we focus on the gross or the net capital shares.²⁸ Second, output drops persistently: a lower capital share leads to less investment activity, either in physical capital or in recruiting, and a lower utilization rate. As recruiting efforts are scaled back, final goods production drops by less than output, but future employment also falls. Third, the value of the representative firm falls persistently. Fourth, wages rise more than the marginal product of labor, again reflecting the change in the bargaining power. Finally, market tightness decreases. Therefore, our model replicates the qualitative features we found in the data for political events in advanced economies such as France and West Germany, i.e., a drop in output and firm values and an increase in the labor income share.

We analyze next the details of the response of the economy after the shock. The value of the firm rises initially, if slightly, as firms shift workers from recruiting to production to raise the output of final goods to take advantage of the existing stocks of workers and capital (this movement also explains the initial increase in the marginal productivity of capital and of Tobin's q). However, as firms reduce their recruiting efforts, employment falls, and with it the marginal product of labor. This, together with the lower return on capital due to the bargaining shock, leads to lower investment and a declining stock of physical capital. Both a lower value of the capital stock and a lower share of the surplus contribute to a fall in firm value.

Interestingly, the reported unconditional impulse responses mask a pronounced state dependence. In particular, the prevailing capital share at the moment of the shock matters. Figure 15 shows that a given shock to bargaining power has smaller effects on redistribution and causes larger drops in GDP and firm values when starting from a situation that already features a low capital share of income. When the capital share is small, further reductions in its bargaining power have a higher marginal cost to the firm, but firms do not have space to redistribute much additional income to workers. In contrast, with a high capital share, the initial drop in the capital share is twice that of GDP and, after five years, the response of GDP is only twice that of the capital share. Similarly, drops in employment are more muted when the capital share is already high. In short, the non-linearities in our model imply that the price and quantity effects of redistribution shocks depend on how polarized the income distribution is.²⁹

How do our results change if firms would substitute capital for labor more or less elastically?

²⁸In the short run, we have some non-monotonicities: the bargaining shock distributes what used to be profits to workers, lowering profits and keeping output initially fixed. The capital share drops. Next output drops, undoing much of the initial increase in the ratio. Then marginal labor productivity and wages rise further, leading again to a



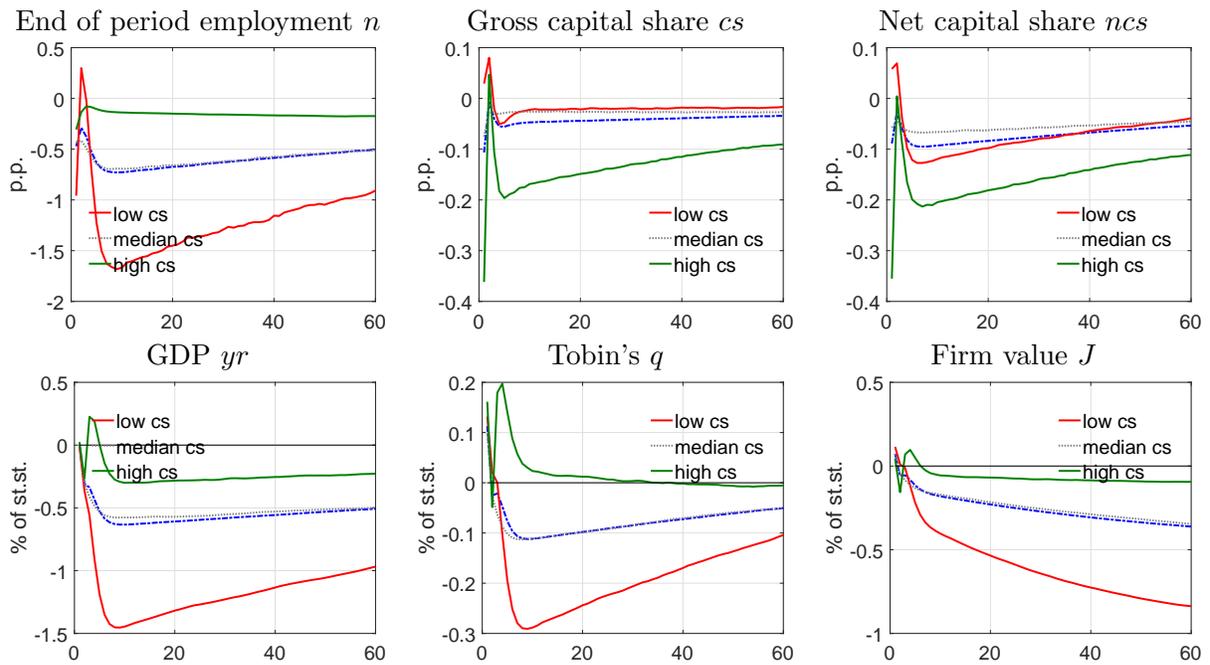
Note: The responses are shown for the 60 months following a shock.

Figure 14: IRFs to one standard deviation shock raising workers' bargaining power.

For the bargaining shock, not much. Figure 16 shows the responses of output, employment, and the capital shares to a bargaining power shock for the same three elasticities of substitution that

lower capital share.

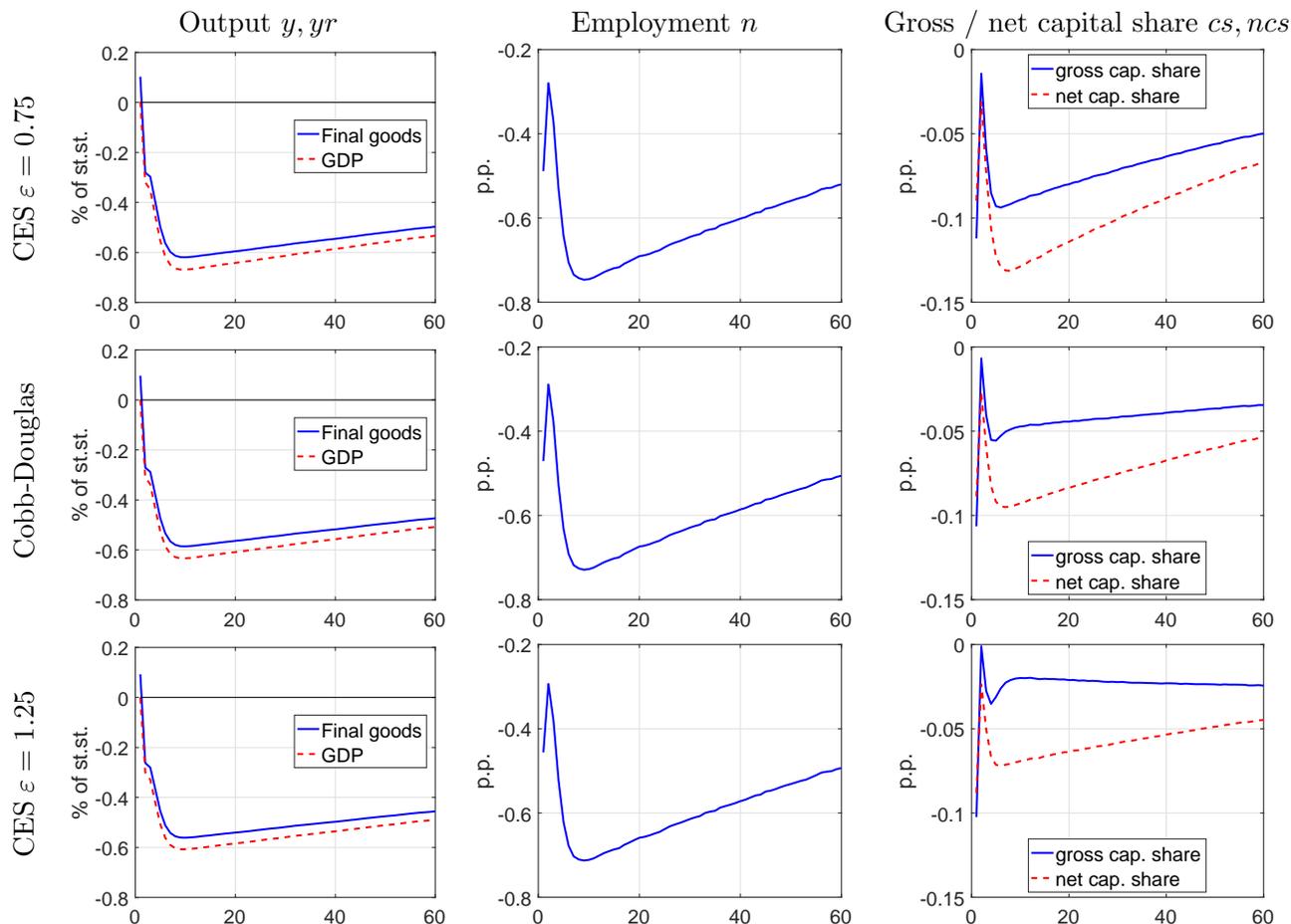
²⁹Our model generates relatively large movements in output relative to those in bargaining power because the match surplus is small. If the model featured efficient bargaining in the presence of product market rents as in Blanchard and Giavazzi (2003), capital shares might become more volatile relative to output.



Note: The responses are shown for the 60 months following a shock. We compute the conditional IRFs by initializing the economy at the states associated with observing a capital share in the top, bottom, or middle 10% of the ergodic distribution.

Figure 15: State dependence in IRFs to one standard deviation bargaining power shock with high vs. low initial capital share.

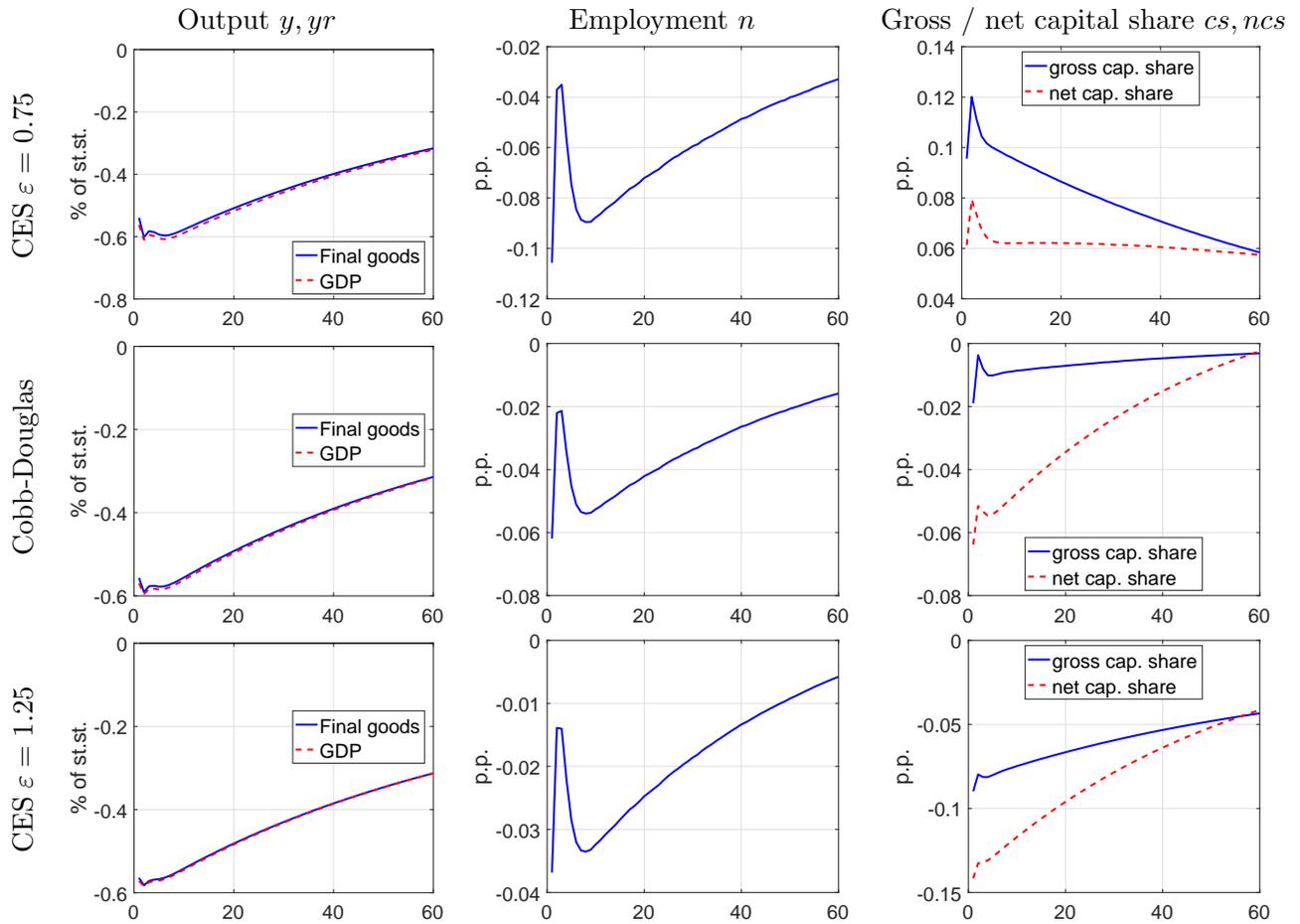
we used before: the baseline Cobb-Douglas case ($\varepsilon = 1$), the low elasticity case ($\varepsilon = 0.75$), and the high elasticity case ($\varepsilon = 1.25$). The responses of most variables change little, except for the gross capital share. Its response is more muted when the elasticity of substitution is larger because firms substitute away from labor when workers' bargaining power rises.



Note: The responses are shown for the 60 months following a shock.

Figure 16: IRFs to one standard deviation bargaining power shock for various elasticities of substitution.

In contrast, the value of the elasticity of substitution is relevant for the response of the economy to technology shocks. Figure 17 shows that the gross capital share moves in the same direction as the productivity shock when $\varepsilon = 1.25$ and in the opposite direction when $\varepsilon = 0.75$. In the Cobb-Douglas case, the response is almost acyclical. Because in the data the capital share is procyclical (Ríos-Rull and Santaaulàlia-Llopis, 2010), productivity shocks have a hard time matching the data when firms substitute capital for labor inelastically.



Note: The responses are shown for the 60 months following a shock.

Figure 17: IRFs to a one standard deviation negative labor productivity shock for various elasticities of substitution.

9 Conclusion

Capital shares of income change and can be volatile. For the three countries for which we have long historical time series, France, the U.K., and the U.S., we observe large declines in the volatility of the capital share after 1950. This volatility also differs across countries. We argue that political factors can be an important driver of fluctuations in the functional income distribution.

Several case studies show that political factors plausibly contribute to distribution. Using international evidence, we show that political events such as transitions in government can be associated with large changes in capital shares. These changes in capital shares are typically accompanied by a move in the domestic stock market valuation in the same direction. For most episodes in OECD countries, output also comoves with the capital share. In the U.S., we find that capital shares rose after the introduction of right-to-work legislation. Overall, this suggests that political factors influence the functional income distribution.

We proceed by building a model that features an endogenous capital share. In our model, workers bargain with firms over the match surplus in the labor market, and their bargaining power is subject to political shocks – which we refer to as political distribution shocks. Filtering the bargaining power from the data confirms our calibration and narrative. Also, our model matches the standard U.S. business cycle moments and the cyclicity of the capital share. Political distribution shocks are powerful in our model: Even though they explain only between 15% and 25% of the volatility of the gross capital share in the U.S., they can account for 35% to 45% of the volatility of output, depending on the elasticity of substitution between capital and labor. In contrast, a [Hansen \(1985\)-Rogerson \(1988\)](#) type RBC model cannot replicate the observed cyclicity of the capital share even with non-unitary elasticity of substitution or factor share shocks.

We then use our model as a laboratory to ask what would happen if the U.S. capital share became more volatile due to increased political risk. We find that increasing the volatility of the capital share in the U.S. by 40%, roughly the relative difference to the U.K., would increase the volatility of GDP and consumption by about 20%. Reversing the relative decline in volatility since 1950 by doubling the volatility of the capital share would raise the volatility of output and consumption by almost 60%. The welfare of the representative household would drop in these cases, by 0.9% and 2.1% of consumption, respectively. In contrast, eliminating political redistribution risk in the U.S. would raise welfare by 2.7%.

The dynamic effects of redistribution shocks in our model are strong, but their size depends on the state of the economy. Our generalized impulse response functions imply that, unconditionally, in response to a one standard deviation increase in workers' bargaining power, the gross capital share at its trough drops by 0.10%, but output drops by 0.5% at its trough. Firm value drops by 0.35%. The effects are, however, non-linear: conditional on an already high capital share, the response of output and firm value is much more muted, whereas the capital share responds more strongly.

References

- ADAMS, Z., L. BISHOP, AND S. DEAKIN (2016): “CBR Labour Regulation Index (Dataset of 117 Countries),” Cambridge: Centre for Business Research.
- ALDER, S., D. LAGAKOS, AND L. OHANIAN (2014): “Competitive Pressure and the Decline of the Rust Belt: A Macroeconomic Analysis,” NBER Working Papers 20538, National Bureau of Economic Research, Inc.
- ANDOLFATTO, D. (1996): “Business Cycles and Labor-Market Search,” *American Economic Review*, 86, 112–32.
- ANDREASEN, M. M., J. FERNÁNDEZ-VILLAYERDE, AND J. F. RUBIO-RAMÍREZ (2017): “The Pruned State-Space System for Nonlinear DSGE Models: Theory and Empirical Applications,” *Review of Economic Studies*, Forthcoming.
- AUTOR, D., D. DORN, L. F. KATZ, C. PATTERSON, AND J. V. REENEN (2017): “The Fall of the Labor Share and the Rise of Superstar Firms,” Working Paper 23396, National Bureau of Economic Research.
- AUTOR, D. H., A. MANNING, AND C. L. SMITH (2016): “The Contribution of the Minimum Wage to US Wage Inequality over Three Decades: A Reassessment,” *American Economic Journal: Applied Economics*, 8, 58–99.
- BARKAI, S. (2017): “Declining Labor and Capital Shares,” Tech. rep., University of Chicago.
- BARRO, R. J. (2009): “Rare Disasters, Asset Prices, and Welfare Costs,” *American Economic Review*, 99, 243–64.
- BINMORE, K., A. RUBINSTEIN, AND A. WOLINSKY (1986): “The Nash Bargaining Solution in Economic Modelling,” *The RAND Journal of Economics*, 17, 176–188.
- BLANCHARD, O. AND F. GIAVAZZI (2003): “Macroeconomic Effects of Regulation and Deregulation in Goods and Labor Markets,” *Quarterly Journal of Economics*, 118, 879–907.
- BLANCHARD, O. J. (1997): “The Medium Run,” *Brookings Papers on Economic Activity*, 28, 89–158.
- BORMANN, N.-C. AND M. GOLDBER (2013): “Democratic Electoral Systems around the World, 1946-2011,” *Electoral Studies*, 32, 360 – 369.
- BUDD, J. W. (2012): *Labor Relations – Striking a Balance*, McGraw Hill, 4th ed.
- CABALLERO, R. J. AND M. L. HAMMOUR (1998): “Jobless Growth: Appropriability, Factor Substitution, and Unemployment,” *Carnegie-Rochester Conference Series on Public Policy*, 48, 51–94.
- CHRISTIANO, L. J., M. S. EICHENBAUM, AND M. TRABANDT (2016): “Unemployment and Business Cycles,” *Econometrica*, 84, 1523–1569.
- COMÌN, D. AND M. GERTLER (2006): “Medium-Term Business Cycles,” *American Economic Review*, 96, 523–551.

- COOLEY, T. F. AND E. C. PRESCOTT (1995): “Economic Growth and Business Cycles,” in *Frontiers of Business Cycle Research*, ed. by T. F. Cooley, Princeton University Press, chap. 1, 1–38.
- DANTHINE, J.-P., J. B. DONALDSON, AND P. SICONOLFI (2008): “Distribution Risk and Equity Returns,” in *Handbook of the Equity Premium Risk*, ed. by R. Mehra, Elsevier, 415–462.
- DE LOECKER, J. AND J. EECKHOUT (2017): “The Rise of Market Power and the Macroeconomic Implications,” Working Paper 23687, National Bureau of Economic Research.
- DRAUTZBURG, T. (2016): “A Narrative Approach to a Fiscal DSGE Model,” unpublished, Federal Reserve Bank of Philadelphia.
- DUBOFSKY, M. AND F. R. DULLES (2017): *Labor in America: A History*, Wiley, 9th ed.
- ELSBY, M., B. HOBIJN, AND A. SAHIN (2013): “The Decline of the U.S. Labor Share,” *Brookings Papers on Economic Activity*, 47, 1–63.
- FEENSTRA, R. C., R. INKLAAR, AND M. P. TIMMER (2013): “The Next Generation of the Penn World Table,” www.ggdc.net/pwt.
- FERNANDEZ-VILLAYERDE, J. AND J. F. RUBIO-RAMIREZ (2006): “Solving DSGE models with perturbation methods and a change of variables,” *Journal of Economic Dynamics and Control*, 30, 2509–2531.
- FERNÁNDEZ-VILLAYERDE, J., J. F. RUBIO-RAMÍREZ, AND F. SCHORFHEIDE (2016): “Solution and Estimation Methods for {DSGE} Models,” in *Handbook of Macroeconomics*, ed. by J. B. Taylor and H. Uhlig, Elsevier, vol. 2, 527–724.
- FLINN, C. (2006): “Minimum Wage Effects on Labor Market Outcomes under Search, Matching, and Endogenous Contact Rates,” *Econometrica*, 74, 1013–1062.
- FORONI, C., F. FURLANETTO, AND A. LEPETIT (2017): “Labor Supply Factors and Economic Fluctuations,” Working paper, Norges Bank.
- GALÍ, J., F. SMETS, AND R. WOUTERS (2012): “Unemployment in an Estimated New Keynesian Model,” *NBER Macroeconomics Annual*, 26, 329–360.
- GERTLER, M., C. HUCKFELDT, AND A. TRIGARI (2016): “Unemployment Fluctuations, Match Quality, and the Wage Cyclicity of New Hires,” NBER Working Papers 22341, National Bureau of Economic Research, Inc.
- GERTLER, M., L. SALA, AND A. TRIGARI (2008): “An Estimated Monetary DSGE Model with Unemployment and Staggered Nominal Wage Bargaining,” *Journal of Money, Credit and Banking*, 40, 1713–1764.
- GERTLER, M. AND A. TRIGARI (2009): “Unemployment Fluctuations with Staggered Nash Wage Bargaining,” *Journal of Political Economy*, 117, 38–86.
- GOLLIN, D. (2002): “Getting Income Shares Right,” *Journal of Political Economy*, 110, pp. 458–474.
- GOMME, P. AND P. RUPERT (2004): “Measuring Labor’s Share of Income,” *Policy Discussion Papers*.

- (2007): “Theory, Measurement and Calibration of Macroeconomic Models,” *Journal of Monetary Economics*, 54, 460–497.
- GREENWALD, D. L., M. LETTAU, AND S. C. LUDVIGSON (2014): “Origins of Stock Market Fluctuations,” Working Paper 19818, National Bureau of Economic Research.
- HAEFKE, C., M. SONNTAG, AND T. VAN RENS (2013): “Wage rigidity and job creation,” *Journal of Monetary Economics*, 60, 887–899.
- HAGEDORN, M., F. KARAHAN, I. MANOVSKII, AND K. MITMAN (2013): “Unemployment Benefits and Unemployment in the Great Recession: The Role of Macro Effects,” Working Paper 19499, National Bureau of Economic Research.
- HALL, R. E. (2005): “Employment Fluctuations with Equilibrium Wage Stickiness,” *American Economic Review*, 95, 50–65.
- HALL, R. E. AND P. R. MILGROM (2008): “The Limited Influence of Unemployment on the Wage Bargain,” *American Economic Review*, 98, 1653–74.
- HANSEN, G. D. (1985): “Indivisible Labor and the Business Cycle,” *Journal of Monetary Economics*, 16, 309–327.
- HARBISON, F. H. (1950): “The General Motors-United Auto Workers Agreement of 1950,” *Journal of Political Economy*, 58, 397–411.
- HIRSCH, B. T. AND D. A. MACPHERSON (2003): “Union Membership and Coverage Database from the Current Population Survey: Note,” *Industrial and Labor Relations Review*, 56, 349–354.
- HOLMES, T. J. (1998): “The Effect of State Policies on the Location of Manufacturing: Evidence from State Borders,” *Journal of Political Economy*, 106, 667–705.
- HOSIOS, A. J. (1990): “On the Efficiency of Matching and Related Models of Search and Unemployment,” *Review of Economic Studies*, 57, 279–298.
- KARABARBOUNIS, L. AND B. NEIMAN (2014): “The Global Decline of the Labor Share,” *Quarterly Journal of Economics*, 129, 61–103.
- KEARNEY, M. S. AND B. H. HARRIS (2014): “The “Ripple Effect” of a Minimum Wage Increase on American Workers,” Tech. rep., Brookings.
- KIDYBA, S. AND D. VEGA (2015): “Distribución Funcional del Ingreso en la Argentina, 1950-2007,” *Estudios y Perspectivas* 44, Oficina de la CEPAL en Buenos Aires.
- KOH, D., R. SANTAÈULÀLIA, AND Y. ZHENG (2015): “Labor Share Decline and the Capitalization of Intellectual Property Products,” 2015 Meeting Papers 844, Society for Economic Dynamics.
- KUMHOF, M., C. LEBARZ, R. RANCIERE, A. W. RICHTER, AND N. A. THROCKMORTON (2012): “Income Inequality and Current Account Imbalances,” IMF Working Papers 12/8, International Monetary Fund.
- LANSING, K. J. (2015): “Asset Pricing with Concentrated Ownership of Capital and Distribution Shocks,” *American Economic Journal: Macroeconomics*, 7, 67–103.

- LEE, D. S. (1999): “Wage Inequality in the United States During the 1980s: Rising Dispersion or Falling Minimum Wage?” *Quarterly Journal of Economics*, 114, 977–1023.
- LEVY, F. AND P. TEMIN (2007): “Inequality and Institutions in 20th Century America,” Working Paper 13106, National Bureau of Economic Research.
- LINDENBOIM, J., J. M. GRAÑA, AND D. KENNEDY (2005): “Distribución Funcional del Ingreso en Argentina. Ayer y Hoy,” Documentos de Trabajo 4, CEPED, Universidad de Buenos Aires.
- LIU, Z., J. MIAO, AND T. ZHA (2013): “Land Prices and Unemployment,” NBER Working Papers 19382, National Bureau of Economic Research.
- LUCAS, R. E. (1977): “Understanding business cycles,” *Carnegie-Rochester Conference Series on Public Policy*, 5, 7–29.
- (1991): *Models of Business Cycles*, Wiley.
- MERTENS, K. AND M. O. RAVN (2013): “The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States,” *American Economic Review*, 103, 1212–47.
- MERZ, M. (1995): “Search in the Labor Market and the Real Business Cycle,” *Journal of Monetary Economics*, 36, 269–300.
- MUCK, J., P. MCADAM, AND J. GROWIEC (2015a): “Endogenous Labor Share Cycles: Theory and Evidence,” Working paper 1765, ECB.
- (2015b): “Will the True Labor Share Stand Up?” Working paper 1806, ECB.
- OBERFIELD, E. AND D. RAVAL (2014): “Micro Data and Macro Technology,” NBER Working Papers 20452, National Bureau of Economic Research.
- PETROSKY-NADEAU, N. AND L. ZHANG (2013): “Solving the DMP Model Accurately,” NBER Working Papers 19208, National Bureau of Economic Research.
- PIKETTY, T. AND G. ZUCMAN (2014): “Capital is Back: Wealth-Income Ratios in Rich Countries 1700-2010,” *Quarterly Journal of Economics*, 129, 1255–1310.
- PISSARIDES, C. A. (2009): “The Unemployment Volatility Puzzle: Is Wage Stickiness the Answer?” *Econometrica*, 77, 1339–1369.
- POWELL, J. M. AND C. L. THYNE (2011): “Global Instances of Coups from 1950 to 2010: A New Dataset,” *Journal of Peace Research*, 48, 249–259.
- PRESCOTT, E. C. (2004): “Why Do Americans Work So Much More than Europeans?” *Quarterly Review*, 28, 2–13.
- RAVENNA, F. AND C. E. WALSH (2011): “Welfare-Based Optimal Monetary Policy with Unemployment and Sticky Prices: A Linear-Quadratic Framework,” *American Economic Journal: Macroeconomics*, 3, 130–162.
- RÍOS-RULL, J.-V. AND R. SANTAELIÀLIA-LLOPIS (2010): “Redistributive Shocks and Productivity Shocks,” *Journal of Monetary Economics*, 57, 931–948.
- ROGERSON, R. (1988): “Indivisible Labor, Lotteries and Equilibrium,” *Journal of Monetary Economics*, 21, 3–16.

- ROGNLIE, M. (2015): “Deciphering the Fall and Rise in the Net Capital Share,” *Brookings Papers on Economic Activity*, 46, 1–69.
- SHIMER, R. (2005): “The Cyclical Behavior of Equilibrium Unemployment and Vacancies,” *American Economic Review*, 95, 25–49.
- (2010): *Labor Markets and Business Cycles*, CREI Lectures in Macroeconomics, Princeton University Press.
- SLESINGER, R. E. (1967): “The Price-Wage Guideposts Revisited,” *American Bar Association Journal*, 53, 525–529.
- SOLCHAGA, C. (1997): *El Fin de la Era Dorada*, Taurus.
- STOCK, J. H. AND M. W. WATSON (2012): “Disentangling the Channels of the 2007-2009 Recession,” *Brookings Papers on Economic Activity*, 81–141.

Appendix

This appendix includes details about the data, the empirical exercises, the model, and the quantitative results.

A Capital share data

A.1 U.S. data

We construct the net capital share in the corporate business sector from BEA Table 1.14, “Gross Value Added of Domestic Corporate Business in Current Dollars and Gross Value Added of Non-financial Domestic Corporate Business in Current and Chained Dollars,” and focus on the data on non-financial corporate businesses. We compute the net capital share as compensation of employees (mnemonic A460RC1) relative to the sum of compensation and the net operating surplus (mnemonic W326RC1). Figure A.1 plots the resulting series.

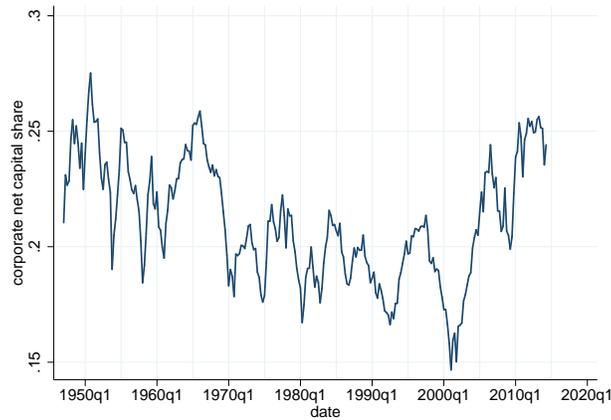


Figure A.1: Net capital share levels: Quarterly U.S. data.

We also consider a number of alternative measures of the U.S. capital share for comparison:

1. Alternative measure for the corporate business sector: We compute the capital share as the reciprocal of wages over net value added (mnemonic A457RC1), effectively treating taxes as coming out of the capital share only.
2. BLS data on the (reciprocal of the) labor share in the overall business sector (mnemonic PRS84006173), the non-farm business sector (mnemonic PRS85006173), and in the corporate non-financial sector (mnemonic PRS88003173). The BLS defines the labor share as the ratio of current labor compensation paid to current dollar output, imputing a cost for labor services by proprietors. See p. 7 of <http://www.bls.gov/lpc/lpcmethods.pdf> for the definition and <http://www.bls.gov/data/#productivity> for the data.
3. Data on the capital share as the reciprocal of the U.S. labor share in the Penn World Tables (Feenstra et al., 2013).

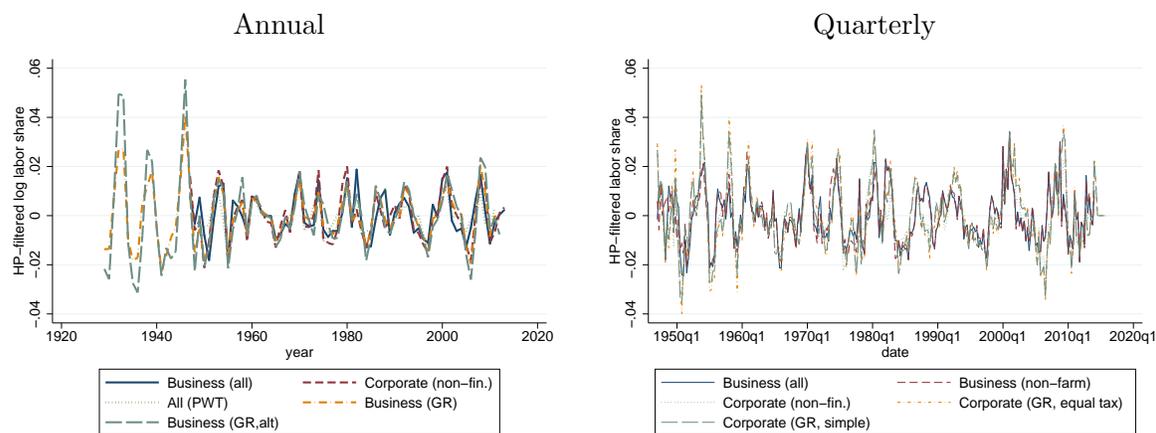


Figure A.2: Detrended labor shares in the U.S.

The different measures are reported in the two panels of Figure A.2. Figure A.3 compares the different measures of the labor share that are available in levels. The left panel shows the annual time series, and the right panel shows the shorter quarterly series. In both the annual and the quarterly data, there is no clear evidence of a trend in the labor share over the full sample period. However, most measures of the labor share are close to their minimum at the end of the sample period. Note that in the quarterly data, adjusting for the share of taxes in corporate net value added only results in a roughly parallel shift of the labor share, whereas taking out net government production in the annual series changes the trend behavior. The different labor shares average between about 65% and 80%.

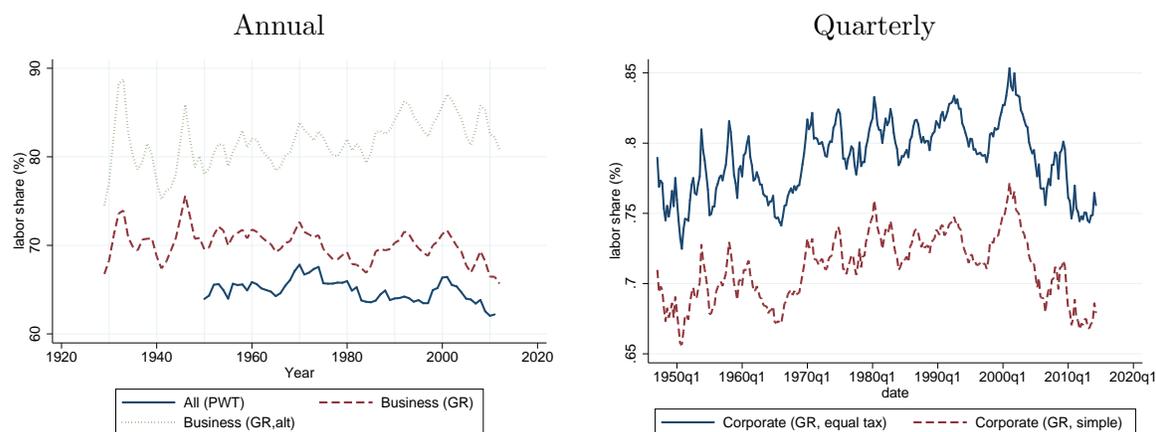


Figure A.3: Labor share levels data: Annual and quarterly.

Extending the comparison to include the BLS data comes at the cost of losing the level information. Figure A.4 shows that the raw data, indexed to 100 in 2009, correlates positively at higher frequencies, but may exhibit different time trends. Figure A.2, therefore, uses HP-filtered data on the log-labor share. Eyeballing both the annual and the quarterly filtered time series suggests a very high agreement. Correlation tables (not shown here) confirm this impression: Raw time series sometimes exhibit low correlations, but filtered correlations are above 0.6 for annual data and above 0.7 for quarterly data except for correlations between manufacturing sectors and broader measures.

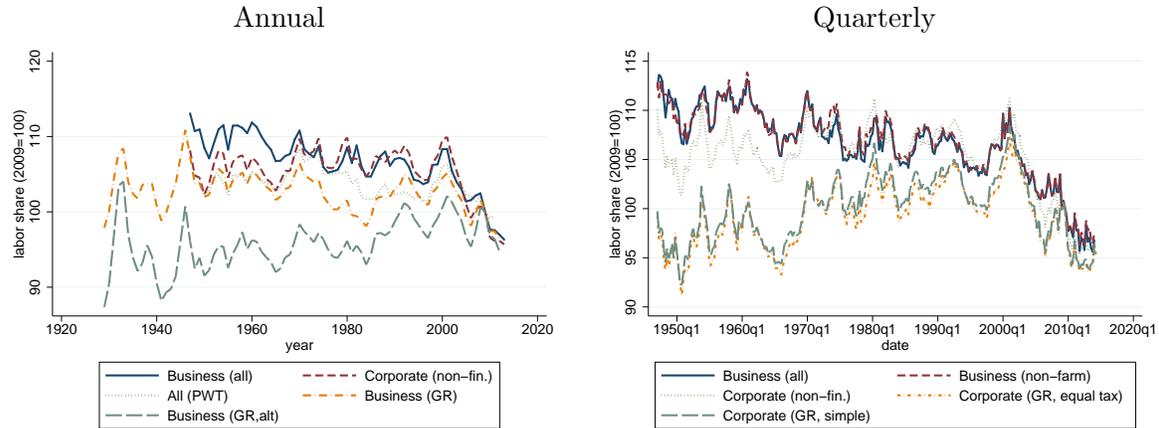


Figure A.4: Raw indexed labor shares: Annual and quarterly.

A.2 International and U.S. state level data

- Long-run capital share data: We downloaded the data in [Piketty and Zucman \(2014\)](#) from <http://gabriel-zucman.eu/capitalisback/> and use the net capital share (“net profit share”) from the data sheets on “profits & wages in the corporate sector.”
- OECD capital share data: We use the OECD business sector database cited in [Blanchard \(1997\)](#), downloaded from <http://fmwww.bc.edu/ec-p/data/oecd/oecd.bsdb.html>.
- ECLAC/CEPAL capital share data: We use the “CEPALSTAT Base de Datos,” available at <http://interwp.cepal.org/sisgen/ConsultaIntegrada.asp?idIndicador=2197&idioma=e> to obtain the wage bill (“remuneración de los asalariados”) and total profits (“excedente de explotación”) on an annual basis in local currency. We compute the capital share as profits over the sum of profits to the wage bill, yielding the net capital share.
- U.S. state capital share and GDP data: We use the Bureau of Economic Analysis Regional Accounts section “Annual Gross Domestic Product By State” from <http://www.bea.gov/regional/> to obtain data on “compensation of employees,” “taxes on production and imports less subsidies” and “GDP in current dollars” to compute the gross capital share as one minus the compensation of employees over GDP minus taxes net of subsidies. All data are confined to (total) “private industry.” Since the five-year periods in the states we are studying do not include 1997, when the BEA switched from SIC to NAICS, we pool the changes in GDP growth and the capital share based on either underlying classification.
- Annual GDP data: We use the data from the web appendix of [Barro \(2009\)](#) on real per capita GDP along with real GDP data from the Penn World Tables ([Feenstra et al., 2013](#)). We detrend the data with a quadratic trend after taking logarithms.
- Stock market capitalization: We used the following (nominal) indices, downloaded from <http://globalfinancialdata.com/> unless otherwise stated:
 - France: “France SBF Industrials,” ticker symbol “_FISID”
 - Western Germany: “Germany CDAX Industrials Price Index,” ticker symbol “_CXKNXD”
 - Spain: “Madrid SE Index (old),” ticker symbol, ESMADM

- Portugal: “Portugal Industrials,” ticker symbol “PTINDUSM”
 - Argentina: “Buenos Aires SE General Index (IVBNG),” ticker symbol, “_IBGD”
 - Chile (financials): “Chile BEC Finance Index,” ticker symbol “_FINANCD”
 - Chile (industrials): “Chile BEC Industrials Index (w/GFD extension),” ticker symbol “_INDUSTD”
- Price indices: We use consumer price indices to deflate the stock market indices. Except for Argentina and Chile, we downloaded the data from <http://research.stlouisfed.org/fred2/>:
 - France: Ticker symbol “FRACPIALLMINMEI”
 - Western Germany: Ticker symbol “DEUCPIALLMINMEI”
 - Spain: Ticker symbol “ESPCPIALLMINMEI”
 - Portugal: Ticker symbol “PRTCPIALLMINMEI”
 - Argentina: Global Financial Database “Argentina Consumer Price Index Inflation Rate,” ticker symbol “CPARGM”
 - Chile: “Índice de Precios al Consumidor - Antecedentes históricos” from http://www.ine.cl/canales/chile_estadistico/estadisticas_precios/ipc/series_antecedentes_historicos/index.php

B Controlling for industry composition

To control for industry composition in the effect of capital income share movements in France, the U.K., and the U.S. as described in Section 2 of the main text, we use EU KLEMS data: <http://www.euklems.net/>. We compute the gross labor share as labor compensation relative to gross value added at basic prices. We drop the following industries from our calculations, as the division between labor and capital income is less straightforward than in other industries:

- Agriculture (code: “AtB”).
- Mining (code: “C”).
- Government (code: “L”).
- Financial intermediation (code: “J”).

We keep the most disaggregated industries available, leaving a total of 27 industries with data available for the three countries.

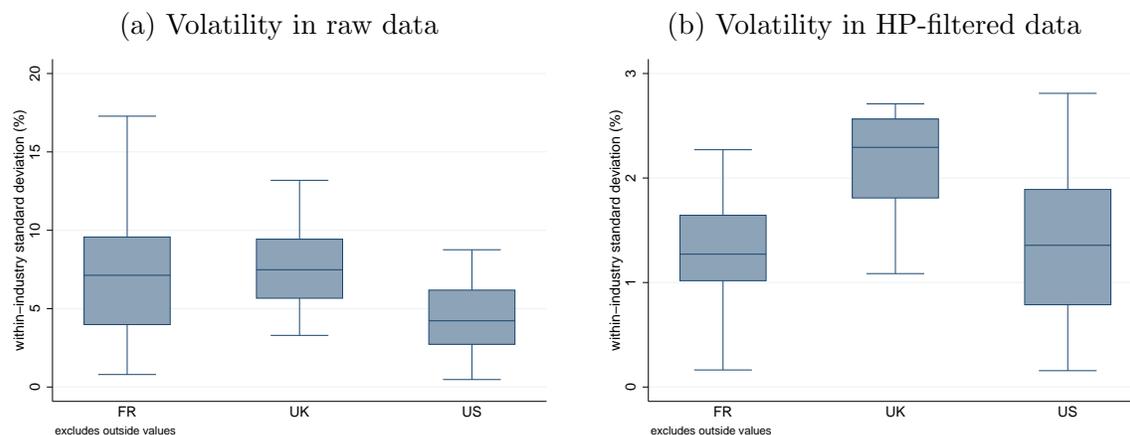


Figure B.5: Within-industry volatility of the gross labor share.

C Additional results on the international evidence

Here we present additional material on the international evidence: first, on the case studies and, second, on labor regulation and capital shares.

C.1 Additional results on the case studies

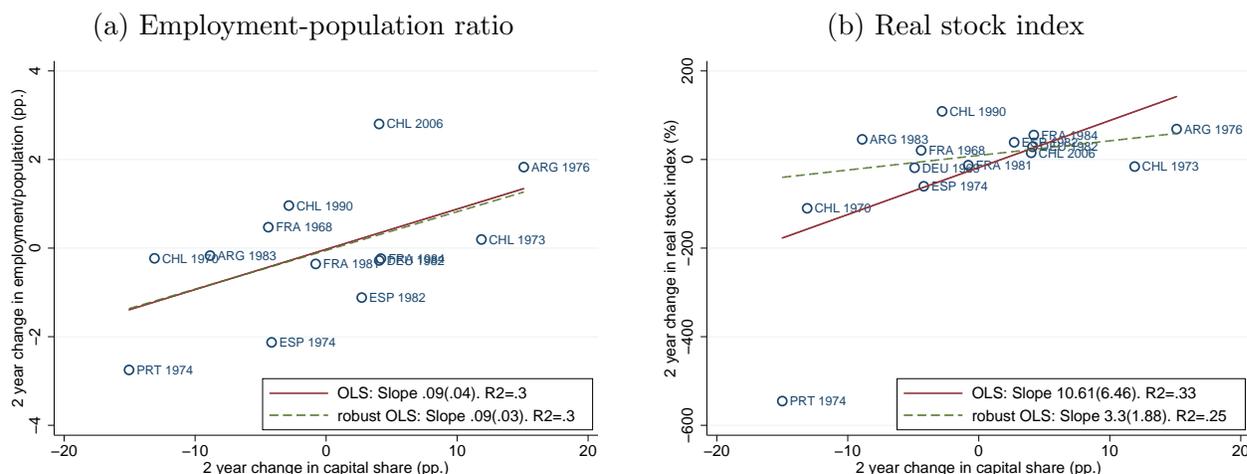
As a supplement to the time series discussed in the main text, we summarize the effect of the political events in the case studies in Table C.1. The table shows the change in the available capital share measure one year after the event year compared to one year before the event, i.e., two-year changes. Also, we show the corresponding changes in the employment-to-population ratio, computed using the [Feenstra et al. \(2013\)](#) data, and the change in the real stock index.

Table C.1: Political events, 2-year changes in capital shares, and employment

OECD data	Date		Δ capital share	Δ employment / population	Δ stock index
	Year	Month	pp.	pp.	%
Spain: Franco's illness	1974	7	-4.2	-2.1	-60.4
Spain: Gonzalez administration	1982	12	2.7	-1.1	38.8
Argentina: Coup against J. Peron	1955	9	5.5		
Argentina: Coup against I. Peron	1976	3	15.1	1.8	68.7
Argentina: Democratic transition	1983	12	-8.9	-.2	45.5
Chile: Allende election	1970	11	-13.1	-.2	-110.1
Chile: Pinochet coup	1973	9	11.9	.2	-15.9
Chile: Democratic election	1990	3	-2.8	1	108.7
Chile: Democratic transition	2006	3	4	2.8	15.1
France: 1968 strikes	1968	5	-4.4	.5	20.7
France: Mitterrand's election	1981	5	-.8	-.4	-12.8
France: Mitterrand's policy change	1984	7	4.2	-.2	55.2
Portugal: Carnation Revolution	1974	4	-15	-2.7	-545.3
W Germany: Brandt election	1969	10	-4.9		-18.6
W Germany: Kohl administration	1982	10	4.1	-.3	28.7

Figure C.6 shows the robust positive association between capital share changes and both employment and stock market changes. We compute both OLS regressions and weighted OLS regressions, where the weights are generated by Stata's robust regression `rreg` command that weighs down

outliers and, in the case of the stock market change in Portugal, drops extreme observations. The relationship with capital share changes is always positive and particularly robust for employment changes, with implied t-statistics between 2.25 and 3.00. The t-statistics for the stock index slopes are somewhat lower, between 1.64 and 1.76. The R^2 statistics are 0.30 for the employment relationship and between 0.25 and 0.33 for the stock market regressions, indicating a moderate to strong correlation.



Heteroskedasticity-robust standard errors for slope coefficients in parentheses.

Figure C.6: Political events: 2-year changes in capital shares vs 2-year changes in employment and stock indices.

C.2 Additional results on labor regulation and capital shares

We report here some additional regression results on labor regulation and capital shares. Table C.2 documents the regression estimates for the three-year effects of changes in labor regulation on capital shares. Table C.3 does the same for the one-year effects of changes in labor regulation on capital shares. We try different specifications, such as examining only changes within the year of the political event or labor-regulation change, and using all countries for which we have labor share and capital share data with OLS, following our algorithm blindly by assigning 1976 as the democratization date for Portugal, or using the Carnation Revolution date of 1974.

In both tables, “5y FE” refers to a fixed effect for the five-year period surrounding the event. “Initial conditions” are the level of capital share and real per capita GDP growth in the year prior to the estimation period. In the baseline IV regressions, we only include countries with political events, as defined in the main text. Alternatively, we include all observations for the countries with political events. For the OLS case, we also run the regression of the sample of all countries with capital share and labor regulation data.

Table C.2: Three-year effects of changes in labor regulation on capital shares: Regression estimates

Specification	5y FE	Initial conditions	Effect on capital share	t-stat	1-stage t-stat
All countries: OLS	–	–	-0.92	-5.20	.
	y	–	-0.86	-4.08	.
All countries: OLS	–	y	-0.90	-4.67	.
	y	y	-0.84	-4.01	.
Event countries: OLS	–	–	-1.49	-3.47	.
	y	–	-1.56	-3.72	.
	–	y	-1.40	-3.13	.
	y	y	-1.49	-3.41	.
Event episodes: OLS	–	–	-5.21	-3.16	.
	y	–	-6.21	-2.86	.
	–	y	-5.43	-2.48	.
	y	y	-5.22	-2.40	.
Carnation Revolution date					
Event episodes: IV	–	–	-6.94	-2.98	2.28
	y	–	-8.39	-3.62	2.62
	–	y	-7.94	-2.18	1.72
	y	y	-8.94	-2.90	1.85
Event countries: IV	–	–	-4.58	-3.21	2.09
	y	–	-4.06	-2.81	3.00
	–	y	-4.06	-2.55	2.01
	y	y	-4.17	-2.90	2.96
Pure algorithm					
Event episodes: IV	–	–	-5.28	-2.31	2.27
	y	–	-5.35	-2.01	2.69
	–	y	-4.74	-1.83	1.89
	y	y	-4.96	-1.63	2.03
Event countries: IV	–	–	-3.99	-3.48	2.29
	y	–	-3.52	-2.91	3.03
	–	y	-3.66	-2.90	2.23
	y	y	-3.61	-2.95	3.01

Table C.3: One-year effects of changes in labor regulation on capital shares: Regression estimates

Specification	5y FE	Initial conditions	Effect on capital share	t-stat	1-stage t-stat
All countries: OLS	–	–	-0.45	-3.34	.
	y	–	-0.44	-3.00	.
All countries: OLS	–	y	-0.43	-3.29	.
	y	y	-0.43	-2.95	.
Event countries: OLS	–	–	-0.82	-2.71	.
	y	–	-0.84	-2.68	.
	–	y	-0.81	-2.73	.
	y	y	-0.84	-2.73	.
Event episodes: OLS	–	–	-3.03	-1.56	.
	y	–	-2.85	-1.24	.
	–	y	-2.89	-1.39	.
	y	y	-2.99	-1.12	.
Carnation Revolution date					
Event episodes: IV	–	–	-5.67	-2.01	2.34
	y	–	-5.35	-2.10	2.45
	–	y	-5.79	-2.01	2.24
	y	y	-5.61	-2.46	2.26
Event countries: IV	–	–	-2.35	-2.43	2.03
	y	–	-2.33	-2.28	2.23
	–	y	-2.25	-2.32	2.02
	y	y	-2.26	-2.22	2.23
Pure algorithm					
Event episodes: IV	–	–	-5.77	-2.00	2.37
	y	–	-5.86	-2.45	2.60
	–	y	-5.40	-2.08	2.37
	y	y	-6.13	-3.20	2.62
Event countries: IV	–	–	-2.10	-2.34	2.12
	y	–	-2.09	-2.27	2.35
	–	y	-2.06	-2.33	2.12
	y	y	-2.05	-2.25	2.34

D Additional evidence regarding right-to-work legislation

We repeat the same exercise as in Subsection 2.3, but now we look at real GDP growth instead of labor shares. Real GDP growth is computed using the change in state total private-sector GDP deflated by the national GDP deflator. Since the data start only in 1963, the year Wyoming adopted the new legislation, GDP growth in Wyoming is normalized to zero for the first year after adoption. Before 1997 we use private SIC industries. From 1997, we use private NAICS industries.

Figure D.7 reports the evolution of real state private industry GDP growth after the adoption of right-to-work legislation (in absolute levels and relative to the U.S.). Table D.4 presents a panel regression analysis of the data. Standard errors are clustered by state and industry, and two-sided p -values are in parentheses.

Change in real GDP growth and change relative to U.S.

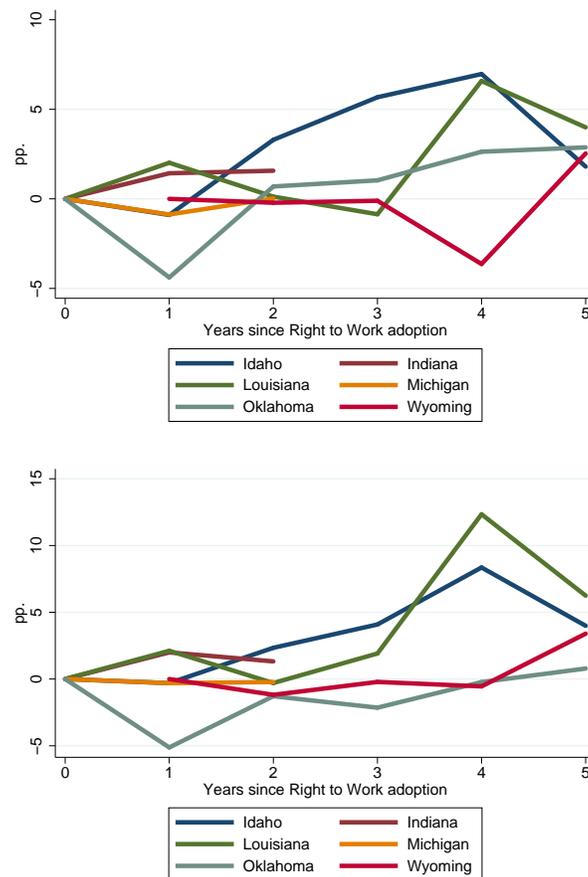


Figure D.7: Change in real state private industry GDP growth after right-to-work adoption.

Table D.4: State-industry panel regression: Right-to-work laws and real GDP growth

Controlling for census region FE, year FE, and industry FE						
	Level	1y change	2y change	3y change	4y change	5y change
Right to Work	1.02 (0.00)					
Change in RtW		0.41 (0.70)	-0.31 (0.69)	-0.12 (0.82)	-0.13 (0.78)	-0.09 (0.85)
Controlling for state FE, and industry FE						
	Level	1y change	2y change	3y change	4y change	5y change
Right to Work	-0.01 (0.99)					
Change in RtW		0.83 (0.43)	0.15 (0.84)	0.96 (0.08)	1.12 (0.02)	0.96 (0.06)
Controlling for state FE, quadratic trend, and industry FE						
	Level	1y change	2y change	3y change	4y change	5y change
Right to Work	0.65 (0.08)					
Change in RtW		0.96 (0.36)	0.14 (0.86)	0.96 (0.08)	1.12 (0.02)	0.97 (0.05)
Controlling for state FE, year FE, and industry FE						
	Level	1y change	2y change	3y change	4y change	5y change
Right to Work	0.41 (0.27)					
Change in RtW		0.56 (0.60)	-0.22 (0.79)	-0.02 (0.97)	-0.02 (0.97)	-0.04 (0.94)

E Additional VAR results

We plot here, in Figure E.8, the IRFs from the small VAR with a quadratic trend.

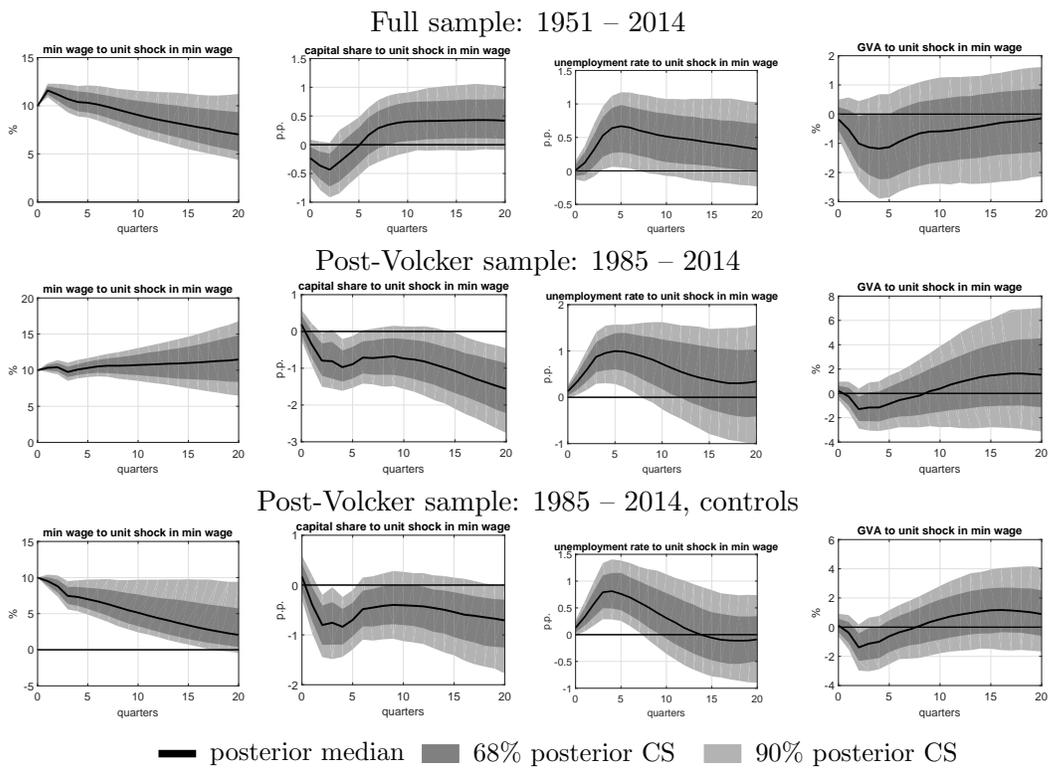


Figure E.8: Responses to a 10% real minimum wage shock in small VAR, quadratic trend.

F Large VAR

To better control for the state of the economy and check the robustness of the VAR exercise in the main text, we now present results using a larger VAR. In addition to the labor market and the non-corporate business sector, this VAR captures asset prices, consumption, and investment. As a result, we arrive at the following ten-variable VAR: (1) the (log) of the federal minimum wage relative to the PCE deflator, (2) the net capital share in the corporate non-financial sector, (3) the average of the total returns of consumer and manufacturing firms, (4) the unemployment rate, (5) non-farm labor productivity in the business sector, (6) labor market tightness, (7) capacity utilization, (8) real private investment, (9) real private consumption, and (10) the average corporate tax rate. Instead of using the cumulative total return in [Greenwald et al. \(2014\)](#), we use the (unweighted) average of the cumulative total return in the consumer and manufacturing sectors based on the five-sector Fama-French industry classification because we expect the minimum wage to be more important in these sectors.³⁰ Again, we use four lags in the estimation.

Minimum wage shocks are also clearly redistributive in this large VAR. Figure F.9 shows the IRFs to a typical minimum wage shock of 10%. Such a shock causes the capital share to drop by 0.25 to 0.5 pp. for two to five quarters with 68% posterior credibility. The labor market worsens, with unemployment rising by 0.5 to 1.5 pp. about a year after the initial shock. Labor productivity increases slightly with a delay, consistent with a selection effect. We also find that the stock market valuation drops significantly. Investment drops 5% at the peak and with it capacity utilization. Finally, there is a delayed decline in the average corporate tax rate. This decline may reflect the progressivity of the corporate tax code as corporate profits fall.

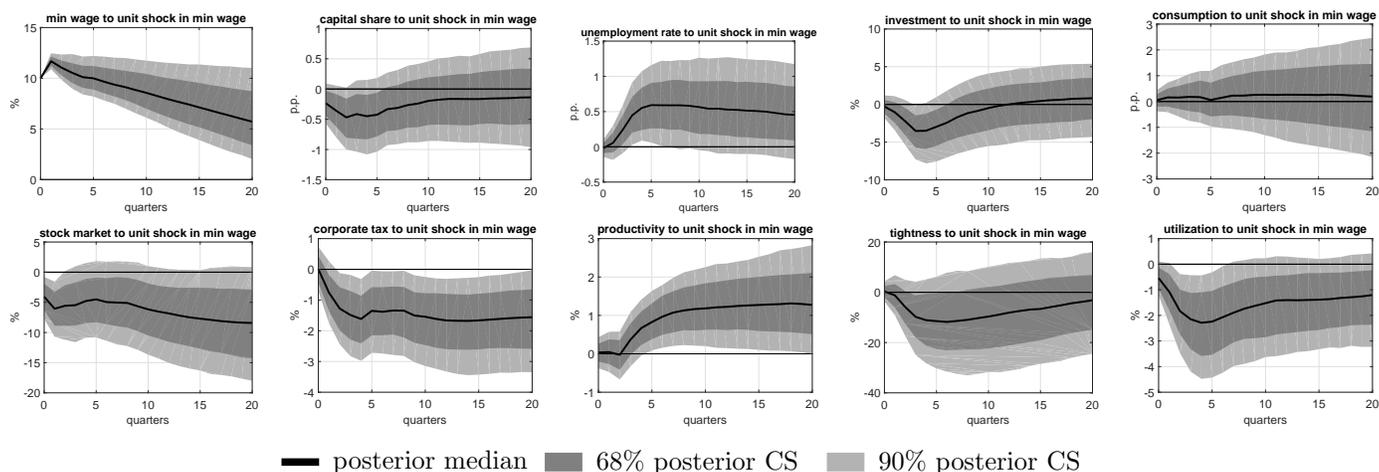


Figure F.9: Responses to a 10% real minimum wage shock in extended VAR: 1951–2014.

Many states set minimum wages above the federal level, particularly in the second half of our full sample (cf. [Autor et al., 2016](#)). Hence, we incorporate state minimum wage changes in our analysis. More concretely, prior to estimation, we aggregate minimum wages across states by weighting them with the relative populations of each state. This weighting is imperfect given

³⁰We use these sectors because our empirical model does not speak much to the other three sectors. We focus on the non-financial corporate business sectors and thus drop the “other” sector that includes financial firms. Also, given that less than 10% of paid hours are directly affected by the minimum wage and spillovers to higher wage groups are limited, we conjecture that the consumer sector (including wholesale and retail) and manufacturing sector are the most affected. See Ken French’s data library for the source data: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html. Our results change little when we include only one of the sectors at a time.

that the unemployment rate in our VAR is labor force weighted and stock returns are weighted by market capitalization.³¹

Combining state and federal minimum wage strengthens the redistributive effects we estimate; see Figure F.10. After a minimum wage shock, there is a drop in the capital share that lasts for three to four years and peaks -1 to -1.5 pp. after six quarters. With a delay, unemployment rises significantly after five quarters, while stock values, consumption, and utilization fall. The differences in the size and shape of the IRFs of this exercise are not due to the different sample period compared to our large VAR baseline.

We also report several robustness exercises. First, in Figure F.11, we plot the IRFs from the large VAR in the post-1974 sample. Second, in Figure F.12, we plot the IRFs from the same VAR, but now with a quadratic trend and using shocks to the real effective state-level minimum wage. Third, in Figure F.13, we plot the IRFs of the same VAR with a quadratic trend for the full 1951-2014 sample.

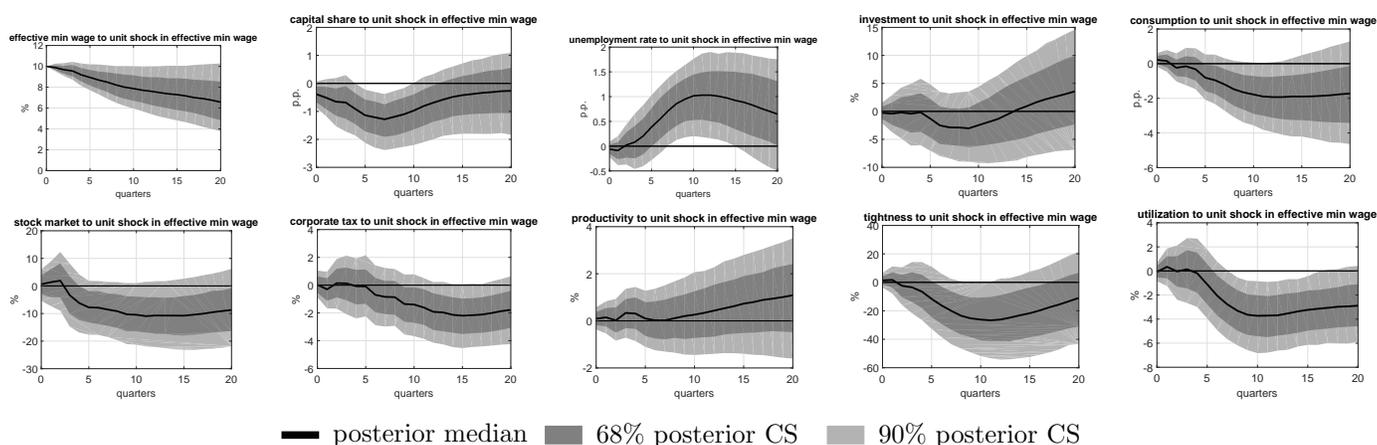


Figure F.10: Responses to a 10% real effective state-level minimum wage shock in extended VAR: 1974-2014.

³¹We use the data from Autor et al. (2016). Their coverage of Washington, D.C., has a gap, so we drop it. For the other states, we compute the change in the maximum of the state and the federal minimum wage, quarter by quarter. We deflate this nominal increase and average it across states using population annual weights.

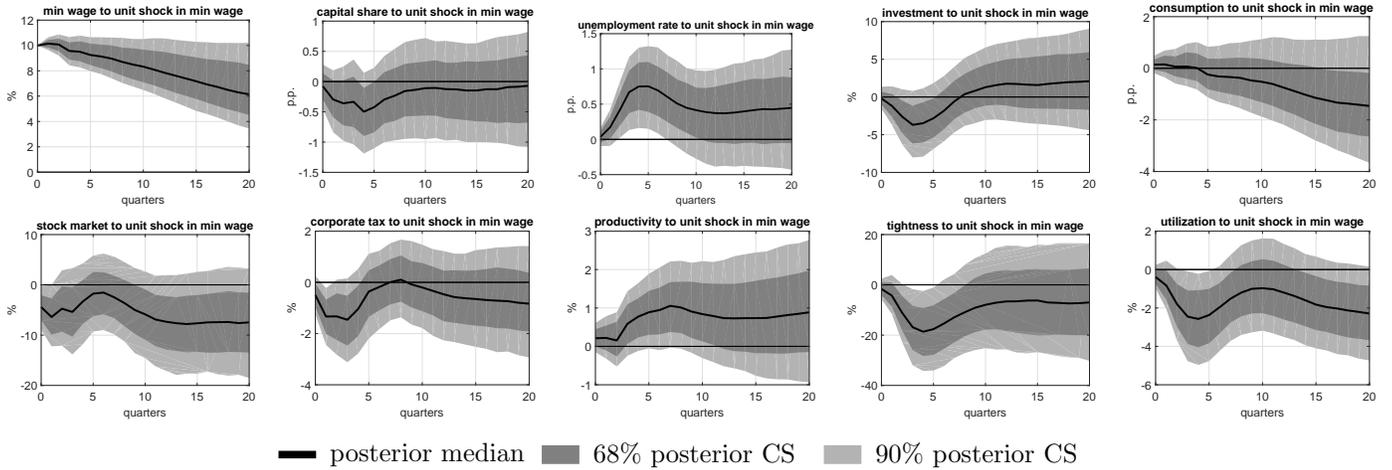


Figure F.11: Responses to a 10% real minimum wage shock in extended VAR: 1974–2014.

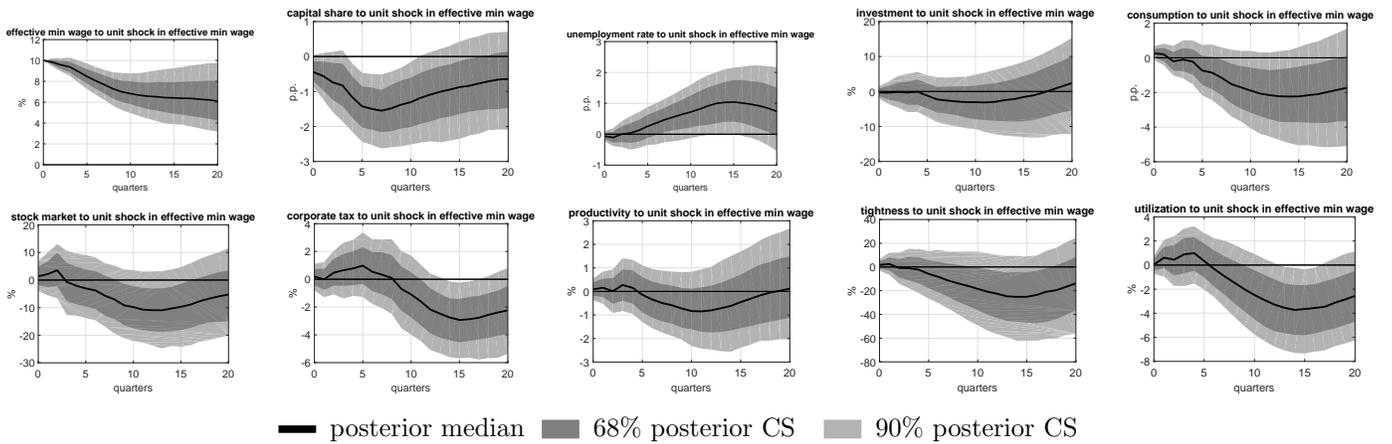


Figure F.12: Responses to a 10% real effective state-level minimum wage shock in extended VAR: 1974–2014, quadratic trend.

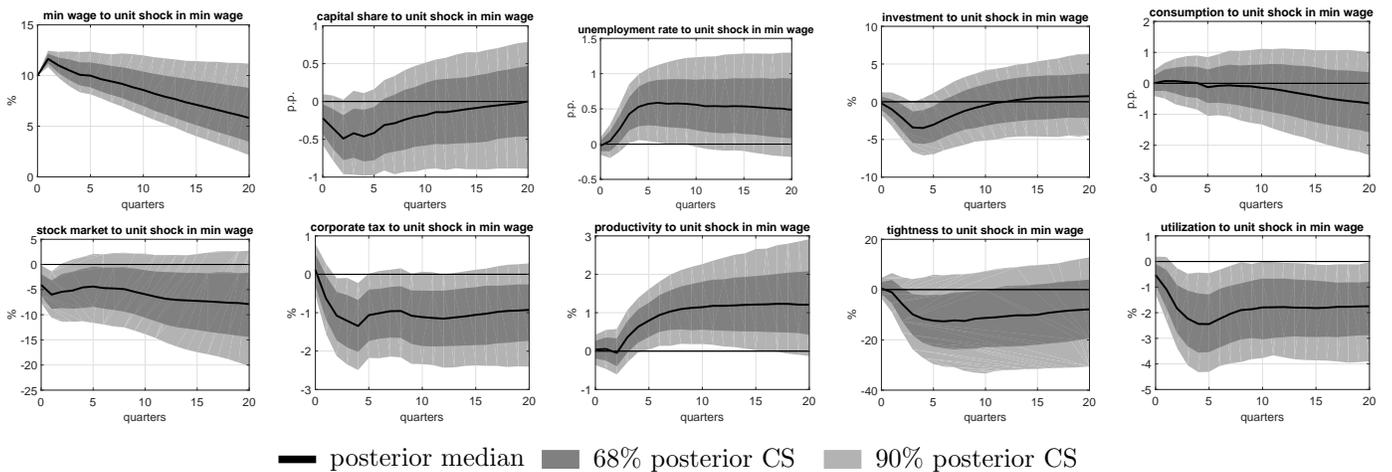


Figure F.13: Responses to a 10% real minimum wage shock in extended VAR: 1951–2014, quadratic trend.

G Model appendix

Our business cycle model with search frictions in the labor market is in the spirit of those in [Andolfatto \(1996\)](#) and [Merz \(1995\)](#) and builds on the formulation of [Shimer \(2010, ch. 3\)](#). Relative to the notation in [Shimer \(2010\)](#), we change the timing convention so that capital k_t and employment n_t are time t measurable, but not time $t - 1$ measurable.

G.1 Households

G.1.1 Preferences and constraints

There is a representative household that perfectly ensures its members against idiosyncratic risk. The following utility function represents its preferences:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{(c_{e,t} - hc_{e,t-1}^a)^{1-\sigma} (1 + (\sigma - 1)\gamma)^\sigma - 1}{1 - \sigma} n_{t-1} + \frac{(c_{u,t} - hc_{u,t-1}^a)^{1-\sigma} - 1}{1 - \sigma} (1 - n_{t-1}) \right), \quad (\text{G.1})$$

where $c_{e,t}$ and $c_{u,t}$ are the consumption of the employed and unemployed household members, respectively, and n_{t-1} denotes the fraction of employed households. The parameter $h \in [0, 1)$ controls the strength of the external habit.

The household faces a lifetime budget constraint given the stochastic discount factor m_t :

$$a_{-1} = \mathbb{E}_0 \sum_{t=0}^{\infty} \left(\prod_{s=0}^t m_s \right) (c_{e,t} n_{t-1} + c_{u,t} (1 - n_{t-1}) - (1 - \tau_n) w_t n_{t-1} - T_t), \quad (\text{G.2})$$

where the present discounted value of consumption equals the beginning of the period financial wealth a_{-1} plus net labor income $(1 - \tau_n) w_t n_{t-1}$ and lump-sum transfers T_t .

When making its decisions, the representative household considers that workers lose their jobs at rate x and find new jobs at rate $f(\theta_t)$, where θ_t is the recruiter-unemployment ratio that the household takes as given. Thus, the fraction of household members employed next period will be:

$$n_t = (1 - x)n_{t-1} + f(\theta_t)(1 - n_{t-1}) \quad (\text{G.3})$$

where $f(\theta_t) = \xi \theta_t^\eta$.

G.1.2 Aggregation

Under perfect insurance within the family, a necessary condition for the household's optimality is that consumption of the employed and unemployed satisfy:

$$\beta^t (c_{e,t} - hc_{e,t-1}^a)^{-\sigma} (1 + (\sigma - 1)\gamma)^\sigma = \beta^t (c_{u,t} - hc_{u,t-1}^a)^{-\sigma} = \lambda m_t,$$

where λ is the Lagrangian multiplier associated with the budget constraint. If $h = 0$ or given the initial condition that $c_{e,t-1}^a = c_{u,t-1}^a (1 + (\sigma - 1)\gamma)$, it follows that:

$$c_{e,t} = c_{u,t} (1 + (\sigma - 1)\gamma)$$

and

$$\begin{aligned} c_t &\equiv c_{e,t}n_{t-1} + c_{u,t}(1 - n_{t-1}) \\ c_{u,t} &= \frac{c_t}{1 + (\sigma - 1)\gamma n_{t-1}} \\ c_{e,t} &= \frac{c_t(1 + (\sigma - 1)\gamma)}{1 + (\sigma - 1)\gamma n_{t-1}}. \end{aligned}$$

Hence, the utility function can be simplified as:

$$U_0 = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t - h c_{t-1}^a \frac{1 + (\sigma - 1)\gamma n_{t-1}}{1 + (\sigma - 1)\gamma n_{t-2}^a} \right)^{1 - \sigma} (1 + (\sigma - 1)\gamma n_{t-1})^\sigma - 1}{1 - \sigma}, \quad (\text{G.4})$$

and the budget constraint becomes:

$$a_{-1} = \mathbb{E}_0 \sum_{t=0}^{\infty} \left(\prod_{s=0}^t m_t \right) (c_t - (1 - \tau_n)w_t n_{t-1} - T_t). \quad (\text{G.5})$$

With $h > 0$, the household partially internalizes that increasing employment changes the size of habit one period ahead. Setting $h = 0$ recovers equation (4.1) in the main text.

G.1.3 Equilibrium conditions

We start the analysis of the labor market by writing the household problem using a recursive formulation:

$$V(a_{-1}, n_{-1}; S) = \max_{a(S'), c, n} \frac{(c - \hat{h}(n_{-1})c_{-1}^a)^{1 - \sigma} (1 + (\sigma - 1)\gamma n_{-1})^\sigma - 1}{1 - \sigma} + \beta \mathbb{E}[V(a(S'), n; S') | S]$$

subject to:

$$n = (1 - x)n_{-1} + f(\theta)(1 - n_{-1}) \quad (\text{G.6})$$

$$c = a_{-1} + (1 - \tau_n)w_t n_{-1} + T_t - \mathbb{E}[m(S')a(S') | S] \quad (\text{G.7})$$

and where:

$$\hat{h}(n_{-1}) = h \frac{1 + (\sigma - 1)\gamma n_{-1}}{1 + (\sigma - 1)\gamma n_{-2}^a}.$$

Complete markets ensure that the household can pick next period's assets as a function of the future state S' .

The equilibrium conditions for an interior equilibrium are:

$$\lambda = (c - \hat{h}(n_{-1})c_{-1}^a)^{-\sigma} (1 + (\sigma - 1)\gamma n_{-1})^\sigma \quad (\text{G.8})$$

$$\lambda m(S') = \beta V_a(a(S'), n; S') = \beta \lambda(S') = \beta (c(S') - \hat{h}(n)c^a)^{-\sigma} (1 + (\sigma - 1)\gamma n)^\sigma. \quad (\text{G.9})$$

Thus, the stochastic discount factor of the economy is:

$$m(S') = \beta \frac{(c(S') - \hat{h}(n)c^a)^{-\sigma}(1 + (\sigma - 1)\gamma n)^\sigma}{(c - \hat{h}(n_{-1})c_{-1}^a)^{-\sigma}(1 + (\sigma - 1)\gamma n_{-1})^\sigma}. \quad (\text{G.10})$$

In equilibrium, $c^a = c$. In what follows, we use m_t as shorthand for $m(S_t)$ with $m_0 = 1$.

The marginal value of employment is given by:

$$\begin{aligned} V_n(a_{-1}, n_{-1}; S) &= \left(\frac{c - \hat{h}(n_{-1})c_{-1}^a}{1 + (\sigma - 1)\gamma n_{-1}} \right)^{-\sigma} (1 - \tau_n)w \\ &\quad - \left(\frac{c - \hat{h}(n_{-1})c_{-1}^a}{1 + (\sigma - 1)\gamma n_{-1}} \right)^{1-\sigma} \gamma \left(\sigma + (\sigma - 1) \frac{\hat{h}(n_{-1})c_{-1}^a}{c - \hat{h}(n_{-1})c_{-1}^a} \right) \\ &\quad + \beta(1 - x - f(\theta))\mathbb{E}[V_n(a(S'), n; S')|S]. \end{aligned} \quad (\text{G.11})$$

A useful equilibrium object is the value of having a worker employed at an arbitrary wage \tilde{w} this period and at the equilibrium wage thereafter:

$$\tilde{V}_n(a, n_{-1}; S) = \left(\frac{c - \hat{h}(n_{-1})c_{-1}^a}{1 + (\sigma - 1)\gamma n_{-1}} \right)^{-\sigma} (1 - \tau_n)(\tilde{w} - w) + V_n(a_{-1}, n_{-1}; S). \quad (\text{G.12})$$

\tilde{V}_n differs from the marginal value of an extra worker employed at the equilibrium wage both this period and thereafter, i.e., V_n , by the marginal utility of income times the difference in the net wage income.

In what follows, we write $\mathbb{E}_t[\cdot]$ for the conditional expectation $\mathbb{E}[\cdot|S_t]$ and similarly index the value function instead of explicitly carrying the state vector and its other arguments.

G.2 Firm

G.2.1 Firm environment

There is a representative firm with n_{-1} workers and capital k_{-1} . It assigns a fraction ν_0 of its n_{-1} workers to recruiting and the remaining $n_{-1}(1 - \nu_0)$ to production. The firm produces a homogeneous output with production function:

$$\begin{aligned} y_t &= \left(\alpha^{1/\varepsilon}(u_t k_{t-1})^{1-1/\varepsilon} + (1 - \alpha)^{1/\varepsilon}(e^{g_z t} z_t n_{t-1}(1 - \nu_t))^{1-1/\varepsilon} \right)^{\frac{\varepsilon}{\varepsilon-1}} \\ &\equiv \psi(u_t k_{t-1}, z_t n_{t-1}(1 - \nu_t)). \end{aligned} \quad (\text{G.13})$$

The constant elasticity of substitution between effective capital and labor in production is given by ε , labor-augmenting growth trend g_z , and the productivity process z_t that follows, for the moment, the AR(1) specified in the main text.

The law of motion for capital is:

$$k_t = (1 - \delta(u_t))k_{t-1} + \chi i_t \left(1 - \frac{1}{2}\kappa \left(\frac{i_t}{k_{t-1}} - \tilde{\delta} \right)^2 \right), \quad (\text{G.14})$$

where $\tilde{\delta} \equiv g_z - (1 - \delta(\bar{u}))$, χ is the marginal efficiency of investment, and

$$\delta(u) = \delta_0 + \delta_1(u - 1) + \frac{1}{2}\delta_2(u - 1)^2. \quad (\text{G.15})$$

The firm's value is given by:

$$J(n_{-1}, k_{-1}) = \mathbb{E} \sum_{t=0}^{\infty} \left(\prod_{s=1}^t m_t \right) ((1 - \tau_k)(y_t - w_t n_t) + \tau_k \delta(\bar{u}) \bar{q} k_{t-1} - i_t),$$

where production and capital follow from equations (G.13) and (G.14) and employment growth satisfies:

$$n_t = (\nu_t \mu(\theta_t) + 1 - x) n_{t-1},$$

where $\mu(\theta_t) \equiv f(\theta_t)/\theta_t$ is the hiring probability per recruiter.

The firm's value can be expressed recursively as:

$$\begin{aligned} J(n_{-1}, k_{-1}) = \max_{\nu, u, k, I} & \left((1 - \tau_k) (\psi(uk_{-1}, zn_{-1}(1 - \nu)) - n_{-1}w) + \tau_k \bar{\delta} k_{t-1} - I \right. \\ & \left. + q \left(-k + (1 - \delta(u))k_{-1} + \chi I \left(1 - \frac{1}{2} \kappa \left(\frac{I}{k_{-1}} - \tilde{\delta} \right)^2 \right) \right) \right) \\ & \left. + \mathbb{E} [mJ(n_{-1}(\nu\mu(\theta) + 1 - x), k)] \right). \end{aligned} \quad (\text{G.16})$$

G.2.2 Firm optimality

At an interior solution for the share of recruiters, the following optimality condition holds:

$$(1 - \tau_k) z_t \underbrace{\left((1 - \alpha) \frac{Y_t}{z_t n_{t-1} (1 - \nu_t)} \right)}_{\equiv \text{mpl}_t}^{\frac{1}{\varepsilon}} = \mu(\theta_t) \mathbb{E} [m_{t+1} J_n(n_t, k_t)]. \quad (\text{G.17})$$

Thus, the marginal value of employment is given by:

$$\begin{aligned} J_n(n_{t-1}, k_{t-1}) &= (1 - \tau_k) (\text{mpl}_t \times (1 - \nu_t) - w_t) + (\nu_t \mu(\theta_t) + 1 - x) \mathbb{E} [m_{t+1} J_n(n_t, k_t)] \\ &= (1 - \tau_k) \left(\text{mpl}_t \left(1 + \frac{1 - x}{\mu(\theta_t)} \right) - w_t \right), \end{aligned} \quad (\text{G.18})$$

using equation (G.17) to substitute for $\mathbb{E} [m_{t+1} J_n(n_t, k_t)]$. The constant taxes τ_k do not distort the recruiting decision because they affect costs and benefits proportionally.

In a similar way to the household problem, define the marginal profit of employing a worker at an arbitrary (off-equilibrium) wage \tilde{w} and at the equilibrium wage from then on, given employment and capital at the firm:

$$\tilde{J}_n(n, k) = (1 - \tau_k)(w_t - \tilde{w}) + J_n(n, k). \quad (\text{G.19})$$

The optimality condition for the utilization rate is:

$$\delta'(u_t)q_t k_{t-1} = (\delta_1 + \delta_2(u_t - 1))q_t k_{t-1} = (1 - \tau_k) \left(\alpha \frac{y_t}{u_t k_{t-1}} \right)^{1/\varepsilon} k_{t-1} \equiv (1 - \tau_k) \frac{mpk_t}{u_t}, \quad (\text{G.20})$$

and for investment:

$$1 = q_t \chi \left(\left(1 - \frac{1}{2} \kappa \left(\frac{i_t}{k_{t-1}} - \tilde{\delta} \right)^2 \right) - \kappa \left(\frac{i_t}{k_{t-1}} - \tilde{\delta} \right) \frac{i_t}{k_{t-1}} \right). \quad (\text{G.21})$$

The optimality condition for capital k' is given by:

$$\begin{aligned} q_t &= \mathbb{E}[m_{t+1} J_k(n_t, k_t)] \\ &= \mathbb{E} \left[m_{t+1} \left(mpk_{t+1}(1 - \tau_k) + \tau_k \bar{\delta} + \left((1 - \delta(u_{t+1})) + \chi \kappa \left(\frac{i_{t+1}}{k_t} \right)^2 \left(\frac{i_{t+1}}{k_t} - \tilde{\delta} \right) \right) q_{t+1} \right) \right] \end{aligned} \quad (\text{G.22})$$

where the marginal product of physical capital is:

$$mpk_{t+1} \equiv u_{t+1} \left(\alpha \frac{Y_{t+1}}{u_{t+1} k_t} \right)^{\frac{1}{\varepsilon}}. \quad (\text{G.23})$$

G.3 Wage determination

Under Nash bargaining, the equilibrium wage solves, for a generic time-varying ϕ_t :

$$w_t = \arg \max_{\tilde{w}} \tilde{V}_n(\tilde{w})^{\phi_t} \tilde{J}_n(\tilde{w})^{1-\phi_t}.$$

The solution of this bargaining problem requires that, after plugging in from equations (G.19) and (G.12), the following condition holds

$$(1 - \phi_t)(1 - \tau_k) \underbrace{V_n(a_t, n_{t-1})}_{\equiv V_{n,t}} \left(\frac{c_t - \hat{h}_{t-1} c_{t-1}^a}{1 + (\sigma - 1)\gamma n_{t-1}} \right)^\sigma = \phi_t(1 - \tau_n) \underbrace{J_n(n_{t-1}, k_{t-1})}_{\equiv J_{n,t}}. \quad (\text{G.24})$$

We use this expression to simplify equation (G.11) - after multiplying (G.11) through by $(1 - \tau_k)$. First, we rewrite:

$$\begin{aligned} &(1 - \phi_t)(1 - \tau_k) V_{n,t} \left(\frac{c_t - \hat{h}_{t-1} c_{t-1}^a}{1 + (\sigma - 1)\gamma n_{t-1}} \right)^\sigma \\ &= (1 - \phi_t)(1 - \tau_k)(1 - \tau_n) w_t - (1 - \phi_t)(1 - \tau_k) \left(\frac{c_t - \hat{h}_{t-1} c_{t-1}^a}{1 + (\sigma - 1)\gamma n_{t-1}} \right) \gamma \left(\sigma + (\sigma - 1) \frac{\hat{h}_{t-1} c_{t-1}^a}{c_t - \hat{h}_{t-1} c_{t-1}^a} \right) \\ &\quad + (1 - x - f_t(\theta_t)) \mathbb{E}_t \left[\beta_t \left(\frac{(c_t - \hat{h}_{t-1} c_{t-1}^a)/(1 + (\sigma - 1)\gamma n_{t-1})}{(c_{t+1} - \hat{h}_t c_t^a)/(1 + (\sigma - 1)\gamma n_t)} \right)^\sigma \frac{1 - \phi_t}{1 - \phi_{t+1}} \right. \\ &\quad \left. \times (1 - \phi_{t+1}) \left(\frac{c_{t+1} - \hat{h}_t c_t^a}{1 + (\sigma - 1)\gamma n_t} \right)^\sigma (1 - \tau_k) V_{n,t+1} \right]. \end{aligned}$$

Next, we substitute from equation (G.24):

$$\begin{aligned} & \phi_t(1 - \tau_n)J_{n,t} \\ = & (1 - \phi_t)(1 - \tau_k)(1 - \tau_n)w_t - (1 - \phi_t)(1 - \tau_k) \left(\frac{c_t - \hat{h}_{t-1}c_{t-1}^a}{1 + (\sigma - 1)\gamma n_{t-1}} \right) \gamma \left(\sigma + (\sigma - 1) \frac{\hat{h}_{t-1}c_{t-1}^a}{c_t - \hat{h}_{t-1}c_{t-1}^a} \right) \\ & + (1 - x - f_t(\theta_t))\mathbb{E}_t \left[\frac{1 - \phi_t}{1 - \phi_{t+1}} m_{t+1} \phi_{t+1} (1 - \tau_n) J_{n,t+1} \right]. \end{aligned}$$

Then, we substitute from equation (G.18) for current J_n :

$$\begin{aligned} & \phi_t(1 - \tau_k)(1 - \tau_n) \left(mpl_t \left(1 + \frac{1 - x}{\mu(\theta_t)} \right) - w_t \right) \\ = & (1 - \phi_t)(1 - \tau_k)(1 - \tau_n)w_t - (1 - \phi_t)(1 - \tau_k) \left(\frac{c_t - \hat{h}_{t-1}c_{t-1}^a}{1 + (\sigma - 1)\gamma n_{t-1}} \right) \gamma \left(\sigma + (\sigma - 1) \frac{\hat{h}_{t-1}c_{t-1}^a}{c_t - \hat{h}_{t-1}c_{t-1}^a} \right) \\ & + (1 - \tau_n)(1 - x - f_t(\theta_t))\mathbb{E}_t \left[\frac{1 - \phi_t}{1 - \phi_{t+1}} \phi_{t+1} m_{t+1} J_{n,t+1} \right]. \end{aligned} \quad (\text{G.25})$$

If ϕ_t were constant, we could substitute out for future J_n conveniently from the recruiting optimality condition (G.17).

G.4 Market clearing

Market clearing involves, first, the resource constraint of the economy:

$$y_t \equiv \left(\alpha^{1/\varepsilon} (u_t k_{t-1})^{1-1/\varepsilon} + (1 - \alpha)^{1/\varepsilon} (z_t n_{t-1} (1 - \nu_t))^{1-1/\varepsilon} \right)^{\frac{\varepsilon}{\varepsilon-1}} = c_t + i_t. \quad (\text{G.26})$$

Second, the law of motion of capital:

$$k_t = (1 - \delta(u_t))k_{t-1} + \chi i_t \left(1 - \frac{\kappa}{2} \left(\frac{i_t}{k_{t-1}} - \tilde{\delta} \right)^2 \right). \quad (\text{G.27})$$

Third, the law of motion for employment:

$$n_t = (1 - x)n_{t-1} + f_t(\theta_t)(1 - n_{t-1}). \quad (\text{G.28})$$

Finally, the recruiter-unemployment ratio (analogous to market tightness):

$$\theta_t = \frac{\nu_t n_{t-1}}{1 - n_{t-1}}. \quad (\text{G.29})$$

G.5 Efficiency

Following Hosios (1990), we assess the allocative efficiency of the decentralized equilibrium. We consider a social planner's problem that is subject to the same set of distortionary taxes as the equilibrium allocation but recognizes the externalities embodied in the matching function. Because the external habit would introduce an additional externality, we set habit $h = 0$ in this section to derive a cleaner result.

The planner solves:

$$W(n_{-1}, k_{-1}; S) = \max_{x, i, k, n, \nu, u} \frac{c^{1-\sigma}(1 + (\sigma - 1)\gamma n_{-1})^\sigma - 1}{1 - \sigma} + \beta \mathbb{E}[W(n, k; S') | S] \quad (\text{G.30})$$

subject to:

$$c + i = (1 - \tau_n)wn_{-1} + (1 - \tau_k)(y - n_{-1}w) + \tau_k \bar{\delta} k_{-1} + T \quad (\text{G.31a})$$

$$k = (1 - \delta(u))k_{-1} + \chi i \left(1 - \frac{\kappa}{2} \left(\frac{i}{k_{-1}} - \tilde{\delta} \right)^2 \right) \quad (\text{G.31b})$$

$$n = (1 - x)n_{-1} + \xi(\nu n_{-1})^\eta (1 - n_{-1}). \quad (\text{G.31c})$$

Let λ_b be the multiplier on the budget constraint (G.31a), λ_k the multiplier on the law of motion for capital (G.31b), and λ_n the multiplier on the law of motion for employment n .

The optimality conditions for c, u, ν, i, n , and k are, respectively:

$$\lambda_b = \left(\frac{c}{1 + (\sigma - 1)\gamma n_{-1}} \right)^{-\sigma} \quad (\text{G.32a})$$

$$\lambda_k k_{-1} \delta'(u) = \lambda_b \frac{mpk}{u} k_{-1} (1 - \tau_k) \quad (\text{G.32b})$$

$$\underbrace{\lambda_n \eta \xi \left(\frac{\nu n_{-1}}{1 - n_{-1}} \right)^{\eta-1}}_{\equiv \mu(\theta)} n_{-1} = \lambda_b (1 - \tau_k) mpl \times n_{-1} \quad (\text{G.32c})$$

$$\lambda_b = \lambda_k \chi \left(1 - \frac{\kappa}{2} \left(\frac{i}{k_{-1}} - \tilde{\delta} \right)^2 - \kappa \frac{i}{k_{-1}} \left(\frac{i}{k_{-1}} - \tilde{\delta} \right) \right) \quad (\text{G.32d})$$

$$\lambda_n = \beta \mathbb{E}[W_n(S') | S] \quad (\text{G.32e})$$

$$\lambda_k = \beta \mathbb{E}[W_k(S') | S]. \quad (\text{G.32f})$$

We also have two envelope conditions with respect to n_{-1} and k_{-1} :

$$W_n = \lambda_n \left(1 - x + \eta \nu \xi \underbrace{\left(\frac{\nu n_{-1}}{1 - n_{-1}} \right)^{\eta-1}}_{\equiv \mu(\theta)} - (1 - \eta) \underbrace{\left(\frac{\nu n_{-1}}{1 - n_{-1}} \right)^\eta}_{\equiv f(\theta)} \right) \lambda_b ((1 - \tau_n) - (1 - \tau_k))w + \lambda_b (1 - \tau_k) mpl (1 - nu) - \lambda_b \frac{\gamma \sigma c}{1 + (\sigma - 1)\gamma n_{-1}} \quad (\text{G.33a})$$

$$W_k = \lambda_k \left(1 - \delta(u) + \tau_k \bar{\delta} + \left(\frac{i}{k_{-1}} \right)^2 \kappa \chi \left(\frac{i}{k_{-1}} - \tilde{\delta} \right) \right) + \lambda_b mpk. \quad (\text{G.33b})$$

We now guess and verify that, when we appropriately choose a constant bargaining power ϕ , the allocation of the planner's problem and the decentralized equilibrium coincide. Define:

$$q \equiv \frac{\lambda_k}{\lambda_b} \quad (\text{G.34a})$$

$$m \equiv \beta \frac{\lambda'_b}{\lambda_b} \quad (\text{G.34b})$$

$$J_n \equiv \eta^{-1} \frac{W_n}{\lambda'_b} \quad (\text{G.34c})$$

$$\phi \equiv 1 - \eta. \quad (\text{G.34d})$$

Guessing that allocations are the same, we can verify that we also obtain the private-sector optimality conditions for utilization, recruiting, investment, and capital. From equation (G.32) and the equilibrium for capital (G.33b) along with the optimality condition for employment (G.32e):

$$q\delta'(u) = \frac{mpk}{u}(1 - \tau_k) \quad (\text{G.32b}')$$

$$(1 - \tau_k)mpl = \mathbb{E} \left[m' \frac{W'_n}{\lambda'_b} \middle| S \right] \eta \mu(\theta) = \mathbb{E}[m' J'_n | S] \mu(\theta) \quad (\text{G.32c}')$$

$$q = \chi^{-1} \left(1 - \frac{\kappa}{2} \left(\frac{i}{k_{-1}} - \tilde{\delta} \right)^2 - \kappa \frac{i}{k_{-1}} \left(\frac{i}{k_{-1}} - \tilde{\delta} \right) \right)^{-1} \quad (\text{G.32d}')$$

$$q = \mathbb{E} \left[m' \left(q'(1 - \delta(u)) + q' \left(\frac{i}{k_{-1}} \right)^2 \kappa \chi \left(\frac{i}{k_{-1}} - \tilde{\delta} \right) + \tau_k \bar{\delta} + mpk' \right) \middle| S \right]. \quad (\text{G.32f}')$$

Therefore, we checked that the guess satisfies all the optimality conditions and the equilibrium condition for capital. We now check the remaining condition, the equilibrium condition for employment, using equation (G.32c'):

$$\eta^{-1} J_n = \left(\left(1 + \frac{1-x}{\mu(\theta)} \right) mpn - w \right) (1 - \tau_k) + (1 - x - f(\theta)) \mathbb{E}[m' J'_n | S] \frac{1 - \eta}{\eta} \\ (1 - \tau_n)w + \frac{\gamma \sigma c}{1 + (\sigma - 1)\gamma n_{-1}}. \quad (\text{G.33a}')$$

Plug in from equation (G.18) for $\left(\left(1 + \frac{1-x}{\mu(\theta)} \right) mpn - w \right) (1 - \tau_k)$:

$$\frac{1 - \eta}{\eta} J_n = (1 - \tau_n)w + \frac{\gamma \sigma c}{1 + (\sigma - 1)\gamma n_{-1}} + (1 - x - f(\theta)) \mathbb{E}[m' J'_n | S] \frac{1 - \eta}{\eta}. \quad (\text{G.33a}'')$$

Compare this to equation (G.25) with constant ϕ and dividing that equation through by $(1 - \phi)(1 - \tau_k)$ and substituting from equation (G.18):

$$\frac{\phi}{1 - \phi} J_n \frac{1 - \tau_n}{1 - \tau_k} \\ = (1 - \tau_n)w - \left(\frac{c}{1 + (\sigma - 1)\gamma n_{t-1}} \right) \gamma \sigma + (1 - x - f(\theta)) \mathbb{E}[m' J'_n | S] \frac{\phi}{1 - \phi} \frac{1 - \tau_n}{1 - \tau_k}. \quad (\text{G.25}')$$

Comparing this equation to equation (G.33a'') shows that the two equations are equal with $\phi = 1 - \eta$ if and only if $\tau_n = \tau_k$.

G.6 Detrended economy

In this subsection, we augment the model by allowing for a stochastic trend in z_t :

$$\ln \frac{z_t}{z_{t-1}} = \ln(g_z) + \epsilon_{p,t} \equiv \ln(g_{z,t}), \quad (\text{G.36})$$

where $\epsilon_{p,t}$ is the permanent shock to productivity (and where we drop the trend growth from the production function).

Capital, consumption, investment, the marginal value of employment, and wages grow with z_t , while all other variables are stationary. We denote detrended variables by \sim . To simplify notation, define the (detrended) marginal products of capital and labor as:

$$\widetilde{mpk}_t \equiv u_t \left(\alpha \frac{\tilde{y}_t}{u_t \tilde{k}_{t-1}} g_{z,t} \right)^{\frac{1}{\varepsilon}} = mpk_t \quad (\text{G.37})$$

$$\widetilde{mpl}_t \equiv \tilde{z}_t \left((1 - \alpha) \frac{\tilde{y}_t}{\tilde{z}_t n_{t-1} (1 - \nu_t)} \right)^{\frac{1}{\varepsilon}}. \quad (\text{G.38})$$

We substitute out for the number of recruiters by using the definition for market tightness:

$$n_{t-1} - \nu_{t-1} n_{t-1} = n_{t-1} - \theta_{t-1} (1 - n_{t-1}). \quad (\text{G.39})$$

Similarly, for the capital law of motion:

$$\tilde{k}_t = (1 - \delta(u_t)) g_{z,t}^{-1} \tilde{k}_{t-1} + \chi \tilde{i}_t \left(1 - \frac{\kappa}{2} \left(\frac{\tilde{i}_t}{\tilde{k}_{t-1}} g_{z,t} - \tilde{\delta} \right)^2 \right), \quad (\text{G.40})$$

the resource constraint

$$\left(\alpha^{1/\varepsilon} (u_t \tilde{k}_{t-1} g_{z,t}^{-1})^{1/\varepsilon} + (1 - \alpha)^{1/\varepsilon} (\tilde{z}_t n_{t-1} (1 - \nu_t))^{1-1/\varepsilon} \right)^{\frac{\varepsilon}{\varepsilon-1}} = \tilde{i}_t + \tilde{c}_t, \quad (\text{G.41})$$

and the firm value with equilibrium choices for investment, capital, utilization, and recruiting:

$$\begin{aligned} \tilde{J}_t = & \left((1 - \tau_k)(\tilde{y}_t - n_{t-1} \tilde{w}_t) - \tilde{i}_t + \delta \tilde{k}_{t-1} / g_{z,t} \right. \\ & + q_t \left(-\tilde{k}_t + (1 - \delta(u)) g_{z,t}^{-1} \tilde{k}_{t-1} + \chi \tilde{i}_t \left(1 - \frac{1}{2} \kappa \left(\frac{\tilde{i}_t}{\tilde{k}_{t-1}} g_{z,t} - \tilde{\delta} \right)^2 \right) \right) \\ & \left. + \mathbb{E}_t \left[m_{t+1} g_z \tilde{J}_{t+1} \right] \right). \end{aligned}$$

Since the constraint on capital accumulation binds, firm value is simply the present discounted value of the cash flow:

$$\tilde{J}_t = \left((1 - \tau_k)(\tilde{y}_t - n_{t-1} \tilde{w}_t) - \tilde{i}_t + \delta \tilde{k}_{t-1} / g_{z,t} + \mathbb{E}_t \left[m_{t+1} g_{z,t+1} \tilde{J}_{t+1} \right] \right). \quad (\text{G.42})$$

We also have the marginal value of employment

$$\tilde{J}_{n,t} = (1 - \tau_k) \left(\widetilde{mpl}_t \left(1 + \frac{1 - x}{\mu(\theta_t)} \right) - \tilde{w}_t \right), \quad (\text{G.43})$$

the recruiting optimality condition:

$$(1 - \tau_k)\widetilde{mpl}_t = \mu(\theta_t)\mathbb{E}_t[m_{t+1}g_{z,t+1}\tilde{J}_{n,t+1}], \quad (\text{G.44})$$

and wage setting:

$$\begin{aligned} & \phi_t(1 - \tau_k)(1 - \tau_n) \left(\widetilde{mpl}_t \left(1 + \frac{1-x}{\mu(\theta_t)} \right) - \tilde{w}_t \right) \\ = & (1 - \phi_t)(1 - \tau_k)(1 - \tau_n)\tilde{w}_t - (1 - \phi_t)(1 - \tau_k) \left(\frac{\tilde{c}_t - \tilde{h}_{t-1}\tilde{c}_{t-1}^a}{1 + (\sigma - 1)\gamma n_{t-1}} \right) \gamma \left(\sigma + (\sigma - 1) \frac{\tilde{h}_{t-1}\tilde{c}_{t-1}^a}{c_t - \tilde{h}_{t-1}\tilde{c}_{t-1}^a} \right) \\ & + (1 - x - f_t(\theta_t))\mathbb{E} \left[\frac{1 - \phi_t}{1 - \phi_{t+1}} m_{t+1}\phi_{t+1}(1 - \tau_n)g_z\tilde{J}_{n,t+1} \right], \end{aligned} \quad (\text{G.45})$$

where $\tilde{h}_{t-1} = \hat{h}_{t-1}/g_{z,t}$ incorporates trend growth. Specifically, in equilibrium with $n_{t-2}^a = n_{t-2}$:

$$\tilde{h}_{t-1} = \frac{h}{g_{z,t}} \frac{1 + (\sigma - 1)\gamma n_{t-1}}{1 + (\sigma - 1)\gamma n_{t-2}}. \quad (\text{G.46})$$

Other equilibrium conditions are optimal utilization:

$$(\delta_1 + \delta_2(u_t - 1))q_t = (1 - \tau_k)\frac{mpk_t}{u_t}, \quad (\text{G.47})$$

optimal capital:

$$q_t = \mathbb{E}_t \left[m_{t+1} \left((1 - \tau_k)\widetilde{mpk}_{t+1} + \delta \frac{\tilde{k}_{t-1}}{g_{z,t}} + \left((1 - \delta(u_{t+1})) + \kappa\chi \left(\frac{\tilde{i}_{t+1}}{\tilde{k}_t} g_{z,t+1} \right)^2 \left(\frac{\tilde{i}_{t+1}}{\tilde{k}_t} g_{z,t+1} - \tilde{\delta} \right) \right) q_{t+1} \right) \right], \quad (\text{G.48})$$

optimal investment:

$$q_t = \left(\left(1 - \frac{1}{2}\kappa \left(\frac{\tilde{i}_t}{\tilde{k}_{t-1}} g_{z,t} - \tilde{\delta} \right)^2 \right) - \kappa \left(\frac{\tilde{i}_t}{\tilde{k}_{t-1}} g_{z,t} - \tilde{\delta} \right) \frac{\tilde{i}_t}{\tilde{k}_{t-1}} g_{z,t} \right)^{-1}, \quad (\text{G.49})$$

and the stochastic discount factor:

$$m_{t+1} = \beta_t g_{z,t+1}^{-\sigma} \left(\frac{\tilde{c}_t - \tilde{h}_{t-1}\tilde{c}_{t-1}^a}{\tilde{c}_{t+1} - \tilde{h}_t\tilde{c}_t^a} \frac{1 + (\sigma - 1)\gamma n_t}{1 + (\sigma - 1)\gamma n_{t-1}} \right)^\sigma. \quad (\text{G.50})$$

Equations (G.40) to (G.50) determine:

1. Detrended capital \tilde{k}_t from equation (G.40).
2. Detrended consumption \tilde{c}_t from the resource constraint (G.41).
3. Detrended firm value \tilde{J} from the Bellman equation (G.42).
4. Detrended marginal value of employment \tilde{J}_n from the envelope condition (G.43).
5. Recruiting intensity ν_t from equation (G.44).

6. Detrended wages \tilde{w}_t from the Nash bargaining equation (G.45).
7. The utilization rate u_t from the utilization equation (G.47).
8. The shadow price of capital q_t from the capital equation (G.48).
9. Detrended investment \tilde{i}_t from the investment equation (G.49).
10. The stochastic discount factor m_{t+1} from equation (G.50).

In addition, the following variables and equations matter:

11. Employment n_t is determined from equation (G.28).
12. Market tightness θ_t (or the number of recruiters) from equation (G.39).

And, for completeness, we add a few definitions:

13. The (detrended) marginal product of capital \widetilde{mpk}_t from equation (G.37).
14. The (detrended) marginal product of labor \widetilde{mpl}_t from equation (G.38).
15. Final goods production \tilde{y}_t

$$\tilde{y}_t \equiv \left(\alpha^{1/\varepsilon} (u_t \tilde{k}_{t-1} g_{z,t}^{-1})^{1/\varepsilon} + (1 - \alpha)^{1/\varepsilon} (\tilde{z}_t n_{t-1} (1 - \nu_t))^{1-1/\varepsilon} \right)^{\frac{\varepsilon}{\varepsilon-1}}. \quad (\text{G.51})$$

16. GDP including recruiting services $\widetilde{y}r_t$ from equation (G.52):

$$\widetilde{y}r_t \equiv \left(\alpha^{1/\varepsilon} (u_t \tilde{k}_{t-1} g_{z,t}^{-1})^{1/\varepsilon} + (1 - \alpha)^{1/\varepsilon} (\tilde{z}_t n_{t-1} (1 - \nu_t))^{1-1/\varepsilon} \right)^{\frac{\varepsilon}{\varepsilon-1}} + n_{t-1} \nu_t \tilde{w}_t. \quad (\text{G.52})$$

17. The gross capital share cs_t from equation (G.53):

$$cs_t \equiv 1 - \frac{n_{t-1} w_t}{\widetilde{y}r_t}. \quad (\text{G.53})$$

18. The net capital share ncs_t from equation (G.54):

$$ncs_t \equiv 1 - \frac{n_{t-1} w_t}{\widetilde{y}r_t} - \delta_t \frac{\tilde{k}_{t-1}}{\widetilde{y}r_t g_{z,t}}. \quad (\text{G.54})$$

In this version of the model, there are three exogenous processes:

19. Bargaining power

$$\log \phi_t = (1 - \rho_\phi) \log(\bar{\phi}) + \rho_\phi \log \phi_{t-1} + \epsilon_{\phi,t}. \quad (\text{G.55})$$

20. Stationary labor productivity

$$\log z_t = (1 - \rho_z) \log(\bar{z}) + \rho_z \log z_{t-1} + \epsilon_{z,t}. \quad (\text{G.56})$$

21. Permanent labor productivity

$$\log(g_{z,t}) = \log(g_z) + \epsilon_{p,t}. \quad (\text{G.57})$$

G.7 Balanced growth path and data matching

Along the balanced growth path, the discount factor becomes:

$$\bar{m} = \beta g_z^{-\sigma} \quad (\text{G.58})$$

and the number of recruiters is given from (G.59):

$$\bar{\nu}\bar{n} = \bar{\theta}(1 - \bar{n}) \quad \Leftrightarrow \quad \bar{n} - \bar{\nu}\bar{n} = \bar{n} - \bar{\theta}(1 - \bar{n}). \quad (\text{G.59})$$

In an initial calibration, we can normalize capacity utilization to be 1 along the balanced growth path to get:

$$\bar{u} = 1 \quad (\text{G.60})$$

$$\delta_1 = (1 - \tau_k)\overline{mpk}. \quad (\text{G.61})$$

If δ_1 is given, rather than calibrated, utilization solves:

$$(\delta_1 + \delta_2(\bar{u}))\bar{q} = (1 - \tau_k)\frac{\overline{mpk}}{\bar{u}}. \quad (\text{G.62})$$

Clearly, if $\bar{u} = \bar{u} = 1$, equation (G.61) holds.

The balanced growth path optimality condition for capital can be written as:

$$\begin{aligned} 1 &= \bar{m} \left((1 - \tau_k)\overline{mpk} + (1 - (1 - \tau_k)\delta(\bar{u}))\bar{q} + \kappa \left(\frac{\bar{i}}{\bar{k}/g_z} \right)^2 \left(\frac{\bar{i}}{\bar{k}/g_z} - \tilde{\delta} \right) \bar{q} \right) \\ \Leftrightarrow \frac{\bar{q}/\bar{m} - (1 - (1 - \tau_k)\delta(\bar{u})) - \kappa \left(\frac{\bar{i}}{\bar{k}/g_z} \right)^2 \left(\frac{\bar{i}}{\bar{k}} - \tilde{\delta} \right)}{1 - \tau_k} &= \overline{mpk}. \end{aligned} \quad (\text{G.63})$$

If $\bar{u} = 1$ holds, the marginal product of capital does not depend on adjustment costs in the steady state.

Investment along the balanced growth path is given by:

$$\bar{i} = \frac{(g_z - (1 - \delta(\bar{u})))\bar{k}}{1 - \frac{1}{2}\kappa \left(\frac{\bar{i}}{\bar{k}/g_z} - \tilde{\delta} \right)^2 g_z}, \quad (\text{G.64})$$

where $\tilde{\delta} \equiv 1 - \frac{1}{1 - \delta_0}g_z$.

The steady-state price of capital is given by:

$$\bar{q} = \frac{1}{1 - \frac{1}{2} \left(\frac{\bar{i}}{\bar{k}/g_z} - \tilde{\delta} \right)^2 - \left(\frac{\bar{i}}{\bar{k}/g_z} \right)^2 \left(\frac{\bar{i}}{\bar{k}/g_z} - \tilde{\delta} \right)}. \quad (\text{G.65})$$

If we cannot calibrate the adjustment costs in investment and utilization, then $\frac{\bar{i}}{\bar{k}/g_z}$, \bar{u} , \bar{q} , and \overline{mpk} are jointly determined by equations (G.62), (G.63), (G.68), and (G.65). If $\bar{q} = \bar{u} = 1$, then $\frac{\bar{i}}{\bar{k}/g_z}$ and \overline{mpk} are available in closed form.

Using the recruiting optimality condition (G.44), the wage equation (G.45) becomes:

$$\begin{aligned} & \bar{\phi}(1 - \tau_k)(1 - \tau_n) \left(\widetilde{mpl}_t \left(1 + \frac{1 - x}{\mu(\bar{\theta})} \right) - \bar{w} \right) \\ &= (1 - \bar{\phi})(1 - \tau_k)(1 - \tau_n) \bar{w} - (1 - \bar{\phi})(1 - \tau_k) \left(\frac{\bar{c}(1 - \tilde{h})}{1 + (\sigma - 1)\gamma\bar{n}} \right) \gamma \left(\sigma + (\sigma - 1) \frac{\tilde{h}}{1 - \tilde{h}} \right) \\ & \quad + \frac{1 - x - f(\bar{\theta})}{\mu(\bar{\theta})} \bar{\phi}(1 - \tau_k) \widetilde{mpl}_t. \end{aligned}$$

Because $1 - \tau_k$ cancels and using that $f(\theta_t) \equiv \theta_t \mu(\theta_t) = \xi \theta^{\eta-1}$.

$$(1 - \tau_n) \bar{w} = \bar{\phi}(1 - \tau_n) \widetilde{mpl} (1 + \bar{\theta}) + (1 - \bar{\phi}) \left(\frac{\bar{c}(1 - \tilde{h})}{1 + (\sigma - 1)\gamma\bar{n}} \right) \sigma \left(\gamma + (\sigma - 1) \frac{\tilde{h}}{1 - \tilde{h}} \right).$$

Thus, after detrending there are two equivalent useful expressions:

$$\begin{aligned} \bar{w} &= \bar{\phi} \overline{mpl} (1 + \bar{\theta}) + \frac{1 - \bar{\phi}}{1 - \tau_n} \left(\frac{\bar{c}(1 - \tilde{h})}{1 + (\sigma - 1)\gamma\bar{n}} \right) \gamma \left(\sigma + (\sigma - 1) \frac{\tilde{h}}{1 - \tilde{h}} \right) \\ &= \bar{\phi} \overline{mpl} (1 + \bar{\theta}) + \frac{1 - \bar{\phi}}{1 - \tau_n} \left(\frac{\bar{c}}{1 + (\sigma - 1)\gamma\bar{n}} \right) \gamma (\sigma - \tilde{h}) \end{aligned} \quad (\text{G.66a})$$

$$\gamma \equiv \frac{RHS}{1 - (\sigma - 1)\bar{n} \times RHS}, \quad RHS \equiv \frac{1 - \tau_n}{(1 - \bar{\phi})\bar{c}(\sigma - \tilde{h})} (\bar{w} - \bar{\phi} \overline{mpl} (1 + \bar{\theta})), \quad (\text{G.66b})$$

where the marginal product of labor along the balanced growth path is given by:

$$\overline{mpl} = \left((1 - \alpha) \frac{\bar{y}}{\bar{n} - \bar{\theta}(1 - \bar{n})} \right)^{1/\varepsilon}.$$

Note that we can rewrite the definition of \overline{mpk} as:

$$\frac{\bar{k}}{g_z} = \bar{n}(1 - \bar{\nu}) \left(\left(\frac{\alpha}{1 - \alpha} \right)^{1/\varepsilon} \left(\frac{(\overline{mpk}/\bar{u})^{\varepsilon-1}}{\alpha} - 1 \right) \right)^{-\frac{\varepsilon}{\varepsilon-1}} \xrightarrow{\varepsilon \rightarrow 1} \bar{n}(1 - \bar{\nu}) \frac{\alpha}{1 - \alpha} (\overline{mpk}/\bar{u})^{-\frac{1}{1-\alpha}}.$$

This expression is useful to express output in terms of \overline{mpk} and employment. Recall the expression for detrended production net of recruiting services:

$$\begin{aligned} \bar{y} &= \left(\alpha^{1/\varepsilon} (u_t \tilde{k}_{t-1} g_z^{-1})^{1/\varepsilon} + (1 - \alpha)^{1/\varepsilon} (\tilde{z}_t n_{t-1} (1 - \nu_t))^{1-1/\varepsilon} \right)^{\frac{\varepsilon}{\varepsilon-1}} \Leftrightarrow \\ \bar{y} &= \frac{(\overline{mpk})^\varepsilon \bar{k}}{\alpha g_z} \bar{u}^{1-\varepsilon} = \bar{n}(1 - \bar{\nu}) \frac{(\overline{mpk}/\bar{u})^\varepsilon}{\alpha} \left(\left(\frac{\alpha}{1 - \alpha} \right)^{1/\varepsilon} \left(\frac{\overline{mpk}^{\varepsilon-1}}{\alpha} - 1 \right) \right)^{-\frac{\varepsilon}{\varepsilon-1}} \\ & \xrightarrow{\varepsilon \rightarrow 1} \bar{n}(1 - \bar{\nu}) (\overline{mpk}/\bar{u})^{-\frac{\alpha}{1-\alpha}} \frac{\alpha}{1 - \alpha}. \end{aligned} \quad (\text{G.67})$$

The law of motion for capital gives us:

$$\frac{\bar{c}}{\bar{y}} = 1 - \left(1 - \frac{1 - \delta_0}{g_z} \right) \frac{\bar{k}}{\bar{y} g_z} = 1 - \left(1 - \frac{1 - \delta_0}{g_z} \right) \frac{\bar{k} g_z}{\bar{y} g_z} \frac{\alpha}{\overline{mpk}^\varepsilon} \bar{u}^{\varepsilon-1}. \quad (\text{G.68})$$

The law of motion for employment implies:

$$\bar{n} = \frac{f(\bar{\theta})}{x + f(\bar{\theta})}. \quad (\text{G.69})$$

If we combine equation (G.17) with (G.18):

$$\bar{w} = \overline{mpl} \left(1 - \frac{1 - (1 - x)\bar{m}g_z}{\bar{m}g_z\mu(\bar{\theta})} \right). \quad (\text{G.70})$$

Per definition:

$$\mu(\bar{\theta}) = \frac{f(\bar{\theta})}{\bar{\theta}} = \xi\theta^{\eta-1}.$$

In general, we have the following unknowns and equations:

1. Employment \bar{n} from the law of motion (G.69).
2. Capital \bar{k} from the first-order condition (G.63).
3. Investment from the capital law of motion (G.68).
4. Capacity utilization follows from equation (G.60) when δ_1 is calibrated or, more generally, from (G.62).
5. The derivative of capacity utilization along the balanced growth path δ_1 from equation (G.61).
6. The price of capital follows from equation (G.65).
7. Consumption \bar{c} from the resource constraint (G.68).
8. Wages \bar{w} from wage setting (G.66).
9. Number of recruiters $\bar{n}\bar{\nu}$ from the definition of market tightness (G.59).
10. The stochastic discount factor \bar{m} from no arbitrage (G.58).
11. Production \bar{y} per definition (G.67).
12. Market tightness $\bar{\theta}$ from the recruiting optimality condition (G.70).

In our calibration, we set the production function parameters as follows:

- Capital share: $\alpha = (\text{NIPA capital share})^\varepsilon \left(\frac{\bar{y}\bar{g}}{\bar{k}} \right)^{1-\varepsilon}$.
- Average depreciation rate: $\delta_0 = \frac{\text{NIPA depreciation}}{\bar{y}\bar{g}} \times \frac{\bar{y}\bar{g}}{\bar{k}}$.
- Rate of time preference: $\bar{\beta} = \bar{g}_z^\sigma \left(1 - \delta_0(1 - \tau_k) + (1 - \tau_k) \left(\alpha \frac{\bar{k}}{\bar{y}\bar{g}_z} \right)^{1/\varepsilon} \right)^{-1}$.

We can also fix \bar{n} and choose γ :

1. Preference for leisure γ given n from wage setting (G.66b).

2. Tightness $\bar{\theta}$ from the law of motion (G.69)

$$\bar{\theta} = \left(\frac{\bar{n}x}{\xi \times (1 - \bar{n})} \right)^{1/\eta}. \quad (\text{G.69}')$$

3. Capital-to-production ratio $\frac{\bar{k}}{\bar{y}g}$ from the first-order condition (G.63).

4. Investment-to-production ratio from the law of motion of capital (G.68).

5. Capacity utilization follows from equation (G.60) when δ_1 is calibrated or, more generally, from (G.62).

6. The derivative of capacity utilization along the balanced growth path δ_1 from equation (G.61).

7. The price of capital follows from equation (G.65).

8. Consumption-to-production ratio $\frac{\bar{c}}{\bar{y}}$ from the resource constraint (G.68).

9. Wages to production $\frac{\bar{w}}{\bar{y}}$ from the recruiting optimality condition (G.70).

10. Number of recruiters $\bar{n}\bar{\nu}$ from the definition of market tightness (G.59).

11. The stochastic discount factor \bar{m} from equation (G.58).

12. Production \bar{y} per definition (G.67).

In addition, six definitions and the three exogenous processes follow directly from the detrended economy.

G.8 U.S. business cycle data

To map observations into variables in the model we proceed as follows. First, we compute consumption as the sum of real services and non-durable consumption, divided by the civilian non-institutionalized population above 16. Specifically:

$$C_t = \frac{\frac{\text{DSERRA3Q086SBEA}_t}{\text{DSERRA3Q086SBEA in 2009}} \times \text{PCESVC96 in 2009} + \frac{\text{DGOERA3Q086SBEA}_t}{\text{DGOERA3Q086SBEA in 2009}} \times \text{PCNDGC96 in 2009}}{\text{CN16OV}_t}.$$

We multiply the base year (2009 average) value of the real consumption expenditure by the corresponding quantity index to obtain dollar amounts for longer horizons, i.e., before 1999.

We compute investment as the sum of consumer durables and gross private domestic investment, divided by the civilian non-institutionalized population above 16. Specifically:

$$I_t = \frac{\text{GPDIC96}_t + \frac{\text{DDURRA3Q086SBEA}_t}{\text{DDURRA3Q086SBEA in 2009}} \times \text{PCDGCC96 in 2009}}{\text{CN16OV}_t}.$$

Real GDP per capita is defined as the sum of real per capita investment and consumption:

$$Y_t = C_t + I_t.$$

G.9 Introducing product market power

An interesting extension of the model is to introduce market power for firms. To do so, we need to differentiate among firms. There is a representative final goods producing firm that produces aggregate output \bar{y}_t as a CES aggregate of intermediate goods $y_t(i)$ with elasticity $\zeta > 1$:

$$\bar{y}_t = \left(\int_0^1 y_t(i)^{1-1/\zeta} di \right) \frac{\zeta}{\zeta - 1}. \quad (\text{G.71})$$

Let $p_t(i)$ denote the price of each individual variety and \bar{p}_t the optimal aggregate price index. Standard cost minimization for the representative final goods firm then implies demand for variety i is given by:

$$y_t(i) = \bar{y}_t \left(\frac{p_t(i)}{\bar{p}_t} \right)^{-\zeta}. \quad (\text{G.72})$$

Each variety is produced according to the following production function:

$$\begin{aligned} y_t(i) &= \left(\alpha^{1/\varepsilon} (u_t(i) k_{t-1}(i))^{1-1/\varepsilon} + (1 - \alpha)^{1/\varepsilon} (z_t n_{t-1}(i) (1 - \nu_t(i)))^{1-1/\varepsilon} \right)^{\frac{\varepsilon}{\varepsilon - 1}} - \Phi_t \\ &\equiv \psi(u_t(i) k_{t-1}(i), z_t n_{t-1}(i) (1 - \nu_t(i)); \Phi_t), \end{aligned} \quad (\text{G.73})$$

where $\Phi_t \geq 0$ is the fixed cost of operating. Along the balanced growth path, it grows at the rate of labor productivity.

The intermediate goods producing firm takes its demand schedule (G.72) into account and has revenues of $p_t(i) \left(\frac{p_t(i)}{\bar{p}_t} \right)^{-\zeta} \bar{y}_t$. Equivalently, revenue as a function of quantities becomes:

$$\bar{p}_t y_t(i)^{1-1/\zeta} \bar{y}_t^{-1/\zeta}.$$

In a symmetric equilibrium, each firm sets the same price so that $\bar{y}_t = y_t(i)$ and $\bar{p}_t = p_t(i)$ for all i . We choose the final good as the numeraire in the period.

With market power, as firms consider employing an extra worker or unit of capital, they take into account that the marginal revenue product is smaller than the marginal product. Importantly, the functional form for the match surplus $\tilde{J}_n(n, k)$ is unchanged but, as (G.18') shows, the marginal value of employment that enters into it reflects the lower marginal revenue product.

To see this, note that now the following optimality condition holds for recruiting:

$$(1 - \tau_k) (1 - 1/\zeta) z_t \underbrace{\left((1 - \alpha) \frac{Y_t}{z_t n_{t-1} (1 - \nu_t)} \right)^{\frac{1}{\varepsilon}}}_{\equiv mrpl_t} = \mu(\theta_t) \mathbb{E}[m_{t+1} J_n(n_t, k_t)]. \quad (\text{G.17}')$$

Thus, the marginal value of employment is given by:

$$\begin{aligned} J_n(n_{t-1}, k_{t-1}) &= (1 - \tau_k) (mrpl_t \times (1 - \nu_t) - w_t) + (\nu_t \mu(\theta_t) + 1 - x) \mathbb{E}[m_{t+1} J_n(n_t, k_t)] \\ &= (1 - \tau_k) \left(mrpl_t \left(1 + \frac{1 - x}{\mu(\theta_t)} \right) - w_t \right), \end{aligned} \quad (\text{G.18}')$$

using equation (G.17') to substitute for $\mathbb{E}[m_{t+1} J_n(n_t, k_t)]$.

The optimality condition for the utilization rate becomes:

$$\begin{aligned} \delta'(u_t)q_t k_{t-1} &= (\delta_1 + \delta_2(u_t - 1))q_t k_{t-1} = (1 - \tau_k)(1 - 1/\zeta) \left(\alpha \frac{y_t}{u_t k_{t-1}} \right)^{1/\varepsilon} k_{t-1} \\ &\equiv (1 - \tau_k) \frac{mrpk_t}{u_t}. \end{aligned} \quad (\text{G.20}')$$

The optimality condition for capital k' becomes:

$$q_t = \mathbb{E} \left[m_{t+1} \left(mrpk_{t+1}(1 - \tau_k) + \tau_k \bar{\delta} + \left((1 - \delta(u_{t+1})) + \chi \kappa \left(\frac{i_{t+1}}{k_t} \right)^2 \left(\frac{i_{t+1}}{k_t} - \tilde{\delta} \right) \right) q_{t+1} \right) \right]. \quad (\text{G.22}')$$

The marginal revenue product of physical capital is:

$$mrpk_{t+1} \equiv u_{t+1}(1 - 1/\zeta) \left(\alpha \frac{y_{t+1}}{u_{t+1} k_t} \right)^{\frac{1}{\varepsilon}}. \quad (\text{G.23}')$$

Market power also has an impact on the calibration. Monopolistic competition is an extra source of profits in the economy: In the detrended economy, the flow profit is \bar{y}/ζ along the balanced growth path. We consider two variants for calibrating the model with market power that keep the aggregate capital share in the economy unchanged:

1. No fixed cost, lower capital share in production. Here, we set the fixed cost of production Φ_t to zero. Then, we calibrate ζ and adjust α so that the gross capital share in the economy is unchanged. Specifically, we target a capital share in production of $1 - (1 - 0.31)(1 - 1/\zeta)^{-1/\varepsilon}$.
2. Fixed cost, same capital share in production. Here, we set the detrended fixed cost of production equal to the share of profits from monopolistic competition: $\tilde{\Phi}_t = \bar{y}/\zeta$.

G.10 Identification: Additional relationships

Recall that we use three moments to pin down three parameters: ω_z , ω_ϕ , and κ/δ_0^2 . In the main text, we show the three bivariate plots that show the important interaction terms among these three parameters. For completeness, we show here in Figure G.14 the additional bivariate plots. It is clear from this figure that the required standard deviations vary little with the adjustment cost and the adjustment cost depends little on ω_ϕ .

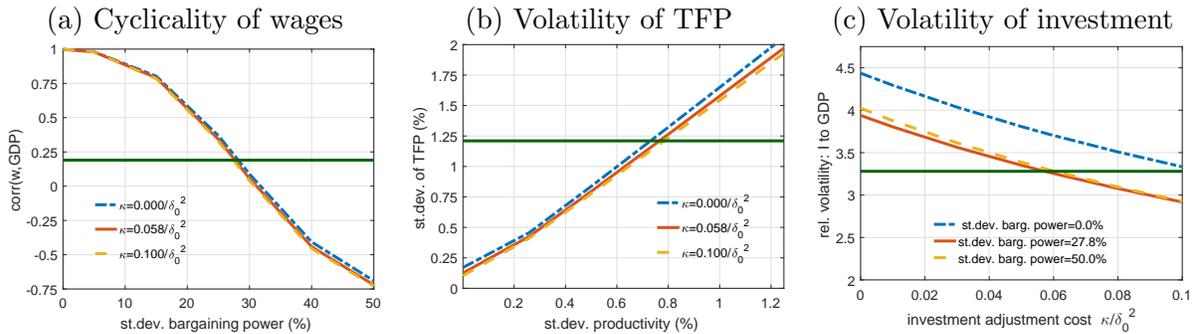


Figure G.14: Identifying ω_z , ω_ϕ , and κ/δ_0^2 . Additional relationships.

G.11 Euler equation errors

Our model has two Euler equations: (1) The recruiting optimality condition (G.44) and (2) the capital optimality condition (G.48). We transform the Euler equation error to consumption units. To do so, take an Euler equation with a generic return R_{t+1}^i . Following Fernandez-Villaverde and Rubio-Ramirez (2006), the Euler equation error in state s_t is:

$$EE(s_t) = \left| 1 - \frac{u_c^{-1} \left(\mathbb{E}_t \left[\beta_t g_z^{-\sigma} u_c(c(s_{t+1}); n(s_{t+1})) R_{t+1}^i(s_{t+1}) \right]; n(s_t) \right) \right|}{c(s_t)}. \quad (\text{G.74})$$

Here:

$$\begin{aligned} R_{t+1}^v &= \left(1 - \tau_k \widetilde{mpl}_t \right)^{-1} \mu(\theta_t) g_{z,t+1} \tilde{J}_{n,t+1} \\ R_{t+1}^k &= q_t^{-1} \left(\widetilde{mpk}_{t+1} (1 - \tau_k) + \bar{\delta} \tau_k + \left((1 - \delta(u_{t+1})) + \chi_{t+1} \left(\frac{\tilde{I}_{t+1}}{\tilde{k}_t} g_{z,t+1} \right)^2 \left(\frac{\tilde{I}_{t+1}}{\tilde{k}_t} g_{z,t+1} - \bar{\delta} \right) \right) \right) q_{t+1} \\ u_c^{-1}(\tilde{u}_c; n) &= \tilde{u}_c^{-\frac{1}{\sigma}} \times (1 + (\sigma - 1)\gamma n). \end{aligned}$$

The difficulty in our setup is that, because of the pruning, the state in terms of the endogenous observables is not uniquely defined: Any given level of capital can be reached by different combinations of the first-, second-, and third-order components of the solution. Thus, as in Andreasen et al. (2017), we resort to Monte Carlo integration (with a burn-in of 1,000 simulations). The pseudo-code below outlines the algorithm.

Pseudo-code for Monte Carlo integration

1. Simulate the model for 6,000 periods.
2. Discard the first 1,000 periods and save the remaining 5,000 draws for the state s_t as $\{s_t^{(\ell)}\}_\ell$.
3. For $\ell = 1, \dots, 5,000$:
 - (a) $s_t^{(\ell)}$, compute the vector of current policies and stack it with the state vector: $s_t^{+,(\ell)}$.
 - (b) For $m = 1, \dots, 1,000$:
 - i. Draw $\epsilon_{t+1}^{(m)} \sim \mathcal{N}(0, I)$.
 - ii. Compute $s_t^{+,(\ell,m)} = f(s_t^{(ell)}, \epsilon_{t+1}^{(m)})$,
 - (c) Average over d :

$$EE(s_t^{(\ell)}) = \left| 1 - \frac{u_c^{-1} \left(1,000^{-1} \sum_{m=1}^{1,000} \left(\beta_t^{(\ell)} g_z^{-\sigma} u_c \left(c_{t+1}^{(\ell,m)} \right); n_{t+1}^{(\ell,m)} \right) R_{t+1}^i(s_t^{(\ell,m)}) \right); n(s_t^{(\ell)}) \right|}{c(s_t^{(\ell)})}$$

4. Compute moments of $EE(s_t)$.

We find that the implied Euler equation errors are reasonably small for both the capital and recruiting Euler equations. Table G.5(a) reports the mean of the Euler equation errors for both

Euler equations along with their distribution. The average Euler equation error is below 10^{-2} , implying that agents would pay less than 1% of their period consumption to avoid the approximation error. The 99th percentile of approximation is only slightly above 1%. This is only a bit worse than the real business cycle analogue of our search model, as panel (c) shows. Errors in the search and matching model without bargaining shocks in panel (b) are smaller than in the RBC model.

(a) Baseline search & matching model								
Euler Equation	Mean	Min	p1	p5	Median	p95	p99	Max
Capital EE	-3.12	-7.67	-5.58	-4.98	-3.86	-2.42	-2.03	-1.56
Recruiting EE	-2.67	-6.38	-4.48	-3.84	-2.79	-2.25	-1.97	-1.55

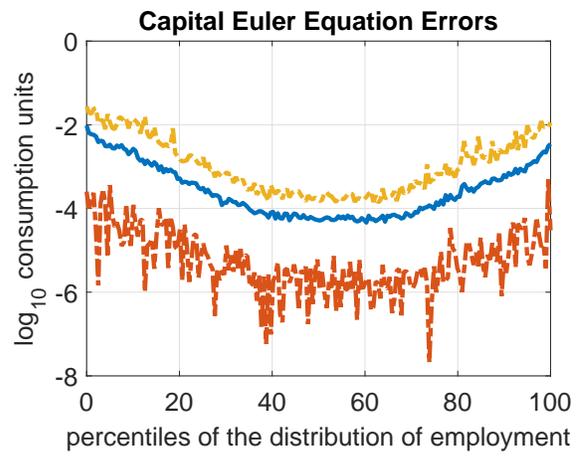
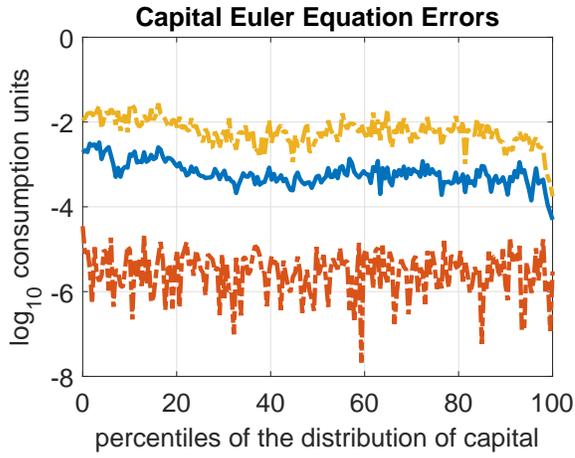
(b) Search & matching model without bargaining shocks								
Euler Equation	Mean	Min	p1	p5	Median	p95	p99	Max
Capital EE	-4.35	-8.87	-6.16	-5.49	-4.42	-3.97	-3.84	-3.64
Recruiting EE	-3.70	-8.04	-5.47	-4.83	-3.78	-3.29	-3.14	-2.87

(c) Hansen-Rogerson RBC model								
Euler Equation	Mean	Min	p1	p5	Median	p95	p99	Max
Capital EE	-4.04	-8.41	-6.05	-5.34	-4.29	-3.52	-3.08	-2.53
Labor supply EE	-3.37	-7.51	-5.58	-4.86	-3.76	-2.77	-2.39	-1.86

Table G.5: Euler equation errors: Mean and distribution.

Figure G.15 shows the mean, minimum, and maximum Euler equation errors also as a function of the endogenous state of the economy, i.e., capital and employment. The errors are largely independent of the value of capital or employment, except for some extreme values of employment (although, even in this case, they still average below 1% of consumption).

errors as a function of capital



errors as a function of employment

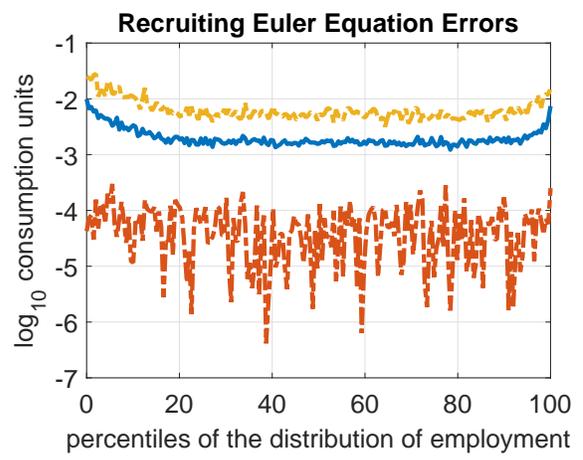
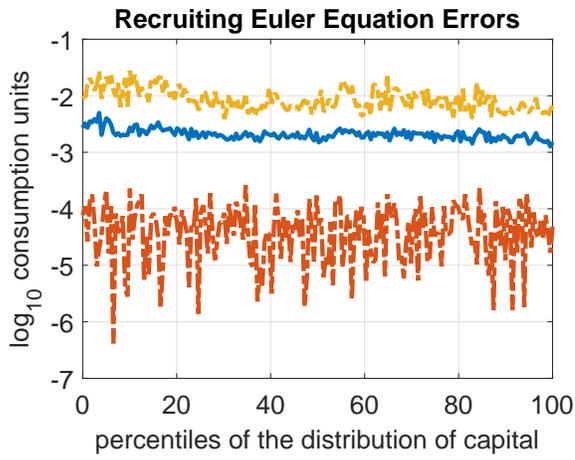


Figure G.15: Euler equation errors as a function of capital and employment: Mean, maximum, and minimum.

G.12 Partial filter for bargaining power

G.12.1 Derivation

We use three equations to derive the partial filter: (1) The wage-setting equation (G.25), (2) recruiting optimality condition (G.17), and (3) the marginal value of employment (G.18).

$$\begin{aligned} & \phi_t(1 - \tau_k)(1 - \tau_n) \left(mpl_t \left(1 + \frac{1 - x}{\mu(\theta_t)} \right) - w_t \right) \\ = & (1 - \phi_t)(1 - \tau_k)(1 - \tau_n)w_t - (1 - \phi_t)(1 - \tau_k) \left(\frac{c_t - \hat{h}_{t-1}c_{t-1}^a}{1 + (\sigma - 1)\gamma n_{t-1}} \right) \gamma \left(\sigma + (\sigma - 1) \frac{\hat{h}_{t-1}c_{t-1}^a}{c_t - \hat{h}_{t-1}c_{t-1}^a} \right) \\ & + (1 - \tau_n)(1 - x - f_t(\theta_t)) \mathbb{E}_t \left[\frac{1 - \phi_t}{1 - \phi_{t+1}} \phi_{t+1} m_{t+1} J_{n,t+1} \right], \end{aligned} \quad (\text{G.25})$$

$$(1 - \tau_k) z_t \underbrace{\left((1 - \alpha) \frac{Y_t}{z_t n_{t-1} (1 - \nu_t)} \right)^{\frac{1}{\varepsilon}}}_{\equiv mpl_t} = \mu(\theta_t) \mathbb{E}[m_{t+1} J_{n,t+1}], \quad (\text{G.17})$$

$$\begin{aligned} J_{n,t} &= (1 - \tau_k) (mpl_t \times (1 - \nu_t) - w_t) + (\nu_t \mu(\theta_t) + 1 - x) \mathbb{E}[m_{t+1} J_{n,t+1}] \\ &= (1 - \tau_k) \left(mpl_t \left(1 + \frac{1 - x}{\mu(\theta_t)} \right) - w_t \right). \end{aligned} \quad (\text{G.18})$$

In what follows, we ignore habit ($h = 0$). Then divide (G.25) by $1 - \phi_t$ and $1 - \tau_n$:

$$\begin{aligned} & \frac{\phi_t}{1 - \phi_t} (1 - \tau_k) \left(mpl_t \left(1 + \frac{1 - x}{\mu(\theta_t)} \right) - w_t \right) \\ = & (1 - \tau_k) w_t - \frac{1 - \tau_k}{1 - \tau_n} \left(\frac{c_t}{1 + (\sigma - 1)\gamma n_{t-1}} \right) \gamma \sigma + (1 - x - f_t(\theta_t)) \mathbb{E}_t \left[\frac{\phi_{t+1}}{1 - \phi_{t+1}} m_{t+1} J_{n,t+1} \right]. \end{aligned}$$

Next, re-write the expectation as a covariance and substitute from (G.18) for the expected discounted value of labor to the firm, $E_t[m_{t+1} J_{n,t+1}]$ and from (G.17) for the value of labor $J_{n,t+1}$.

$$\begin{aligned} & \mathbb{E}_t \left[\frac{\phi_{t+1}}{1 - \phi_{t+1}} m_{t+1} J_{n,t+1} \right] = \\ & \mathbb{E}_t \left[\frac{\phi_{t+1}}{1 - \phi_{t+1}} (m_{t+1} J_{n,t+1} - \mathbb{E}_t[m_{t+1} J_{n,t+1}]) \right] + \mathbb{E}_t \left[\frac{\phi_{t+1}}{1 - \phi_{t+1}} \right] \mathbb{E}_t[m_{t+1} J_{n,t+1}] \\ & = \text{Cov}_t \left[\frac{\phi_{t+1}}{1 - \phi_{t+1}}, (1 - \tau_k) m_{t+1} \left(mpl_{t+1} \left(1 + \frac{1 - x}{\mu(\theta_{t+1})} \right) - w_{t+1} \right) \right] + \\ & \quad \mathbb{E}_t \left[\frac{\phi_{t+1}}{1 - \phi_{t+1}} \right] (1 - \tau_k) \frac{mpl_t}{\mu(\theta_t)} \end{aligned} \quad (\text{G.75})$$

Note that, as in the main paper, we work with a transform of bargaining power $\ln \frac{\phi_t}{1 - \phi_t}$ that follows:

$$\ln \frac{\phi_t}{1 - \phi_t} = \underbrace{(1 - \rho_\phi) \ln \frac{\bar{\phi}}{1 - \bar{\phi}}}_{\equiv \kappa_\phi} + \rho_\phi \ln \frac{\phi_{t-1}}{1 - \phi_{t-1}} + \omega_\phi \epsilon_{\phi,t}. \quad (\text{G.76})$$

Next, use (G.75) and (G.76) in the surplus splitting rule and divide by $1 - \tau_k$:

$$\begin{aligned}
& e^{\ln \frac{\phi_t}{1-\phi_t}} \left(mpl_t \left(1 + \frac{1-x}{\mu(\theta_t)} \right) - w_t \right) \\
&= w_t - \frac{1}{1-\tau_n} \left(\frac{c_t}{1+(\sigma-1)\gamma n_{t-1}} \right) \gamma \sigma + e^{\kappa_\phi + \rho_\phi \ln \frac{\phi_t}{1-\phi_t}} (1-x-f_t(\theta_t)) \times \\
& \quad \times \left(\text{Cov}_t \left[e^{\omega_\phi \epsilon_{\phi,t+1}}, m_{t+1} \left(mpl_{t+1} \left(1 + \frac{1-x}{\mu(\theta_{t+1})} \right) - w_{t+1} \right) \right] + e^{\frac{1}{2}\omega_\phi^2} \frac{mpl_t}{\mu(\theta_t)} \right). \tag{G.77}
\end{aligned}$$

Now, we need only an estimate of the conditional covariance between $\frac{\phi_t}{1-\phi_t}$ and the discount firm surplus to back out the bargaining power. We propose to estimate a VAR to back out this covariance (this VAR could be time-varying; we will come back to this point below). We could either proceed with the VAR in levels of $\frac{\phi_{t+1}}{1-\phi_{t+1}}$ and $m_{t+1} \left(mpl_{t+1} \left(1 + \frac{1-x}{\mu(\theta_{t+1})} \right) - w_{t+1} \right)$, plus a vector of controls, and neglect the fact that $\frac{\phi_{t+1}}{1-\phi_{t+1}}$ is strictly positive. Alternatively, if joint (conditional) normality of all variables is a good approximation, (G.77) simplifies due to Stein's Lemma as follows:³²

$$\begin{aligned}
& \frac{\phi_t}{1-\phi_t} \left(mpl_t \left(1 + \frac{1-x}{\mu(\theta_t)} \right) - w_t \right) \\
&= w_t - \frac{1}{1-\tau_n} \left(\frac{c_t}{1+(\sigma-1)\gamma n_{t-1}} \right) \gamma \sigma \\
& \quad + (1-x-f_t(\theta_t)) \left(e^{\kappa_\phi + \rho_\phi \ln \frac{\phi_t}{1-\phi_t} + \frac{1}{2}\omega_\phi^2} \text{Cov}_t \left[\omega_\phi \epsilon_{\phi,t+1}, m_{t+1} \left(mpl_{t+1} \left(1 + \frac{1-x}{\mu(\theta_{t+1})} \right) - w_{t+1} \right) \right] \right. \\
& \quad \left. + e^{\kappa_\phi + \rho_\phi \ln \frac{\phi_t}{1-\phi_t} + \frac{1}{2}\omega_\phi^2} \frac{mpl_t}{\mu(\theta_t)} \right),
\end{aligned}$$

and after rearranging:

$$\begin{aligned}
& e^{\ln \frac{\phi_t}{1-\phi_t}} \left(mpl_t \left(1 + \frac{1-x}{\mu(\theta_t)} \right) - w_t \right) \\
& \quad - (1-x-f_t(\theta_t)) e^{\kappa_\phi + \rho_\phi \ln \frac{\phi_t}{1-\phi_t} + \frac{1}{2}\omega_\phi^2} \left(\text{Cov}_t \left[\omega_\phi \epsilon_{\phi,t+1}, m_{t+1} \left(mpl_{t+1} \left(1 + \frac{1-x}{\mu(\theta_{t+1})} \right) - w_{t+1} \right) \right] + \frac{mpl_t}{\mu(\theta_t)} \right) \\
&= w_t - \frac{1}{1-\tau_n} \left(\frac{c_t}{1+(\sigma-1)\gamma n_{t-1}} \right) \gamma \sigma \tag{G.78}
\end{aligned}$$

We can write the covariance term equivalently as $\text{Cov}_t \left[\omega_\phi \epsilon_{\phi,t+1}, m_{t+1} \left(mpl_{t+1} \left(1 + \frac{1-x}{\mu(\theta_{t+1})} \right) - w_{t+1} \right) \right]$ and as $\text{Cov}_t \left[\ln \frac{\phi_{t+1}}{1-\phi_{t+1}}, m_{t+1} \left(mpl_{t+1} \left(1 + \frac{1-x}{\mu(\theta_{t+1})} \right) - w_{t+1} \right) \right]$, because only $\omega_\phi \epsilon_{\phi,t+1}$ is a surprise to $\ln \frac{\phi_{t+1}}{1-\phi_{t+1}}$ given the time t information set. Below and in the main text we therefore write the covariance in terms of $\ln \frac{\phi_{t+1}}{1-\phi_{t+1}}$.

³² $\text{Cov}_t[g(X), Y] = \mathbb{E}_t[g'(X)]\text{Cov}_t[X, Y]$, where Y is the discounted match surplus, $X = \omega_\phi \epsilon_{\phi,t+1}$, $g(\circ) = \exp(\circ)$, and $\mathbb{E}_t[g'(X)] = e^{\frac{1}{2}\omega_\phi^2}$.

G.12.2 Sampler

We estimate a VAR(p) in X_t , where X_t includes $\left(\ln \frac{\phi_t}{1-\phi_t}\right)$ and the discounted firm surplus, and an AR(1) for $\left(\ln \frac{\phi_t}{1-\phi_t}\right)$ given an estimate of the bargaining power process. Given the parameter estimates, we back out the implied bargaining power process. Formally:

1. Initialize $\text{Cov}_t = 0$ and ρ_ϕ, ω_ϕ as calibrated in the model. Back out $\left(\ln \frac{\phi_t}{1-\phi_t}\right)^{(0)}$.
2. Estimate parameters:
 - (a) Set $X_t^{(d)} \equiv \left[\left(\ln \frac{\phi_t}{1-\phi_t}\right)^{(d-1)}, m_t \left(m_{pl_t} \left(1 + \frac{1-x}{\mu(\theta_t)} \right) - w_t \right), m_{pl_t}, \theta_t, w_t, c_t \right]$. Alternatively, use a VAR in just the first two variables.
 - (b) Draw $\Sigma^{(d)}$ from \mathcal{IW} using standard results for a Bayesian VAR with p lags: $X_t = \sum_{\ell=1}^p A_{\ell,t} X_{t-\ell} + B_t \epsilon_t$. Set $\text{Cov}_t^{(d)} = \Sigma^{(d)}(2, 1) \forall t$.
 - (c) Draw $\rho_\phi^{(d)}, \omega_\phi^{(d)}$ from the normal-gamma posterior for the AR(1) $\left(\ln \frac{\phi_t}{1-\phi_t}\right)^{(d-1)} = \mu^{(d)} + \rho_\phi^{(d)} \left(\ln \frac{\phi_{t-1}}{1-\phi_{t-1}}\right)^{(d-1)} + \omega_\phi^{(d)} \epsilon_{\phi,t}$.
3. Solve for $\left\{ \left(\ln \frac{\phi_t}{1-\phi_t}\right)^{(d)} \right\}_t$ given data and, $\text{Cov}_t^{(d)}, \omega_{\phi,t}^{(d)}, \rho_\phi^{(d)}$.
4. Iterate on Steps 2 and 3.
5. Discard the first third of the sample.

It would be conceptually appealing to allow for a time-varying parameter VAR to generate time-variation in the conditional covariances that may be generated from the non-linearities in our underlying model. As we explained in the main text, we find that the covariance term is so small that our results are unlikely to change much if we allowed for time-variation in parameters. As a check of overfit, we estimate a VAR just in $\left(\ln \frac{\phi_t}{1-\phi_t}\right)^{(d-1)}$ and $m_t \left(m_{pl_t} \left(1 + \frac{1-x}{\mu(\theta_t)} \right) - w_t \right)$. Results do not change noticeably.

G.12.3 Measurement

To implement our filter, we need data on: (1) The real wage, (2) the marginal product of labor, (3) labor market tightness, (4) the unemployment rate, and (5) consumption. The data sources are the same as for our main model, so we just discuss the mapping into model variables.

1. We use either raw consumption, real wages, and real GVA or first remove a log-linear trend.
2. We re-scale the average real-wage (an index) to the steady-state wage in the model.
3. We implement our model for the Cobb-Douglas case of the production function. Thus, the average product of labor is proportional to the marginal product of labor.³³ We consider two different measures:

³³Unfortunately, there is no easy way to differentiate in the data the marginal productivity of production workers (the object of interest in the model) from the marginal productivity of recruiters. Our prior is that the bias induced by considering the aggregate marginal productivity of both types of workers is negligible.

- Real GVA in the business sector divided by (1-unemployment) and re-scaled.
- Real GVA in the business sector population ratio instead of 1-unemployment.

We first re-scale the average marginal product of labor to the steady-state marginal product of labor in the model. Second, we shift the marginal product of labor up so that it lies weakly above the real wage.

4. We compute the monthly job finding rate implied by labor market tightness as $f_m(\theta_t)$. We then adjust the job finding rate and the separation rate x for the quarterly data frequency in the following way: The quarterly separation rate is $x_q = (1 + x_m/100)^3 - 1$. The quarterly job finding rate is $f_q = f_m + (1 - f_m)f_m + (1 - f_m)^2 f_m$. This neglects within-quarter separations.
5. Given the real-wage rate, the static component of the household surplus turns negative in the 1990s. We shift the average disutility of working up until the implied average bargaining power in the data [ignoring covariance terms] equals 0.5 as in the model.
6. When we use the employment-to-population ratio to compute labor productivity, we also use the employment-to-population ratio to compute the disutility from working. However, our model is calibrated to an average employment-to-participation ratio of 0.95. To avoid having the data counterpart to n_t in the model exceed unity, we re-scale the employment-to-participation ratio so that it averages 0.95 and has the same range (max – min) as the unemployment rate.

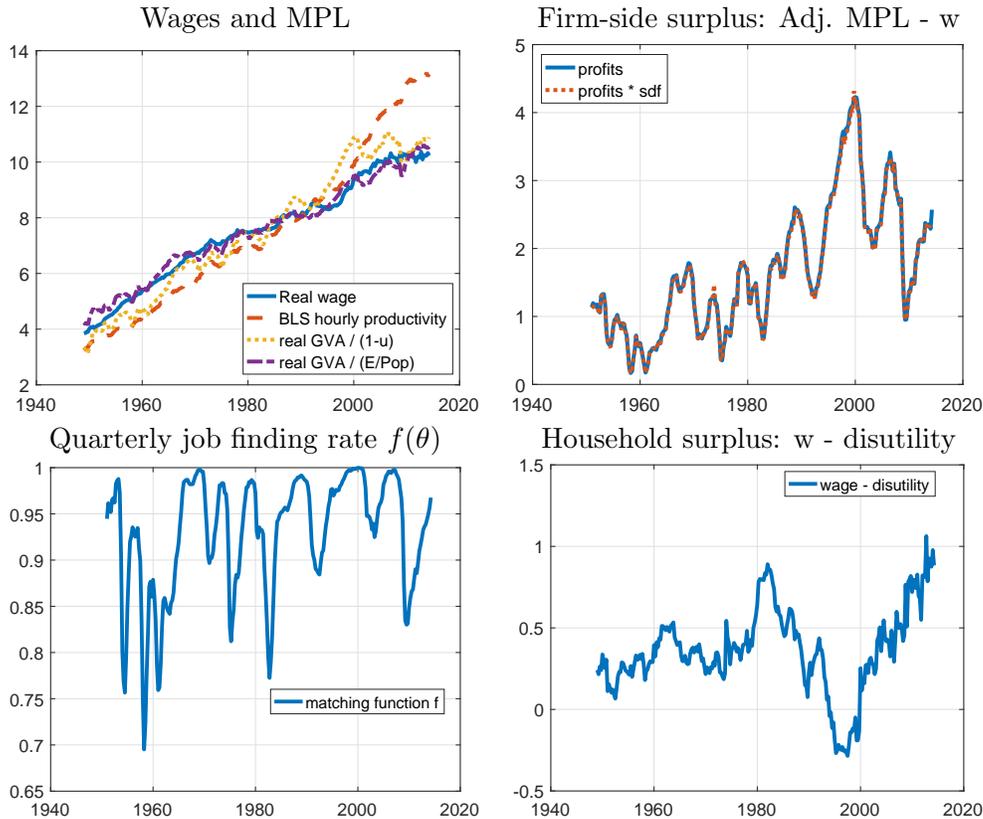


Figure G.16: Variables entering the filter

G.12.4 New hire wages

Since the wages of new hires are much more procyclical than the wages of continuing workers, [Pissarides \(2009\)](#) argues that wage rigidity à la [Hall \(2005\)](#) or [Gertler and Trigari \(2009\)](#) is unlikely to be a realistic way to make unemployment more volatile in search and matching models of the labor market. Given that all wages adjust every period in our model, wage stickiness is irrelevant in our setup. However, the cyclicality of real wages is a central calibration target and may affect our historical estimates.

As a robustness check, we consider a measure of the wage of new hires. Specifically, we use median hourly wages in the private sector from [Haefke et al. \(2013\)](#), extended by the Federal Reserve Bank of Philadelphia.³⁴ This series begins in 1979.Q1. The left panel of Figure G.17 shows the change in the real wages from [Haefke et al. \(2013\)](#) and the updated series for when they overlap. The correlation is very high at 0.85. The right panel of Figure G.17 plots the nominal series. We splice the nominal series together by adjusting the updated series down in the last quarter for which we have data from [Haefke et al. \(2013\)](#). We deflate the series with the PCE deflator.

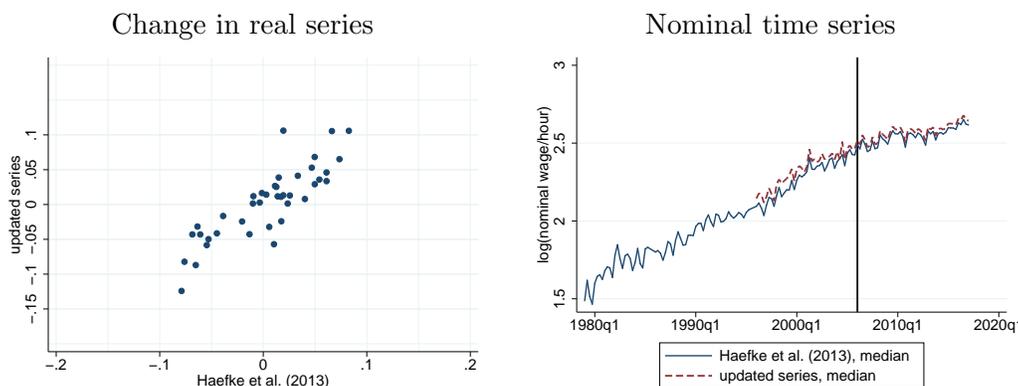


Figure G.17: Bargaining power process implied by the baseline calibration: Baseline wage measure and new hire wage

Once we HP-filter this series, we find that the wage of new hires is as acyclical with respect to GDP (constructed, on a model-consistent basis, as the sum of real consumption and investment), similar to the composition-adjusted employment cost index, which we also consider; see Table G.6.³⁵ Our finding is in line with [Gertler et al. \(2016\)](#). These authors report that wages of new hires from unemployment are no more procyclical than aggregate wages, based on SIPP data, once they control for match quality. Our finding differs somewhat from [Haefke et al. \(2013\)](#), who document that their measure of composition-adjusted real wage growth of new hires correlates much more strongly with labor productivity growth than the analogous hourly wage for all workers. While we replicate these authors' results (which are subject to large sample uncertainty) with their sample period, we find that the cyclicality of new wages and continuing wages is close in the extended sample. [Haefke et al. \(2013\)](#) exclude the early Volcker years (up to the end of 1983) from their baseline analysis and their sample ends in 2006.Q1. In that sample but with new productivity data, we find a point estimate (t -statistics) of 0.56 (1.08) for the new hire wage, relative to 0.40 (3.79) for the overall wage rate and 0.41 (3.49) for the BLS wage rate. Adding the three observations raises the coefficient on the

³⁴We are grateful to Paul van Vliet for sharing his data.

³⁵Note that, in Table G.6, we change the length of the sample of aggregate variables in each row to make it consistent with the corresponding wage sample. That is why the statistics of these aggregate variables slightly vary across rows.

BLS wage to 0.46 (3.84) and lowers it to 0.46 (0.86) for the new hire wage. Adding the 1983 and earlier years yields similar results.

Table G.6: Business cycle statistics: Different wage measures and samples

	Volatility							
	Y [%]	$\frac{\text{std(I)}}{\text{std(Y)}}$	$\frac{\text{std(C)}}{\text{std(Y)}}$	std(ncs) [pp.]	std(cs) [pp.]	std(w) [%]	std(u) [%]	std(TFP) [%]
Baseline wage & sample	1.99	3.28	0.58	1.07	0.86	0.95	0.83	1.21
ECI wage & sample	1.77	3.06	0.47	0.94	0.72	0.48	0.77	0.96
New hire wage & sample	1.87	2.93	0.52	0.95	0.73	2.76	0.76	0.98
	Cyclicalilty							
	Y	I	C	ncs	cs	w	u	TFP
Baseline wage & sample	1.00	0.91	0.84	0.57	0.36	0.19	-0.76	0.78
ECI wage & sample	1.00	0.95	0.81	0.46	0.21	-0.25	-0.85	0.68
New hire wage & sample	1.00	0.95	0.83	0.50	0.28	-0.26	-0.81	0.71
	Persistence							
	Y	I	C	ncs	cs	w	u	TFP
Baseline wage & sample	0.87	0.82	0.78	0.76	0.74	0.67	0.90	0.78
ECI wage & sample	0.89	0.86	0.76	0.78	0.74	0.78	0.93	0.79
New hire wage & sample	0.90	0.87	0.82	0.79	0.74	0.16	0.93	0.80

Note: Quarterly data, HP-filtered with smoothing parameter $\lambda = 1,600$.

Given that our series for new wages has acyclicity properties similar to those of the other measures of wages, it is not a surprise that our backed-out bargaining power is not materially affected. Figure G.18 compares the implied bargaining power. While the bargaining power implied by the new hire wage data is noisier (the new wage data, based on survey data, are themselves noisier), it closely mimics our baseline measure. Both backed-out bargaining power series have a high degree of comovement and identify similar peaks and troughs. The levels of the series are not comparable, because we calibrate the bargaining power to average 0.5 over the entire available sample, but not over the sub-sample shown for our baseline measure.

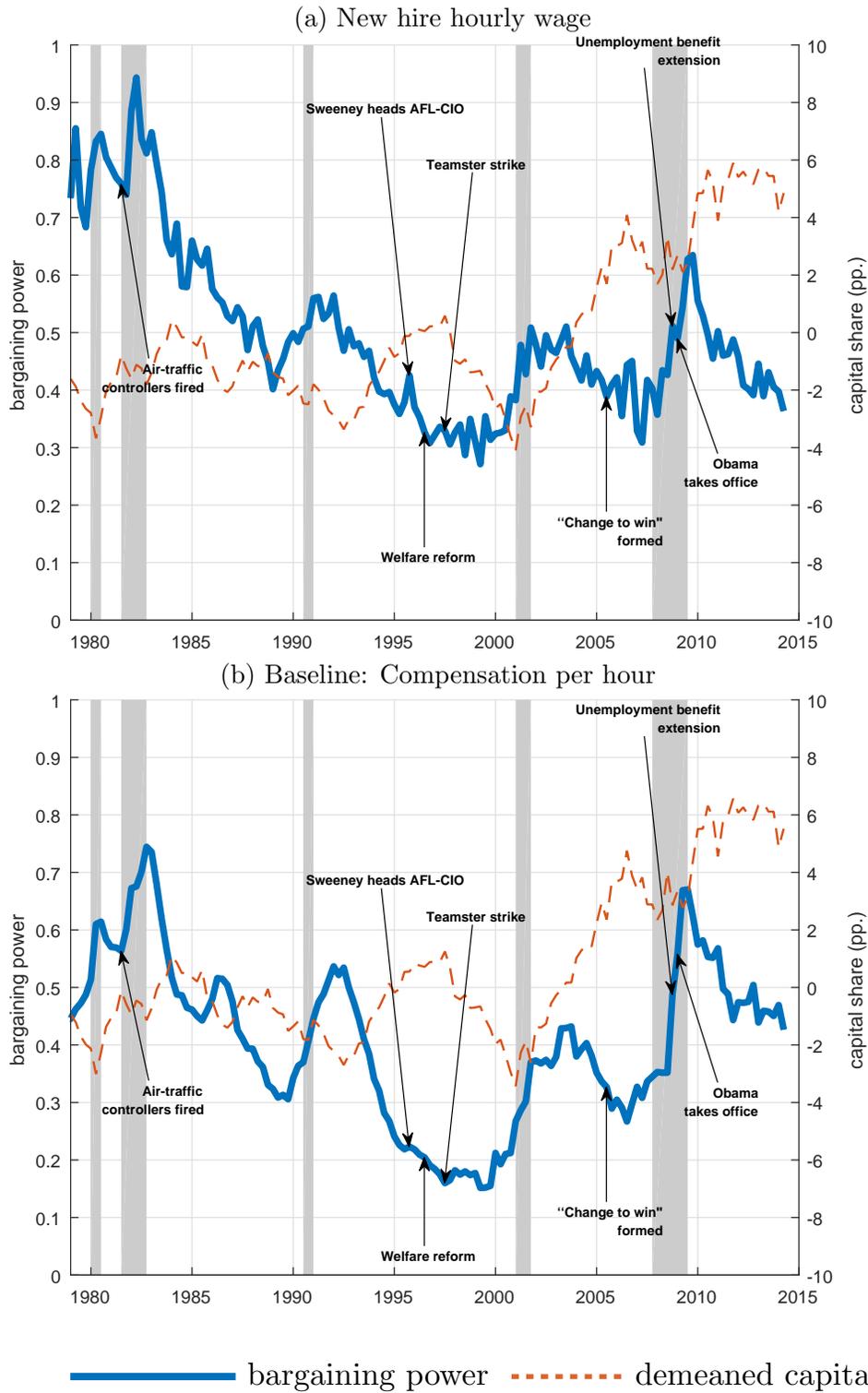


Figure G.18: Bargaining power process implied by the baseline calibration: Baseline wage measure and new hire wage

G.12.5 Additional results

When we use an alternative measure of labor productivity or detrend non-stationary variables prior to filtering, we find only small changes in the implied moments: See Table G.7(a) to (c).

Table G.7: Implied bargaining power process moments

(a) Productivity based on complement of the unemployment rate, log-linear detrending

	Median	5th percentile	95th percentile
In-sample autocorrelation	0.9568	0.9567	0.9569
Posterior autocorrelation	0.9560	0.9269	0.9834
In-sample AR(1) st.dev.	0.1728	0.1727	0.1729
Posterior AR(1) st.dev.	0.1719	0.1610	0.1850
In-sample $\text{Cov}_t[o]$	0.0013	0.0013	0.0013
Posterior $\text{Cov}_t[o]$	0.0015	0.0008	0.0023
In-sample average bargaining power	0.4992	0.4991	0.4993

(b) Productivity based on employment-to-population ratio, no detrending

	Median	5th percentile	95th percentile
In-sample autocorrelation	0.9483	0.9482	0.9485
Posterior autocorrelation	0.9474	0.9157	0.9774
In-sample AR(1) st.dev.	0.1424	0.1423	0.1426
Posterior AR(1) st.dev.	0.1417	0.1326	0.1525
In-sample $\text{Cov}_t[o]$	0.0008	0.0008	0.0008
Posterior $\text{Cov}_t[o]$	0.0009	0.0005	0.0014
In-sample average bargaining power	0.4992	0.4991	0.4994

(c) Productivity based on employment-to-population ratio, log-linear detrending

	Median	5th percentile	95th percentile
In-sample autocorrelation	0.9662	0.9662	0.9662
Posterior autocorrelation	0.9655	0.9414	0.9881
In-sample AR(1) st.dev.	0.1173	0.1173	0.1174
Posterior AR(1) st.dev.	0.1167	0.1093	0.1256
In-sample $\text{Cov}_t[o]$	0.0015	0.0015	0.0015
Posterior $\text{Cov}_t[o]$	0.0017	0.0011	0.0023
In-sample average bargaining power	0.4993	0.4993	0.4994

G.12.6 A comparison with an alternative bargaining power index

Levy and Temin (2007) propose to measure bargaining power as the inverse of the real unit labor cost. They call this measure the “bargaining power index.” We compute their measure for our longer sample as the real hourly compensation divided by the real hourly output, both measured in the non-farm business sector.³⁶ This measure exhibits a pronounced downward trend, perhaps due to changes in the underlying industry or occupation mix. To compare our measures, we remove a quadratic trend from (the log of) their measure and do the same for our measure. Figure G.19 shows the resulting time series. Despite the very different methodological approaches, the two series move together. The overall correlation between the detrended series is 0.42. They track each other particularly well from the beginning of our sample period to the mid-1970s and again during the 2000s.

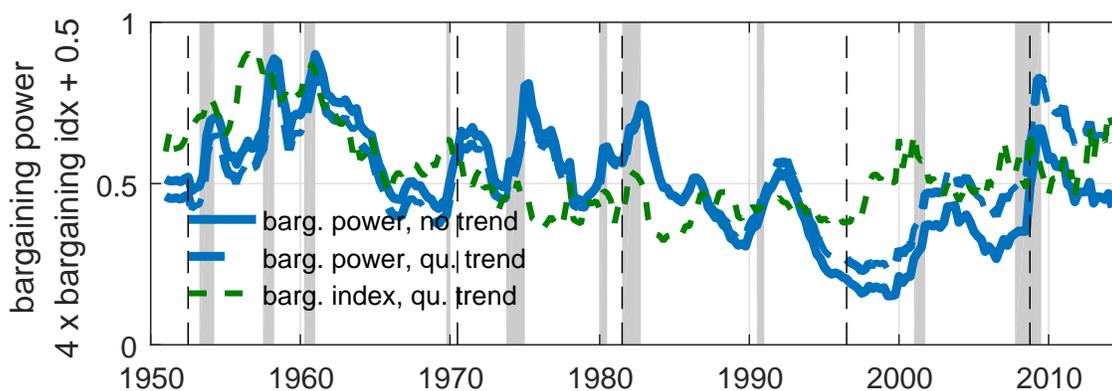


Figure G.19: Filtered bargaining power and Levy and Temin (2007) bargaining index

Quarterly changes in our filtered bargaining power tend to move with the changes in (log of) the Levy and Temin (2007) bargaining index, as Figure G.20 shows. The overall correlation is 0.45, and both measures pick up on the increased bargaining power due to the extension of unemployment benefits in late 2008 and the reversal during several periods after the Great Recession. While both measures may contain measurement error, it is reassuring that the 10 lowest and highest changes in our bargaining power index also tend to be classified as such in the bargaining power index. The figure dates these data points, and their correlation is 0.69.

We have also argued in the main text that increases in the real minimum wage resemble increases in bargaining power, as pointed out by Flinn (2006). Figure G.21 plots the real minimum wage alongside our bargaining power – the real federal minimum wage (green solid line) and the real effective minimum wage, that is, the population-weighted average of the maximum of the state and federal minimum wage. Overall, the correlation between the real federal minimum wage and our bargaining power is a low 0.18. However, from 1974 on, when the federal minimum wage is unified and has the broadest coverage, the correlation is 0.57. For most of the period since 1974, we also have data on state minimum wages from Autor et al. (2016) and the correlation with the effective minimum wage is 0.48. Given that our filtered bargaining power was high before 1974 and the minimum wage was less broadly applicable, we view this evidence as consistent with the notion that our bargaining power index reflects redistributive measures such as the minimum wage when bargaining power is low.

³⁶Levy and Temin (2007) use the median, not the mean compensation. We prefer the mean because, due to demographic changes, who the median worker is has noticeably changed over the last few decades.

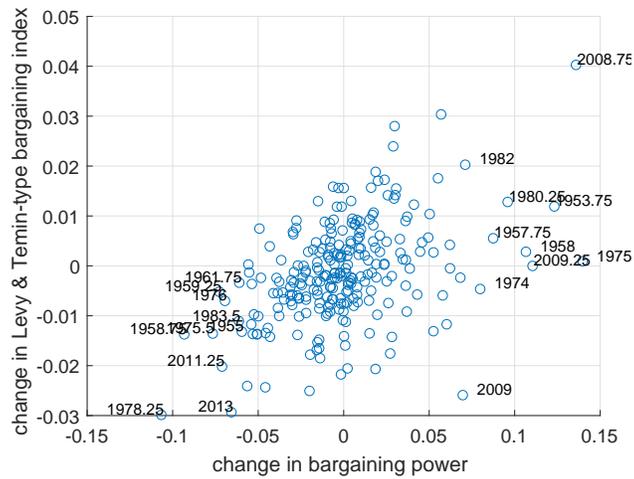
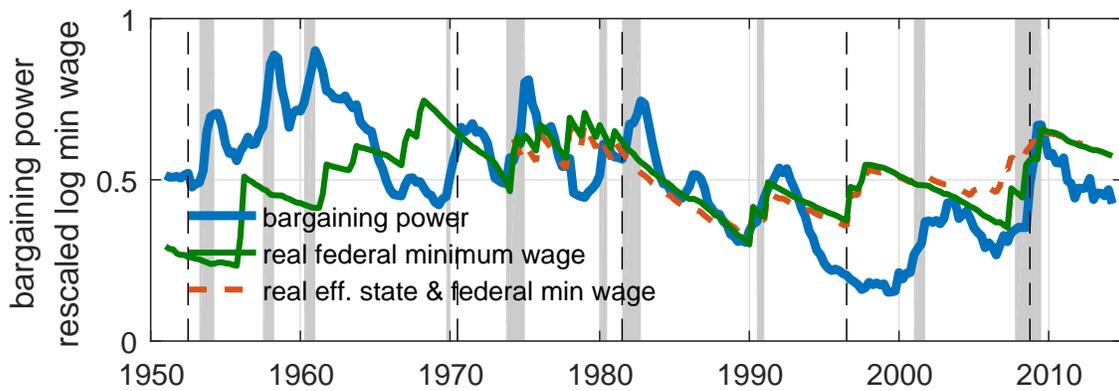


Figure G.20: Change in filtered bargaining power and [Levy and Temin \(2007\)](#) bargaining index



We demean the log real minimum wage measures, divide them by 100, and re-center them at 0.5 to ease the comparison.

Figure G.21: Filtered bargaining power and real minimum wage measures

G.12.7 Counterfactual unemployment

Our final exercise in this subsection is to filter the historical bargaining power with our calibrated stochastic process. Specifically, we set $\epsilon_{\phi,1} = \omega_{\phi}^{-1} \left(\tilde{\phi}_1 - (1 - \rho_{\phi}) \log \frac{\tilde{\phi}}{1-\tilde{\phi}} \right)$ and for subsequent observations $\epsilon_{\phi,1} = \omega_{\phi}^{-1} \left(\tilde{\phi}_t - \rho_{\phi} \tilde{\phi}_{t-1} - (1 - \rho_{\phi}) \log \frac{\tilde{\phi}}{1-\tilde{\phi}} \right)$.

With this series, we can compute the implied unemployment rate coming out of our model. More concretely, for each realization of the bargaining power shock, we take one draw of the labor productivity shock from its distribution and compute the difference to a world with bargaining power shocks set to zero, but the same productivity shocks. Figure G.22 displays the result for the unemployment rate. We also plot the simulated level of bargaining power to confirm that our procedure is consistent.

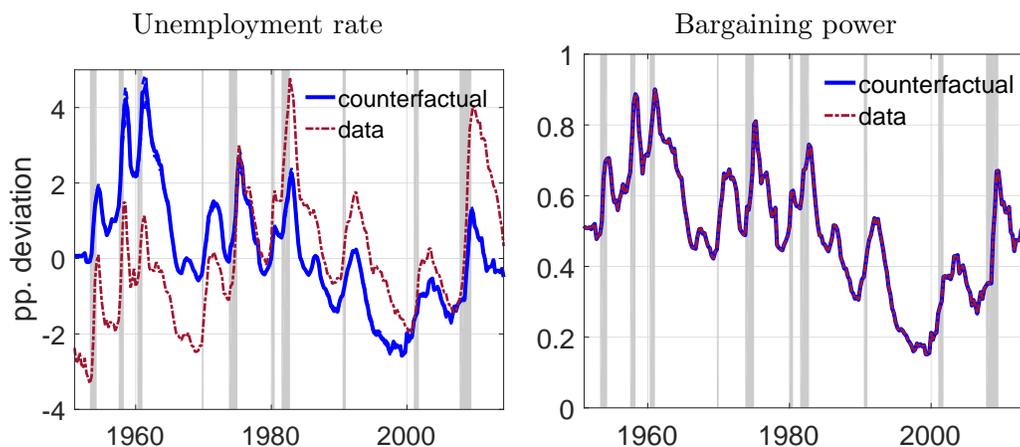


Figure G.22: Historical counterfactuals implied by bargaining power process

The bargaining power shock explains just short of 30% of the historical fluctuations in the unemployment rate. Its correlation with the historical unemployment rate is 0.32, and its relative standard deviation is 0.91. Multiplying these two numbers gives a share of the explained variance of 0.29.³⁷

³⁷The correlation is $\frac{\text{Cov}[x,y]}{\text{Var}[x]^{1/2} \text{Var}[y]^{1/2}}$. Multiplying this correlation by the ratio of standard deviations gives the covariance relative to the variance. Because the variance is, up to a first order, the sum of the variance due to bargaining shocks and the remainder due to all other shocks, the reported measure is the historical variance accounted for by the bargaining power shock.

G.13 Search and matching model: All IRFs

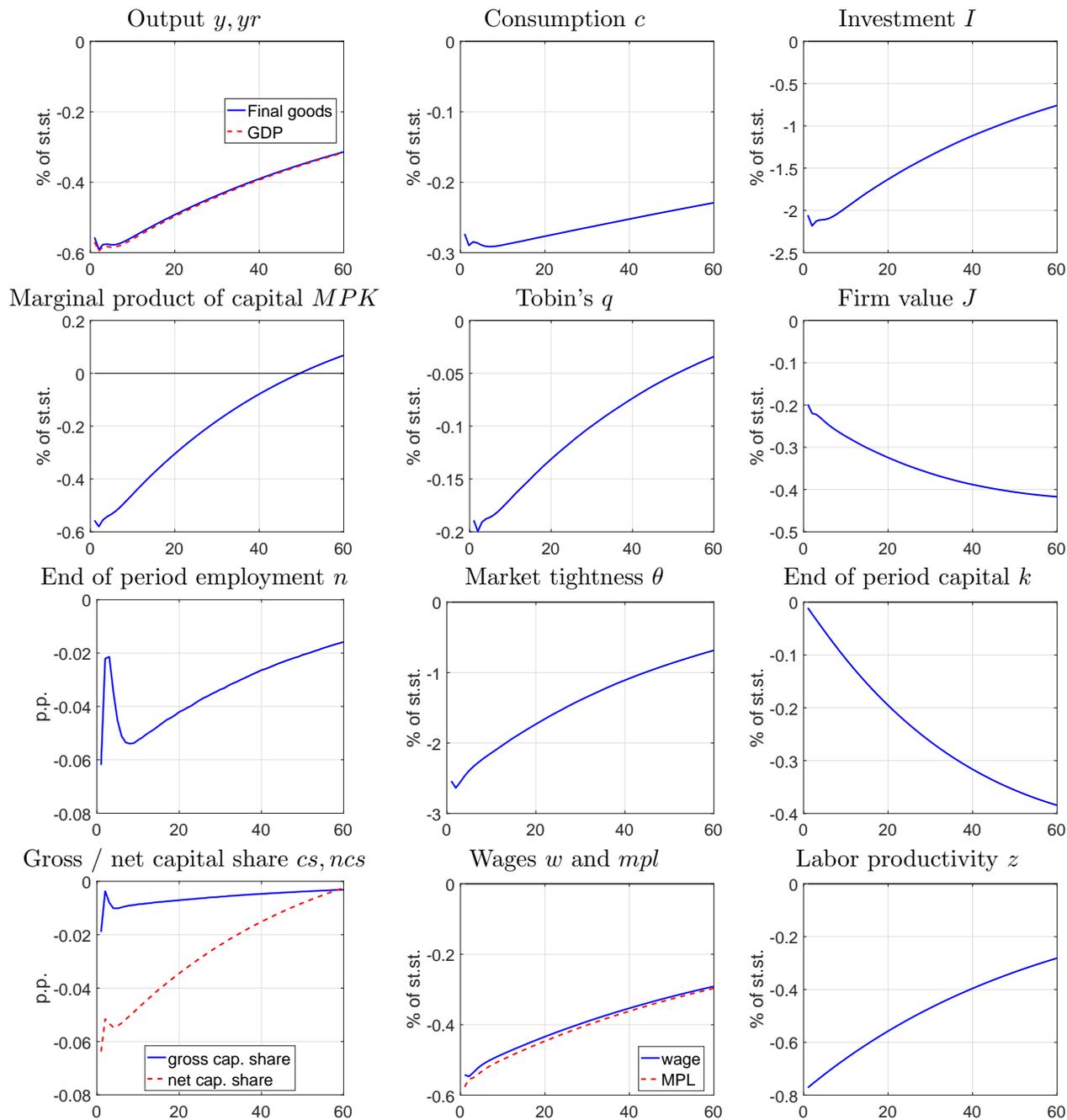


Figure G.23: IRFs to a negative one standard deviation shock to labor productivity with Cobb-Douglas technology.

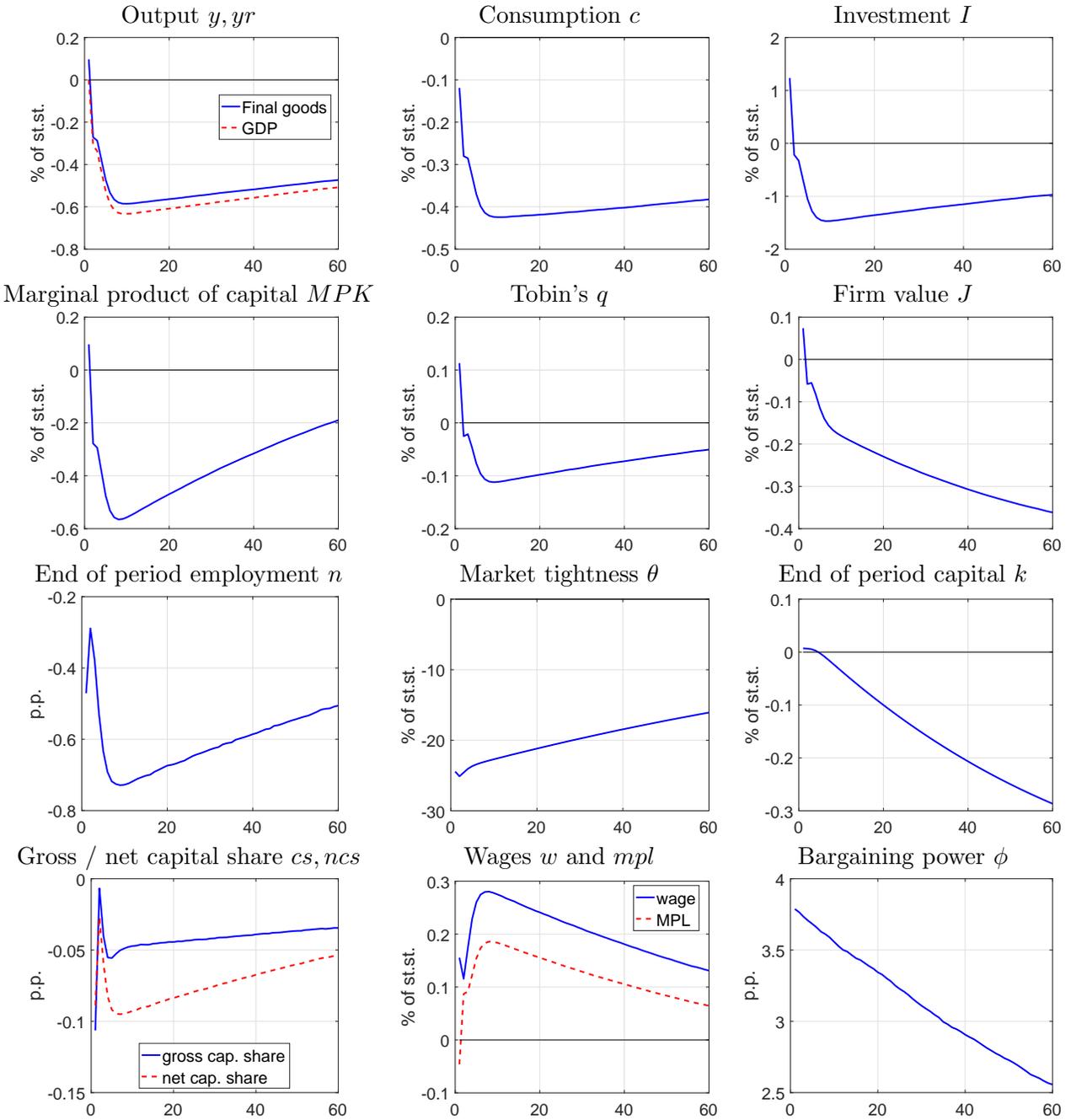


Figure G.24: IRFs to a one standard deviation shock to workers' bargaining power with Cobb-Douglas technology.

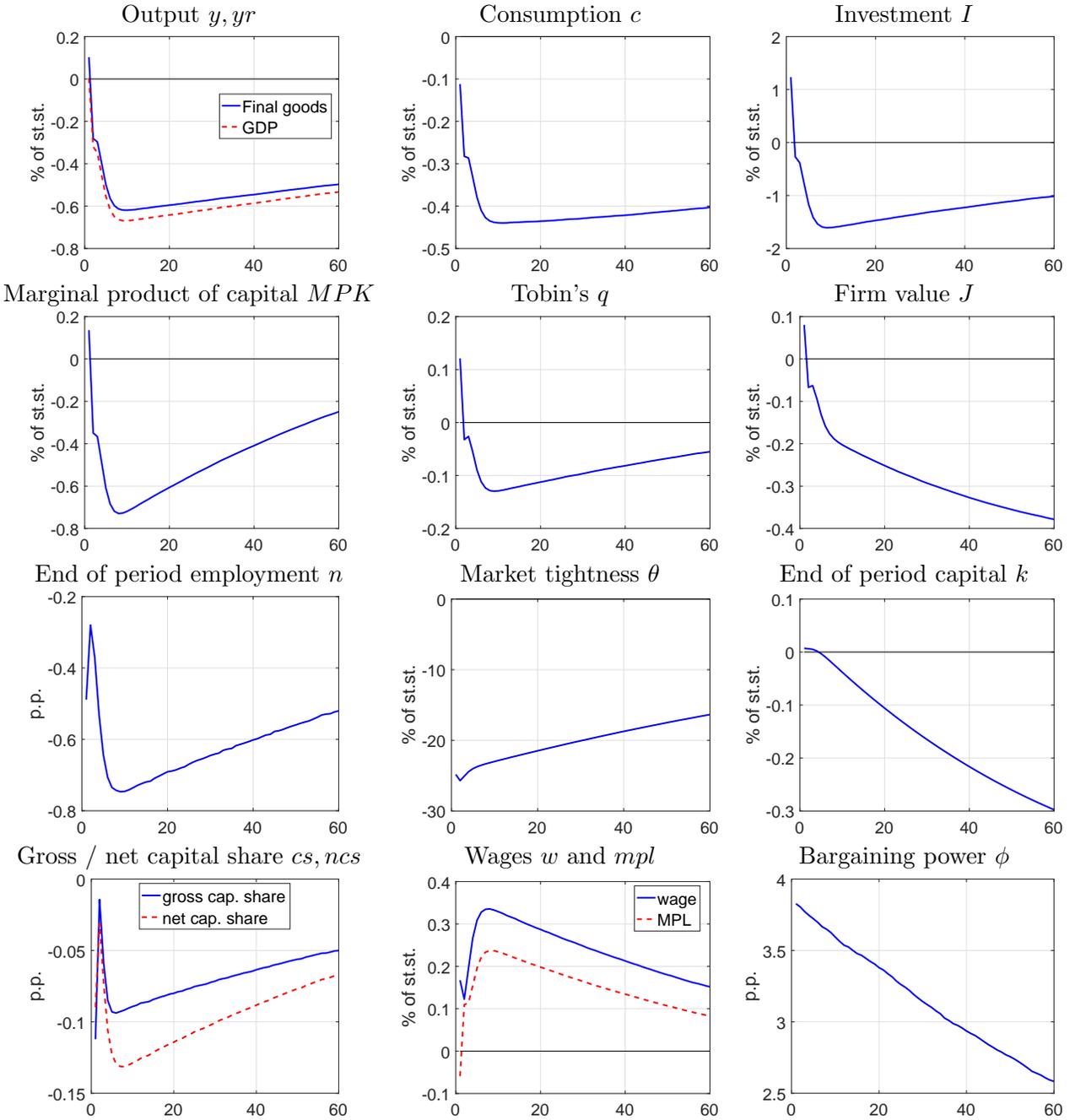


Figure G.25: IRFs to a one standard deviation shock to workers' bargaining power with CES $\varepsilon = 0.75$.

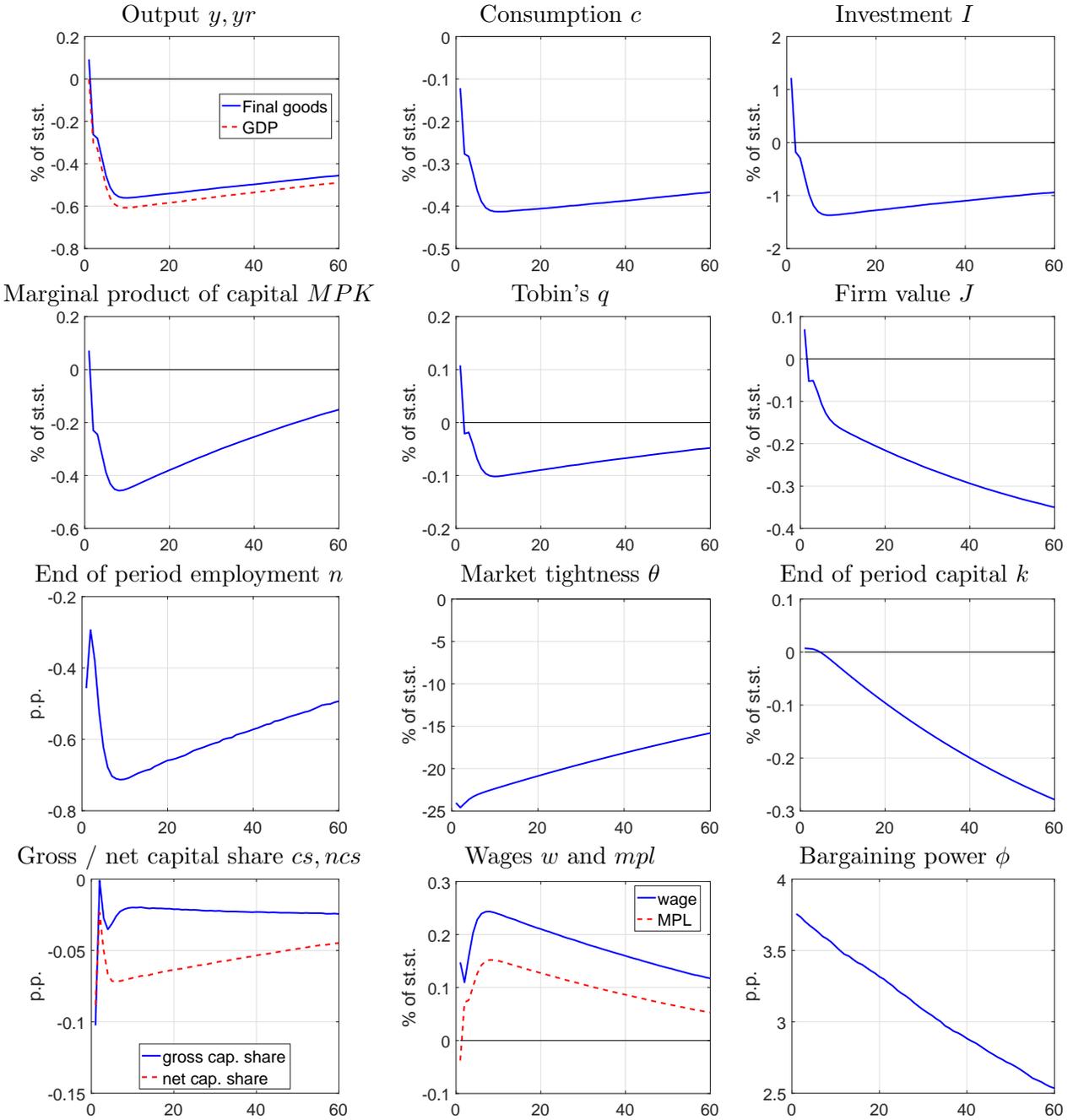


Figure G.26: IRFs to a one standard deviation shock to workers' bargaining power with CES $\varepsilon = 1.25$.

G.14 IRF comparison: Search and matching vs. RBC model

We benchmark our model against a real business cycle analogue to our economy. Since our baseline model features indivisible labor, its real business cycle analogue is closest to Hansen (1985) and Rogerson (1988). In keeping with our timing convention, however, labor is also hired and paid one period in advance. Also, employed and unemployed agents have the same consumption and hence the period utility function is simply:

$$U_t = \frac{(c_t - hc_{t-1}^a)^{1-\sigma} - 1}{1-\sigma} - \gamma n_{t-1}.$$

Compared to the solution of the search model, this implies the following changes:

- The detrended habit function $\tilde{h}(\cdot)$ in (G.46) is constant at $\tilde{h} = hg_z^{-\frac{1}{1-\alpha}}$.
- The law of motion for employment (G.6) drops out as well as the recruiting optimality condition (G.17) – the fraction of recruiters ν_t and labor market tightness θ_t are not defined.
- There are alternative ways of setting wages that allow us to retain the assumption that labor is set one period in advance. We pick a structure where labor supply is predetermined:
 - The equation (G.43) for the marginal value of employment J_n is replaced by

$$\widetilde{mpl}_t - w_t = 0.$$

In words, the wage rate equals the marginal product of labor state by state – keeping the labor share of income constant with a Cobb-Douglas production function.

- The wage-setting equation (G.66a) is replaced by an indifference condition for the household:

$$\mathbb{E}_t \left[m_{t+1} g^{\frac{1}{1-\alpha}} \left((1 - \tau_n) w_t - \sigma \gamma \frac{c_{t+1} - h\bar{c}_t}{1 + (\sigma - 1)\gamma n_t} \right) \right] = 0.$$

Households choose labor supply one period in advance so that, on expectation, they are indifferent between leisure and work.

We can then compare the responses to the common productivity shock, using the same deep parameters that we calibrated for our baseline model – except that we also recalibrate γ to make sure the employment levels in both models are the same.

We show the comparison of IRFs from this model and our baseline model in Figures G.27 (for unitary elasticity of substitution) and G.28 (for $\epsilon = 0.75$). Finally, in Figure G.30, we show the comparison of IRFs with the RBC model with factor share shocks.

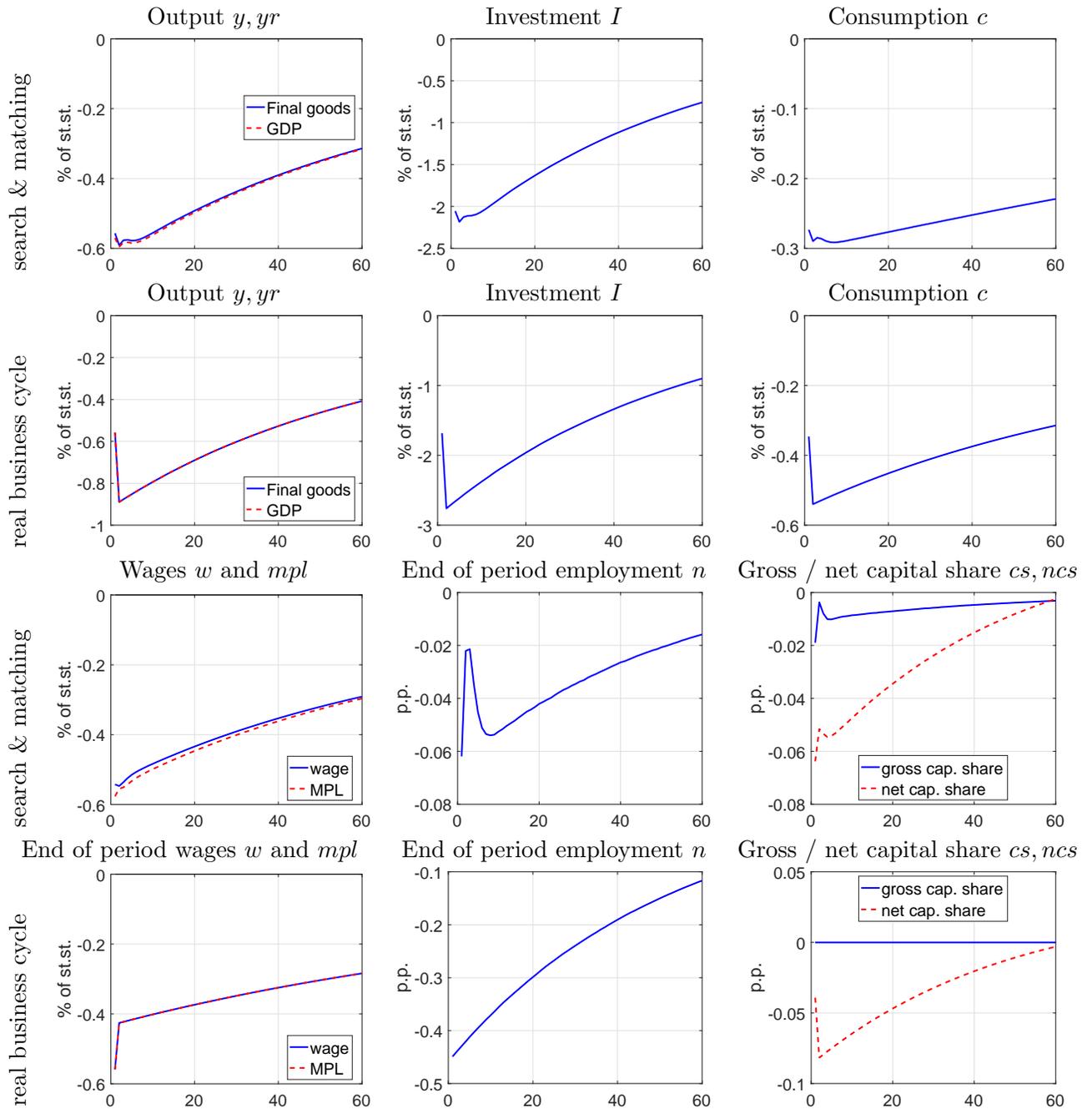


Figure G.27: IRFs to a negative one standard deviation labor productivity shock: Search and matching vs. RBC model with Cobb-Douglas production function.

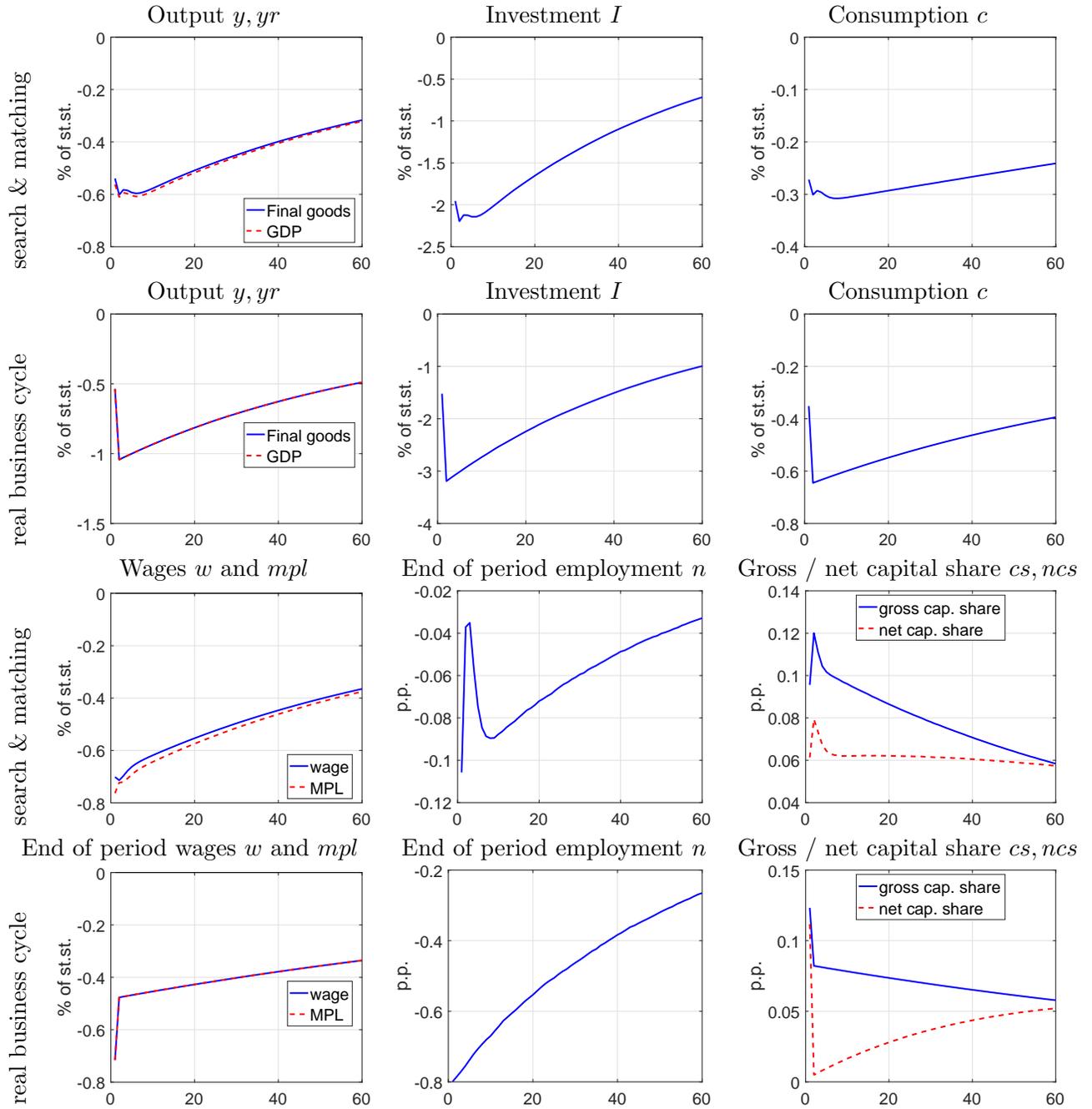


Figure G.28: IRFs to a negative one standard deviation labor productivity shock: Search and matching vs. RBC model with CES $\varepsilon = 0.75$.

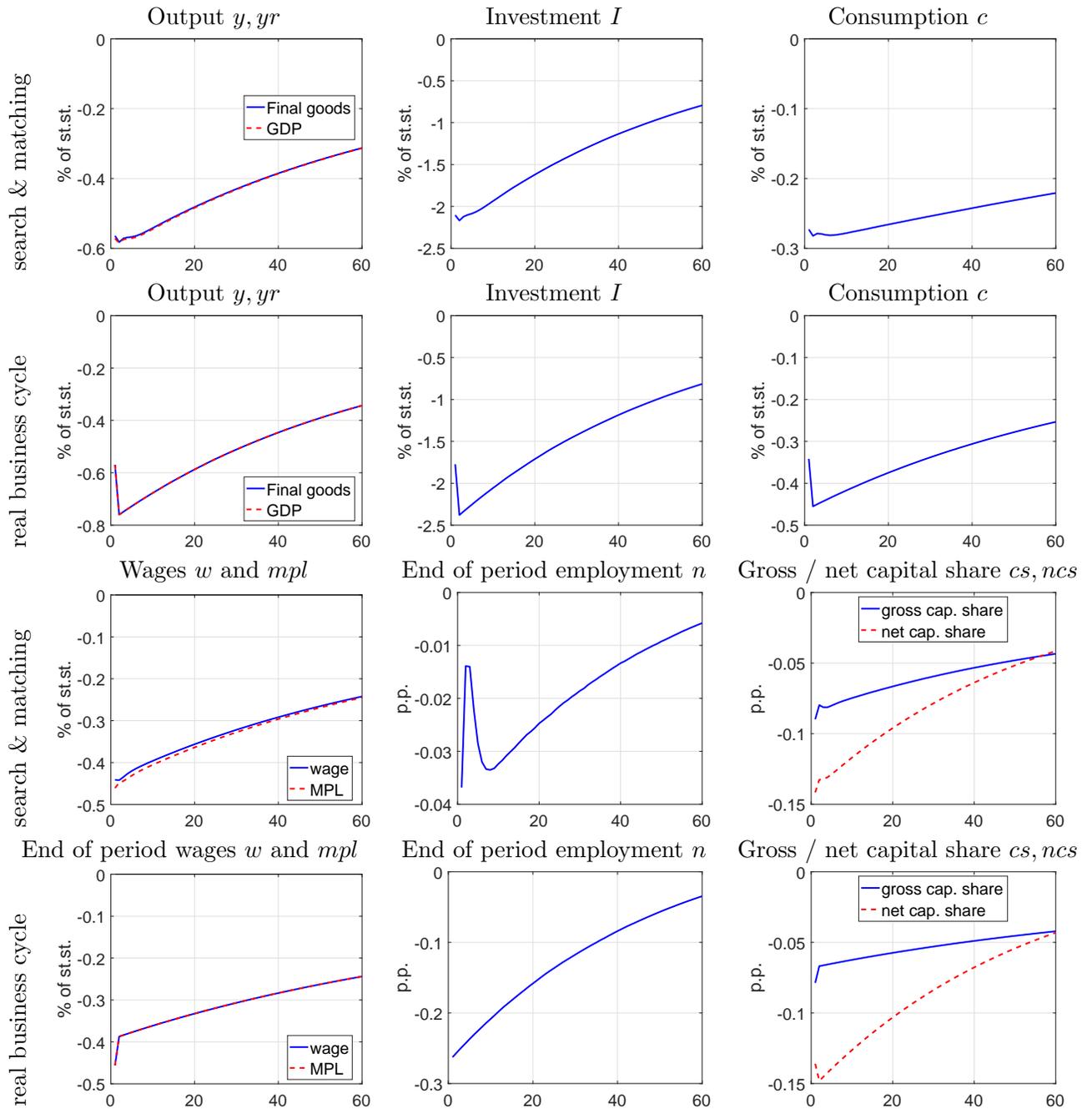


Figure G.29: IRFs to a negative one standard deviation labor productivity shock: Search and matching vs. RBC model with CES $\varepsilon = 1.25$.

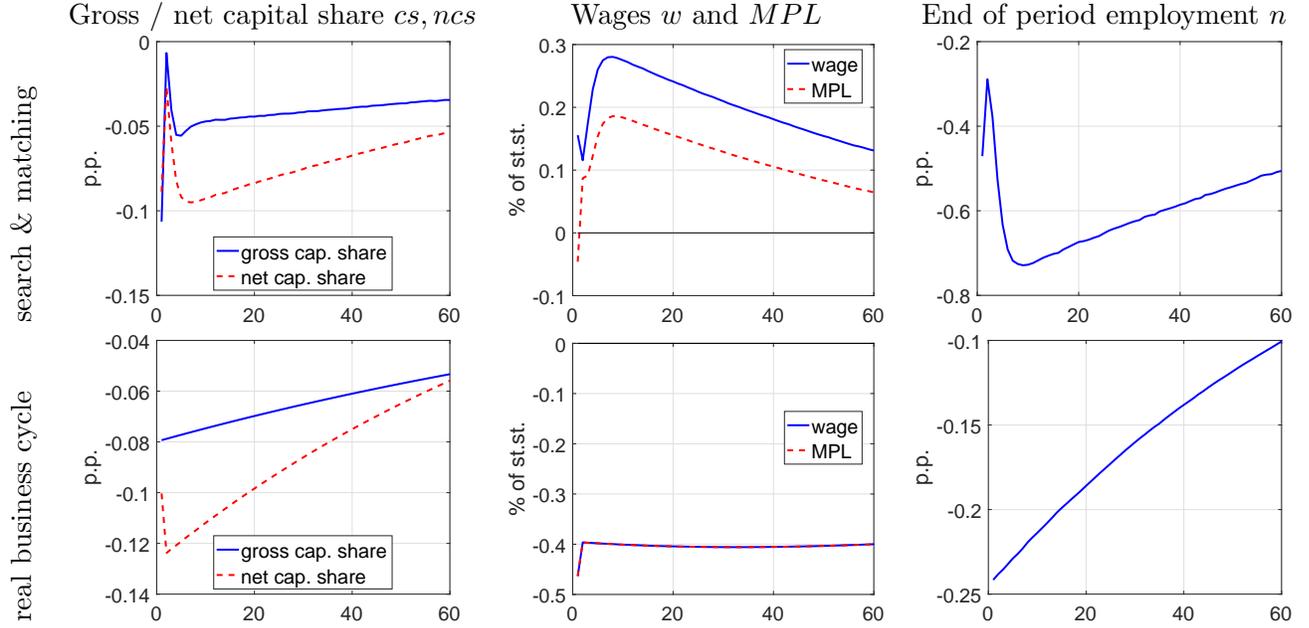


Figure G.30: Bargaining shock in search and matching model compared to factor share shock in RBC.

G.15 Sensitivity analysis

In this final subsection, we include an extensive sensitivity analysis of the quantitative properties of the model.

G.15.1 The role of persistence

First, we consider different values of the persistence of the bargaining power shock in addition to the baseline value of $\rho_\phi = 0.98^{1/3}$. For the low persistence, we choose $\rho_\phi = 0.95^{1/3}$. For the high persistence, we choose $\rho_\phi = 0.9914^{1/3}$. For each value, we re-calibrate the model.

Table G.8 and Figure G.31 summarize the results. In short, the output effects of bargaining power shocks are roughly invariant to the persistence. In contrast, with shorter-lived shocks the bargaining power shock explains more variation in the capital share. This is unsurprising, given that, as argued in the main text, steady-state changes in bargaining power have virtually no effects on capital shares.

Table G.8: Business cycle statistics with different persistence for the bargaining power shock and re-calibrated persistence and investment adjustment cost: 1947Q1–2015Q2.

	Volatility							
	Y [%]	$\frac{\text{std}(I)}{\text{std}(Y)}$	$\frac{\text{std}(C)}{\text{std}(Y)}$	std(ncs) [pp.]	std(cs) [pp.]	std(w) [%]	std(u) [%]	std(TFP) [%]
U.S. data	1.99	3.28	0.58	1.07	0.86	0.95	0.83	1.21
	Models							
S&M, $\rho_\phi^3 = 0.95$	1.98	3.28	0.57	0.38	0.21	1.34	1.84	1.21
S&M, $\rho_\phi^3 = 0.95$: no barg. shock	1.30	3.52	0.53	0.18	0.02	1.14	0.14	1.20
S&M, $\rho_\phi^3 = 0.98$ (baseline)	2.01	3.28	0.59	0.36	0.17	1.31	1.86	1.21
S&M, $\rho_\phi^3 = 0.98$: no barg. shock	1.33	3.86	0.46	0.19	0.02	1.15	0.16	1.21
S&M, $\rho_\phi^3 = 0.9914$	2.03	3.28	0.61	0.35	0.14	1.28	1.98	1.21
S&M, $\rho_\phi^3 = 0.9914$: no barg. shock	1.31	3.88	0.46	0.18	0.02	1.13	0.16	1.20
	Cyclicalities							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	1.00	0.91	0.84	0.57	0.36	0.19	-0.76	0.78
	Models							
S&M, $\rho_\phi^3 = 0.95$	1.00	0.97	0.99	0.82	0.30	0.19	-0.77	0.71
S&M, $\rho_\phi^3 = 0.95$: no barg. shock	1.00	0.99	0.99	0.98	0.87	1.00	-0.96	1.00
S&M, $\rho_\phi^3 = 0.98$ (baseline)	1.00	0.96	0.98	0.87	0.33	0.19	-0.76	0.71
S&M, $\rho_\phi^3 = 0.98$: no barg. shock	1.00	0.99	0.99	0.97	0.91	1.00	-0.96	1.00
S&M, $\rho_\phi^3 = 0.9914$	1.00	0.94	0.96	0.91	0.43	0.19	-0.70	0.72
S&M, $\rho_\phi^3 = 0.9914$: no barg. shock	1.00	0.99	0.99	0.97	0.91	1.00	-0.96	1.00
	Persistence							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	0.87	0.82	0.78	0.76	0.74	0.67	0.90	0.78
	Models							
S&M, $\rho_\phi^3 = 0.95$	0.82	0.80	0.83	0.76	0.65	0.79	0.83	0.78
S&M, $\rho_\phi^3 = 0.95$: no barg. shock	0.79	0.80	0.80	0.78	0.58	0.78	0.82	0.78
S&M, $\rho_\phi^3 = 0.98$ (baseline)	0.83	0.79	0.85	0.78	0.66	0.79	0.81	0.78
S&M, $\rho_\phi^3 = 0.98$: no barg. shock	0.80	0.80	0.80	0.79	0.62	0.78	0.82	0.78
S&M, $\rho_\phi^3 = 0.9914$	0.83	0.76	0.86	0.78	0.61	0.78	0.65	0.79
S&M, $\rho_\phi^3 = 0.9914$: no barg. shock	0.80	0.80	0.80	0.79	0.62	0.78	0.82	0.78

Note: Quarterly data, HP-filtered with smoothing parameter $\lambda = 1,600$. We average the monthly model-generated data first within quarters before HP-filtering.

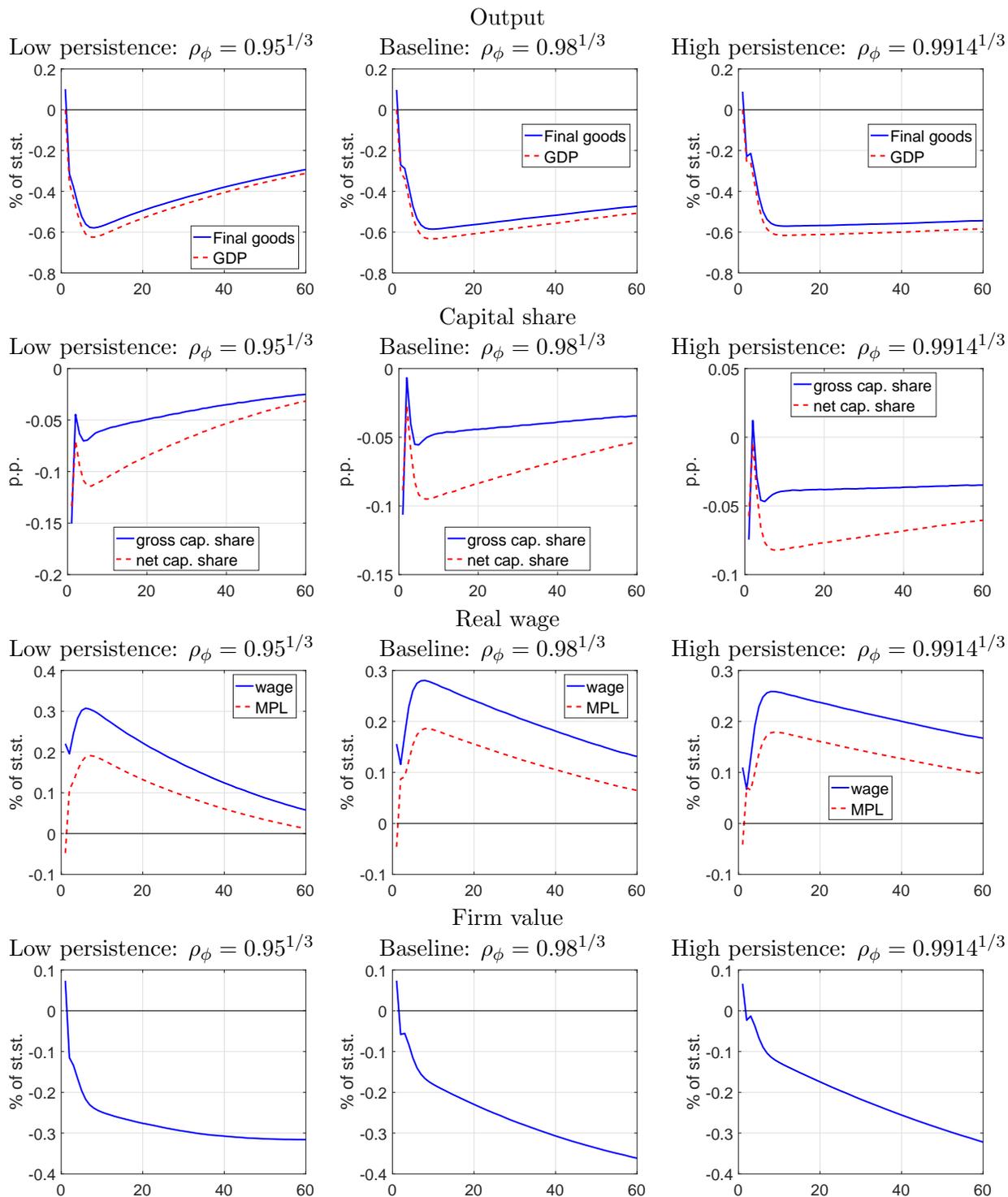


Figure G.31: IRFs of output, capital share, real wage, and firm value with the model calibrated to different levels of persistence.

G.15.2 The role of the elasticity of substitution

Next, we document in Table G.9 some properties of the model as we change the elasticity of substitution.

Table G.9: Elasticity of substitution and business cycle statistics: 1947Q1-2015Q2. Full results.

	Volatility							
	Y [%]	$\frac{\text{std}(I)}{\text{std}(Y)}$	$\frac{\text{std}(C)}{\text{std}(Y)}$	std(ncs) [pp.]	std(cs) [pp.]	std(w) [%]	std(u) [%]	std(TFP) [%]
U.S. data	1.99	3.28	0.58	1.07	0.86	0.95	0.83	1.21
	$\varepsilon = .75$							
S&M	2.12	3.28	0.58	0.35	0.33	1.67	1.92	1.21
S&M	1.37	3.68	0.50	0.15	0.24	1.47	0.27	1.20
RBC	2.22	3.28	0.61	0.07	0.18	1.04	2.41	1.21
	$\varepsilon = 1.25$							
S&M	1.94	3.28	0.59	0.41	0.24	1.08	1.81	1.21
S&M	1.27	3.76	0.48	0.33	0.17	0.93	0.09	1.20
RBC	1.62	3.28	0.59	0.35	0.14	0.83	0.63	1.21
	Cyclicalities							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	1.00	0.91	0.84	0.57	0.36	0.19	-0.76	0.78
	$\varepsilon = 0.75$							
S&M	1.00	0.97	0.98	0.61	-0.02	0.19	-0.79	0.72
S&M	1.00	0.99	0.99	-0.79	-0.99	1.00	-0.95	0.99
RBC	1.00	0.97	0.99	0.80	-0.95	0.95	-0.77	0.99
	$\varepsilon = 1.25$							
S&M	1.00	0.96	0.97	0.84	0.42	0.19	-0.75	0.70
S&M	1.00	0.99	0.99	0.99	1.00	1.00	-0.96	1.00
RBC	1.00	0.99	0.99	0.99	0.98	0.98	-0.93	0.99
	Persistence							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	0.87	0.82	0.78	0.76	0.74	0.67	0.90	0.78
	$\varepsilon = 0.75$							
S&M	0.83	0.79	0.85	0.75	0.72	0.78	0.80	0.79
S&M	0.80	0.80	0.80	0.62	0.79	0.78	0.82	0.78
RBC	0.80	0.80	0.80	0.24	0.75	0.75	0.79	0.79
	$\varepsilon = 1.25$							
S&M	0.83	0.78	0.84	0.77	0.74	0.79	0.81	0.78
S&M	0.79	0.79	0.79	0.79	0.78	0.78	0.82	0.78
RBC	0.80	0.80	0.80	0.79	0.78	0.77	0.79	0.78

Note: Quarterly data, HP-filtered with smoothing parameter $\lambda = 1,600$. We average the monthly model-generated data first within quarters before HP-filtering.

G.15.3 The role of market power

Table G.10 summarizes our findings on the role of market power.

Table G.10: Business cycle statistics: 1947Q1–2015Q2. The role of market power.

	Volatility							
	Y [%]	$\frac{\text{std}(I)}{\text{std}(Y)}$	$\frac{\text{std}(C)}{\text{std}(Y)}$	std(ncs) [pp.]	std(cs) [pp.]	std(w) [%]	std(u) [%]	std(TFP) [%]
U.S. data	1.99	3.28	0.58	1.07	0.86	0.95	0.83	1.21
	Fixed cost							
S&M: with bargaining shock	1.99	3.28	0.54	0.49	0.23	1.14	1.66	1.21
S&M: no bargaining shock	1.28	3.73	0.41	0.28	0.10	0.99	0.14	1.18
RBC	1.81	3.28	0.54	0.39	0.13	0.78	0.87	1.21
	No fixed cost							
S&M: with bargaining shock	2.16	3.28	0.59	0.38	0.17	1.25	1.95	1.21
S&M: no bargaining shock	1.29	3.75	0.48	0.18	0.01	1.12	0.15	1.18
RBC	1.89	3.28	0.60	0.25	0.00	0.92	1.06	1.21
	Cyclicalities							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	1.00	0.91	0.84	0.57	0.36	0.19	-0.76	0.78
	Fixed cost							
S&M: with bargaining shock	1.00	0.96	0.96	0.95	0.83	0.19	-0.78	0.79
S&M: no bargaining shock	1.00	0.99	0.99	0.99	1.00	1.00	-0.97	1.00
RBC	1.00	0.99	0.99	0.99	1.00	0.97	-0.97	0.99
	No fixed cost							
S&M: with bargaining shock	1.00	0.96	0.98	0.87	0.33	0.19	-0.79	0.74
S&M: no bargaining shock	1.00	0.99	0.99	0.97	0.88	1.00	-0.96	1.00
RBC	1.00	0.98	0.99	0.98	NaN	0.96	-0.95	0.99
	Persistence							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	0.87	0.82	0.78	0.76	0.74	0.67	0.90	0.78
	Fixed cost							
S&M: with bargaining shock	0.83	0.78	0.85	0.83	0.79	0.79	0.82	0.79
S&M: no bargaining shock	0.80	0.80	0.80	0.80	0.78	0.78	0.82	0.79
RBC	0.80	0.80	0.80	0.81	0.80	0.77	0.79	0.79
	No fixed cost							
S&M: with bargaining shock	0.83	0.79	0.85	0.79	0.64	0.78	0.80	0.79
S&M: no bargaining shock	0.80	0.80	0.80	0.79	0.60	0.78	0.82	0.78
RBC	0.80	0.80	0.80	0.81	NaN	0.77	0.79	0.79

Note: Quarterly data, HP-filtered with smoothing parameter $\lambda = 1,600$. We average the monthly model-generated data first within quarters before HP-filtering.

G.15.4 The role of exogenous shocks

Table G.11 reports business cycle statistics with endogenous policy changes.

Table G.11: Business cycle statistics with endogenous policy changes: 1947Q1–2015Q2.

	Volatility							
	Y [%]	$\frac{\text{std(I)}}{\text{std(Y)}}$	$\frac{\text{std(C)}}{\text{std(Y)}}$	std(ncs) [pp.]	std(cs) [pp.]	std(w) [%]	std(u) [%]	std(TFP) [%]
U.S. data	1.99	3.28	0.58	1.07	0.86	0.95	0.83	1.21
	Models							
S&M model: policy rule	2.13	3.28	0.65	0.34	0.12	1.28	2.22	1.21
S&M model: no bargaining shock	1.32	4.03	0.43	0.19	0.02	1.13	0.17	1.20
RBC model: baseline	1.90	3.28	0.60	0.25	0.00	0.92	1.04	1.21
	Cyclicality							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	1.00	0.91	0.84	0.57	0.36	0.19	-0.76	0.78
	Models							
S&M model: policy rule	1.00	0.92	0.94	0.91	0.29	0.19	-0.67	0.72
S&M model: no bargaining shock	1.00	0.99	0.99	0.97	0.92	1.00	-0.97	1.00
RBC model: baseline	1.00	0.98	0.99	0.98	NaN	0.96	-0.95	0.99
	Persistence							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	0.87	0.82	0.78	0.76	0.74	0.67	0.90	0.78
	Models							
S&M model: policy rule	0.79	0.80	0.80	0.78	0.60	0.78	0.82	0.78
S&M model: no bargaining shock	0.80	0.80	0.80	0.79	0.62	0.78	0.82	0.78
RBC model: baseline	0.80	0.80	0.80	0.81	NaN	0.76	0.79	0.78

Note: Quarterly data, HP-filtered with smoothing parameter $\lambda = 1,600$. We average the monthly model-generated data first within quarters before HP-filtering.

G.15.5 Alternative calibrations

We report two alternative calibrations: matching the industry- and occupation-adjusted wage rate (Table G.12) and matching the unemployment rate volatility and business cycle statistics (Table G.13).

Table G.12: Matching the industry- and occupation-adjusted wage rate. Business cycle statistics: 1980Q1-2014Q4.

	Volatility							
	Y [%]	$\frac{\text{std}(I)}{\text{std}(Y)}$	$\frac{\text{std}(C)}{\text{std}(Y)}$	std(ncs) [pp.]	std(cs) [pp.]	std(w) [%]	std(u) [%]	std(TFP) [%]
U.S. data	1.77	3.06	0.47	0.94	0.72	0.48	0.77	0.96
	Models							
S&M model: matching ECI wage	2.25	3.06	0.60	0.45	0.22	1.23	2.42	0.96
S&M model: no bargaining shock	1.03	3.57	0.48	0.15	0.01	0.90	0.12	0.95
RBC model: baseline	1.51	3.06	0.60	0.21	0.00	0.73	0.79	0.96
	Cyclicalities							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	1.00	0.95	0.81	0.46	0.21	-0.25	-0.85	0.68
	Models							
S&M model: matching ECI wage	1.00	0.96	0.98	0.84	0.33	-0.25	-0.83	0.59
S&M model: no bargaining shock	1.00	0.99	0.99	0.97	0.91	1.00	-0.98	1.00
RBC model: baseline	1.00	0.99	0.99	0.98	NaN	0.97	-0.97	0.99
	Persistence							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	0.89	0.86	0.76	0.78	0.74	0.78	0.93	0.79
	Models							
S&M model: matching ECI wage	0.84	0.78	0.86	0.77	0.67	0.79	0.75	0.79
S&M model: no bargaining shock	0.79	0.80	0.80	0.79	0.61	0.78	0.81	0.78
RBC model: baseline	0.80	0.80	0.80	0.82	NaN	0.76	0.79	0.78

Note: Quarterly data, HP-filtered with smoothing parameter $\lambda = 1,600$. We average the monthly model-generated data first within quarters before HP-filtering.

Table G.13: Matching the unemployment rate volatility and business cycle statistics: 1947Q1-2015Q2.

	Volatility							
	Y [%]	$\frac{\text{std}(I)}{\text{std}(Y)}$	$\frac{\text{std}(C)}{\text{std}(Y)}$	std(ncs) [pp.]	std(cs) [pp.]	std(w) [%]	std(u) [%]	std(TFP) [%]
U.S. data	1.99	3.28	0.58	1.07	0.86	0.95	0.83	1.21
	Models							
S&M model: matching std(u)	1.46	3.28	0.57	0.23	0.07	1.19	0.83	1.21
S&M model: no bargaining shock	1.31	3.47	0.54	0.18	0.02	1.16	0.14	1.21
RBC model: baseline	1.89	3.28	0.60	0.25	0.00	0.92	1.04	1.21
	Cyclicalities							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	1.00	0.91	0.84	0.57	0.36	0.19	-0.76	0.78
	Models							
S&M model: matching std(u)	1.00	0.98	0.99	0.93	0.38	0.76	-0.57	0.90
S&M model: no bargaining shock	1.00	0.99	0.99	0.98	0.87	1.00	-0.96	1.00
RBC model: baseline	1.00	0.98	0.99	0.98	NaN	0.96	-0.95	0.99
	Persistence							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	0.87	0.82	0.78	0.76	0.74	0.67	0.90	0.78
	Models							
S&M model: matching std(u)	0.80	0.79	0.81	0.78	0.55	0.78	0.84	0.78
S&M model: no bargaining shock	0.79	0.80	0.80	0.78	0.57	0.78	0.82	0.78
RBC model: baseline	0.80	0.80	0.80	0.81	NaN	0.76	0.79	0.78

Note: Quarterly data, HP-filtered with smoothing parameter $\lambda = 1,600$. We average the monthly model-generated data first within quarters before HP-filtering.

G.15.6 The Hosios rule and the welfare cost of political risk

The Hosios condition holds in our model when $\tau_n = \tau_k$ and $\phi = 1 - \eta$. In comparison, in our baseline calibration, we have that $\tau_n = 0.4$, $\tau_k = 0.3$, and $\phi = 1 - \eta = \frac{1}{2}$. Below we show results for $\tau_n = \tau_k = 0.3$ and explore whether welfare gains increase when the violation of the Hosios condition is larger.

We re-calibrate the model for each parameter combination. Table G.14 shows the implied business cycle statistics. The violation of the Hosios condition in the steady state is immaterial for our results. With equal tax rates and for a higher elasticity of the matching function, we find a smaller role for bargaining power shocks than in our baseline model – and a larger role for a smaller elasticity of the matching function. For $\eta = \frac{3}{4}$, the role of bargaining power is largely invariant to whether the Hosios condition holds in the steady state. For $\eta = \frac{1}{4}$, in contrast, we find that our calibration strategy yields much more volatile GDP and capital shares when the Hosios condition is indeed violated.

The welfare implications are in line with these findings. Welfare is largely unaffected in our baseline calibration when we lower the calibrated labor income tax rate so that the Hosios condition holds in the steady state; see Table G.15. With $\eta = \frac{3}{4}$, the violation of the Hosios condition yields slightly larger welfare gains (+0.1 pp.) when we eliminate bargaining power shocks. With $\eta = \frac{1}{4}$, the welfare gains are much larger when the Hosios condition is violated, by 0.5 pp. relative to the calibration with the Hosios condition in the steady state.

Intuitively, the actual bargaining power in our model is highly persistent, so that deviations from the Hosios condition are long-lasting independent of the steady-state calibration.³⁸ Thus, steady-state efficiency may have little effect on efficiency in the stochastic economy.

³⁸We also re-calibrate the steady state of the model to attain the same calibration targets, including the employment level, independent of whether the Hosios condition holds.

Table G.14: Business cycle statistics: 1947Q1–2015Q2

	Volatility							
	Y	$\frac{\text{std(I)}}{\text{std(Y)}}$	$\frac{\text{std(C)}}{\text{std(Y)}}$	std(ncs)	std(cs)	std(w)	std(u)	std(TFP)
	[%]			[pp.]	[pp.]	[%]	[%]	[%]
U.S. data	1.99	3.28	0.58	1.07	0.86	0.95	0.83	1.21
	Models							
Baseline	2.01	3.28	0.59	0.36	0.17	1.31	1.86	1.21
No bargaining shock	1.31	3.73	0.49	0.18	0.02	1.14	0.15	1.20
$\tau_n = \tau_k = 0.3$	2.03	3.28	0.59	0.36	0.17	1.31	1.87	1.21
same, no barg. shock	1.31	3.80	0.47	0.18	0.02	1.14	0.16	1.21
$\tau_n = \tau_k = 0.3, \eta = 1 - \bar{\phi} = \frac{3}{4}$	2.10	3.28	0.60	0.35	0.13	1.27	1.93	1.21
same, no barg. shock	1.39	3.73	0.49	0.20	0.03	1.09	0.29	1.20
$\tau_n = \tau_k = 0.3, \eta = \frac{3}{4}, \bar{\phi} = \frac{1}{2}$	2.03	3.28	0.60	0.32	0.12	1.32	1.95	1.21
same, no barg. shock	1.26	3.73	0.49	0.17	0.01	1.16	0.09	1.20
$\tau_n = \tau_k = 0.3, \eta = 1 - \bar{\phi} = \frac{1}{4}$	2.19	3.28	0.58	0.43	0.24	1.21	2.59	1.21
same, no barg. shock	1.48	3.82	0.48	0.20	0.01	1.08	0.54	1.20
$\tau_n = \tau_k = 0.3, \eta = \frac{1}{4}, \bar{\phi} = \frac{1}{2}$	2.51	3.28	0.58	0.49	0.31	1.10	5.47	1.21
same, no barg. shock	1.76	3.64	0.53	0.24	0.04	0.96	1.30	1.19
	Cyclicality							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	1.00	0.91	0.84	0.57	0.36	0.19	-0.76	0.78
	Models							
Baseline	1.00	0.96	0.98	0.87	0.33	0.19	-0.76	0.71
No bargaining shock	1.00	0.99	0.99	0.97	0.89	1.00	-0.96	1.00
$\tau_n = \tau_k = 0.3$	1.00	0.96	0.98	0.87	0.33	0.19	-0.76	0.71
same, no barg. shock	1.00	0.99	0.99	0.97	0.90	1.00	-0.96	1.00
$\tau_n = \tau_k = 0.3, \eta = 1 - \bar{\phi} = \frac{3}{4}$	1.00	0.96	0.98	0.91	0.37	0.19	-0.79	0.72
same, no barg. shock	1.00	0.99	0.99	0.97	0.77	1.00	-0.96	0.99
$\tau_n = \tau_k = 0.3, \eta = \frac{3}{4}, \bar{\phi} = \frac{1}{2}$	1.00	0.96	0.98	0.90	0.24	0.19	-0.76	0.70
same, no barg. shock	1.00	0.99	0.99	0.97	0.87	1.00	-0.98	1.00
$\tau_n = \tau_k = 0.3, \eta = 1 - \bar{\phi} = \frac{1}{4}$	1.00	0.97	0.98	0.80	0.27	0.19	-0.73	0.75
same, no barg. shock	1.00	0.99	0.99	0.97	0.67	0.98	-0.82	0.99
$\tau_n = \tau_k = 0.3, \eta = \frac{1}{4}, \bar{\phi} = \frac{1}{2}$	1.00	0.99	0.99	0.79	0.27	0.19	-0.61	0.83
same, no barg. shock	1.00	0.99	0.99	0.96	0.30	0.91	-0.79	0.97
	Persistence							
	Y	I	C	ncs	cs	w	u	TFP
U.S. data	0.87	0.82	0.78	0.76	0.74	0.67	0.90	0.78
	Models							
Baseline	0.83	0.79	0.85	0.78	0.66	0.79	0.81	0.78
No bargaining shock	0.79	0.80	0.80	0.78	0.60	0.78	0.82	0.78
$\tau_n = \tau_k = 0.3$	0.83	0.79	0.85	0.78	0.68	0.79	0.80	0.78
same, no barg. shock	0.79	0.80	0.80	0.79	0.61	0.78	0.82	0.78
$\tau_n = \tau_k = 0.3, \eta = 1 - \bar{\phi} = \frac{3}{4}$	0.83	0.79	0.85	0.71	0.22	0.78	0.83	0.79
same, no barg. shock	0.80	0.81	0.81	0.76	0.44	0.79	0.82	0.78
$\tau_n = \tau_k = 0.3, \eta = \frac{3}{4}, \bar{\phi} = \frac{1}{2}$	2.03	3.28	0.60	0.32	0.12	1.32	1.95	1.21
same, no barg. shock	0.79	0.79	0.80	0.78	0.56	0.78	0.82	0.78
$\tau_n = \tau_k = 0.3, \eta = 1 - \bar{\phi} = \frac{1}{4}$	0.82	0.79	0.84	0.63	0.42	0.77	0.77	0.79
same, no barg. shock	0.81	0.81	0.81	0.81	0.34	0.78	0.83	0.79
$\tau_n = \tau_k = 0.3, \eta = \frac{1}{4}, \bar{\phi} = \frac{1}{2}$	0.82	0.82	0.83	0.48	0.11	0.69	0.76	0.79
same, no barg. shock	0.82	0.82	0.82	0.77	0.12	0.78	0.83	0.79

Note: Quarterly data, HP-filtered with smoothing parameter $\lambda = 1,600$. We average the monthly model-generated data first within quarters before HP-filtering.

Table G.15: Welfare effects of increased or reduced political distribution risk

Specification	std(Y) [%]	$\frac{\text{Std}(C)}{\text{Std}Y}$	Std(cs) [%]	Std(n) [%]	Welfare change Consumption units
Baseline	2.01	0.59	0.17	1.86	0
No redistribution risk	1.31	0.49	0.02	0.15	+2.71%
Hosios condition holds					
$\tau_n = \tau_k = 0.3$	2.03	0.59	0.17	1.87	0
Same, no redistribution risk	1.31	0.47	0.02	0.16	+2.74%
Hosios condition holds					
$\tau_n = \tau_k = 0.3, \eta = 1 - \bar{\phi} = \frac{3}{4}$	2.10	0.60	0.13	1.93	0
Same, no redistribution risk	1.39	0.49	0.03	0.29	+2.58%
Hosios condition fails					
$\tau_n = \tau_k = 0.3, \eta = \frac{3}{4}, \bar{\phi} = \frac{1}{2}$	2.03	0.60	0.12	1.95	0
Same, no redistribution risk	1.26	0.49	0.01	0.09	+2.73%
Hosios condition holds					
$\tau_n = \tau_k = 0.3, \eta = 1 - \bar{\phi} = \frac{3}{4}$	2.19	0.58	0.24	2.59	0
Same, no redistribution risk	1.48	0.48	0.01	0.54	+2.60%
Hosios condition fails					
$\tau_n = \tau_k = 0.3, \eta = \frac{3}{4}, \bar{\phi} = \frac{1}{2}$	2.51	0.58	0.31	5.47	0
Same, no redistribution risk	1.76	0.53	0.04	1.30	+3.14%