Political Distribution Risk and Business Cycles

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Abstract

We argue that one important determinant of the variation in income shares is political risk. To that end, we document significant changes in the capital share after political events such as the introduction of right-to-work legislation in U.S. states and international events such as the Carnation Revolution in Portugal. These policy changes are often associated with significant fluctuations in output and asset prices. To quantify the importance of these political shocks for the U.S., 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 unemployment. We calibrate the model to the U.S. corporate non-financial business sector with a standard process for productivity. A one standard deviation redistribution shock reduces the capital share up 0.2 percentage point on impact and leads to a drop in output of 0.6 percent. Our calibration also implies that political distribution risk can explain 15 to 25% of the observed volatility of U.S. gross capital shares – and 35 to 45 percent of output volatility, depending on the elasticity of substitution between capital and labor. Eliminating political redistribution risk in the U.S. would raise the welfare of the representative household by 1.6 percent of steady state consumption.

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1 Introduction

The political process is an important driver of income distribution. Labor and goods market regulations determine, in part, the quantity and prices of productive inputs. Collective bargaining rules, hiring and firing restrictions, overtime provisions, minimum wages, or antitrust legislation -among many other policies- affect the relative payments 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 are thorough modifications in labor market regulations and fast changes in the capital income share. And the current presidential campaign in the U.S. illustrates the political viability of candidates with widely different agendas regarding how labor markets should be organized. Thus, political distribution creates income risk for workers and owners of capital.

In this paper, we argue that this political distribution risk is a quantitatively relevant source of aggregate fluctuations and asset pricing observations. To do so, we first document the existence of the political distribution risk through several case studies for OECD countries, data on the introduction of right-to-work legislation in the U.S., and data for a number of Latin American and Caribbean countries. For example, the adoption of right-to-work legislation by several U.S. states was followed by increases in the state capital share around 2 percentage points relative to the U.S., three to five years after adoption.

Second, we augment an otherwise standard stochastic neoclassical growth model with labor search with shocks to the bargaining power of workers. We interpret these shocks as 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 bargaining protocol of an underlying dynamic bargaining game (Binmore, Rubinstein, and Wolinsky, 1986). In our model, political distribution risk is separate from distributional change due to endogenous changes in the bargaining position of workers and firms. We calibrate our model to quarterly observations of the U.S. non-financial corporate business sector and the U.S. labor market.

In our calibration, distribution risk shocks account for 35-45% of the volatility of output and one third of the volatility of capital shares. At the same time, the U.S. has benefited from a comparatively stable capital share compared to other industrialized countries such as the U.K. – large changes have been less common and the overall volatility of the capital share lower is about 40% lower than in the U.K.. If increased redistribution risk cause the capital share to become 40% more volatile, our model predicts a 25% higher output and consumption volatility. This increased volatility would lower the volatility of the representative household by 0.7% of consumption. Also one-time distribution shocks can have important consequences. A one-standard deviation shock to distribution risk already causes a 0.2 percentage point drop in the U.S. capital share and goes along with a 0.6 percent drop in output.

Fluctuations in the capital share of income are well documented and, running counter to Kaldor stylzed growth facts, show trend declines (e.g. Castaneda, Diaz-Gimenez, and Rios-Rull, 1998; Karabarbounis and Neiman, 2014). While the recent rise of the capital share has commanded much attention, its origins are still debated. The trend decline in the capital share have previously been attributed to changes in factor prices, or unionization. While these channels may be present, they have been questioned recently. For example, Karabarbounis and Neiman (2014) argue that the relative fall in the price of capital has lead to capital deepening that substituted for labor. But Oberfield and Raval (2014) argue that since capital and labor are gross complements in the micro data, the trend decline in labor shares cannot be explained by capital deepening or the falling relative price of investment. Elsby, Hobijn, and Sahin (2013) present suggestive evidence that unionization does not explain the trend rise in the capital share.

Fortunately for our investigation, in this paper we can remain agnostic about these reasons. Our point is not that all sources of fluctuations in the capital share have a political origin: we only claim that part of these fluctuations are.

Our paper builds on a large previous literature. Earlier models that focus on how changes in the bargaining power affect factor shares are Blanchard and Giavazzi (2003), the working paper version of Kumhof, Ranciere, and Winant (2015), i.e. Kumhof and Ranciere (2010), and Kumhof, Lebarz, Ranciere, Richter, and Throckmorton (2012). Unlike our work, Kumhof, Lebarz, Ranciere, Richter, and Throckmorton (2012) link shocks to bargaining power to changes in income inequality in a model of workers and capitalists. Blanchard and Giavazzi (2003) are concerned with the trend decline in the labor share in Europe, whereas we focus on cyclical fluctuations. Liu, Miao, and Zha (2013) also allow for time-varying bargaining power, but they do not focus on the distributional implications. Ríos-Rull and Santaeulàlia-Llopis (2010) interpret redistribution shocks as technological shocks to the production function, whereas we propose an explanation for redistribution that does not affect technology.

Broadly, our paper contributes to a number of recent papers that explore the effects of new shocks on the asset pricing implications of macro models. For example, Albuquerque, Eichenbaum, and Rebelo (2012) explore the effect of discount factor shocks. Our paper is closer to Danthine, Donaldson, and Siconolfi (2008) and Lansing (2015). They argue that distribution risk can be important for explaining macro-asset prices more generally. But it remains unclear what is driving the fluctuations in the factor shares. We provide a model that allows us to quantify both the endogenous and exogenous factors behind the changing capital share. See also Greenwald, Lettau, and Ludvigson (2014) for empirical evidence. Also Harald Uhlig's Laffont lecture ("What moves the stock market?") for time series evidence. We provide historical case studies and a model backing up their findings using aggregate data.

The rest of the paper is organized as follows. In section 2, we review the historical evidence documenting how political interventions affect factor shares. VAR evidence. In section 4, we present our model and its quantitative analysis. Section 5 concludes. An extensive appendix discusses further details.

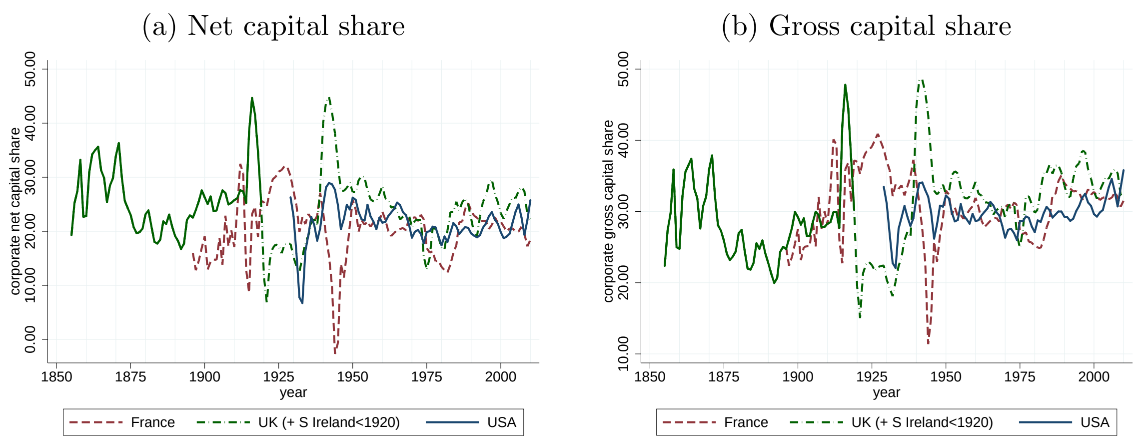
2 Factor shares: Historical evidence

In this section, we will present historical evidence regarding the evolution of factor shares and the role that political interventions may have in them. In the next section, we will formalize our investigation using structural VARs. We start, first, with a brief discussion about measurement and some 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 practical measurement is plagued with difficulties. For example, one needs to divide ambiguous sources of income such as rental or proprietors' income between labor and capital. Also, one has to make a decision about how to deal with indirect taxes. And, finally, for going from the gross to the net share, one needs to take a stand on the rates of depreciation.

Gomme and Rupert (2004) and Gomme and Rupert (2007) discuss the measurement issues in the U.S. and Gollin (2002) analyzes the challenge of proprietors income in a cross-section of countries. In Appendix A, we overview different measurements of the capital income share in the U.S. economy. Suffice it to say here that these several alternative calculations agree among themselves regarding the behavior of capital income share over business cycle frequencies (see Figure A.1). Thus, for the purposes of this paper, picking one measure or another in the U.S. case is inconsequential. On the other hand, across countries, we often do not have access to comparable data and our empirical statements will be more nuanced.



Note that the data on the U.K. includes Ireland prior to its independence. The is from Piketty and Zucman (2014).

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

Figure 1(a) shows data over long horizons for the net corporate capital share for France, the U.K. and the U.S. It moves in parallel with the gross capital share in panel (b), but the net corporate capital share is particularly informative about the incentives faced by investors: It eliminates compensation for depreciation and, therefore, uncovers the compensation for intertemporal accumulation and risk-taking.

The data, taken from Piketty and Zucman (2014), reveal two facts. First, the capital share has been relatively stable since WWII in all three economies, with larger fluctuations before that time. We can appreciate, nevertheless, the most recent increase in the capital share in all three countries. Second, the U.S. has exhibited the least volatile capital share among the three countries, 30 percent less volatile than in France and 40 percent less than in the U.K. Table 1 list the raw and filtered volatility of the historical data in its top panel. For comparion's sake, it uses data on gross capital shares. In the bottom panel of Table 1, we show that income shares are much more volatile in the U.K. than in the U.S. even after controlling for industry composition. For France, the same is true only in the raw data, but not after detrending. While the standard deviation fell in the U.S. in the 1950 to 2010 period to 2.16, it fell about proportionally in the U.K. and France.

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

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

	Raw			HP-filtered		
Country	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

	Raw		HP-filtered	
Country	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

Note: Note: The data for panel (a) comes from Piketty and Zucman (2014), the data for panel (b) from the EU KLEMS database and exclude agriculture, mining, and finance. Standard errors in panel (b) clustered by industry and country.

2.2 Factor shares and policy changes: International evidence

In what follows, we will argue that the timing of policy changes and subsequent observed swings in the capital share of income across many countries suggest that the latter can be, at least partially, accounted by the former. Furthermore, this will also include a tentative explanation for part of the differences in the volatility of capital shares across countries and over time. In a later, we will focused on the U.S. experience.

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).[1] This data is

[1] Note that this database is no longer maintained by the OECD. We obtained a copy from http://fmwww.bc.edu/ec-p/data/oecd/oecd.bsdb.html.

available over longer horizons and at a higher frequency than the measures provided in the Penn World Table (Feenstra, Inklaar, and Timmer, 2013) and Karabarbounis and Neiman (2014). It provides data 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 Carribean and is provided by the Economic Commission for Latin America and the Caribbean (ECLAC). This dataset 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.

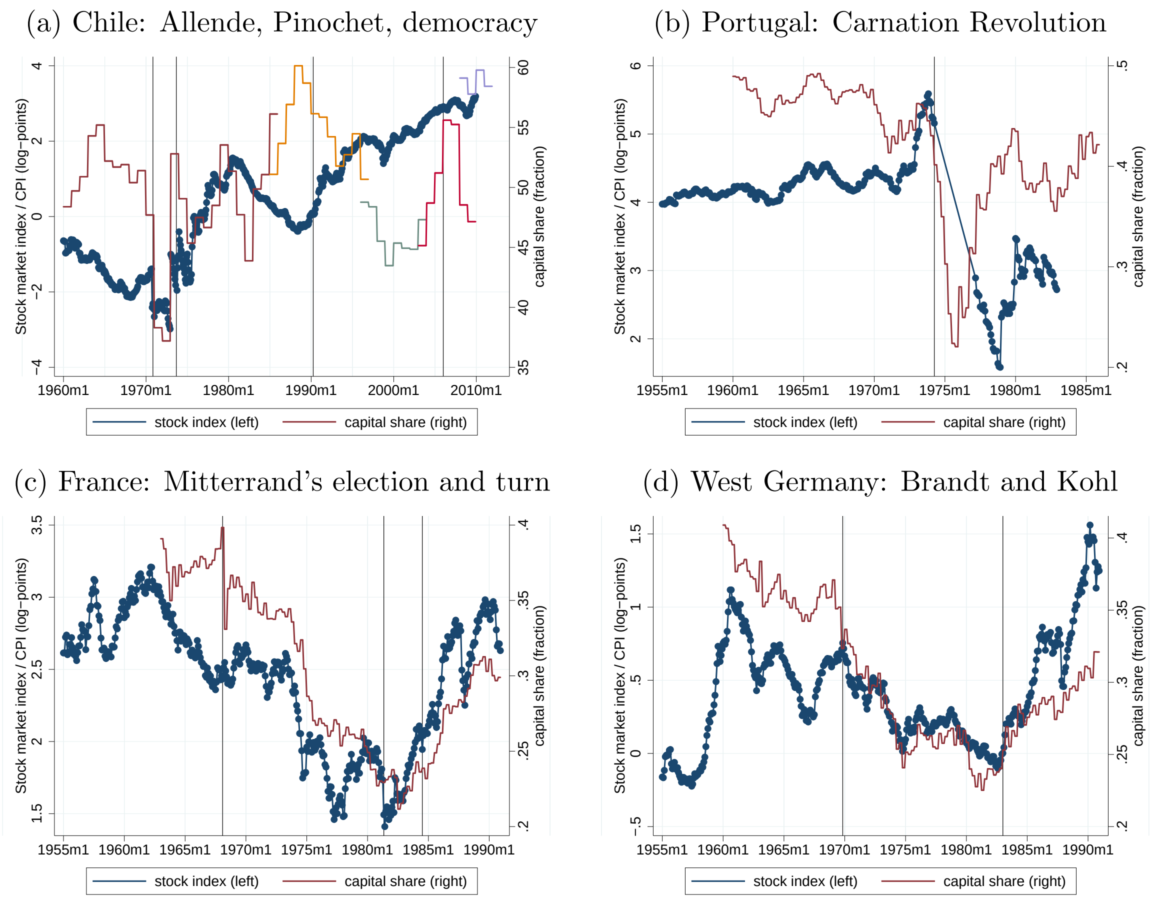
2.2.1 Four cases studies

As a first exercise, Figure 2 summarizes four case studies. In each of them, we look at countries where momentous political changes were accompanied by significant changes in the capital income share. While Panel (a) is not a formal econometric assessment (we avoid such exercise due to data and identification limitations), all four cases are suggestive that economic policy can have a material effect on income distribution between labor and capital.

Our first case study is Chile. Panel (a) 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), the 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 line), and, finally, the more left-wing first presidency of Bachelet (the area to the right of the fourth vertical). While we do not have a continuous time series, Panel (a) 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 rises sharply around Pinochet's coup, with its violent policy against worker's unions, and falls after the transition to democracy and the return of a friendlier environment for workers' political action.

Our second case study is Portugal. Panel (b) documents how, after the Carnation Revolution on 25 April 1974, the capital share fall 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 25 November 1975 and the return toward 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*.

Less dramatic, but still instructive are the cases of France and West Germany in panels (c) and (d). In 1982, Mitterrand was elected as the first socialist president of the Fifth Republic on a left-wing platform (first vertical line). We see the capital share fall slightly after his election, but Mitterrand was building on a large number of already existing pro-labor measures introduced in France since the big strikes of 1968 (see Caballero and Hammour, 1998, for a detail list of policy changes in favor of labor approved in France between 1968 and 1983). The worsening economic



The graphs show the gross capital share and stock market indices for Chile, France, Portugal, and West Germany. The data is at lower frequencies for capital shares. Overlaid are black vertical lines that indicate major political events as described in the main text. 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

conditions forced Mitterrand to appoint Laurent Fabius as his new prime minister on July 1984 (second vertical line), to drop his alliance with the French Communist Party, and to inaugurate an era of more market-friendly policies and focus on price stability. After that change, the capital share of income started growing.

Similarly, in West Germany, the rise to power in October 1969 (first vertical line) of the first government led by a socialdemocratic chancellor since 1930, i.e. Brandt, was associated with a drop in the capital share. This decline was reversed when the Christian democrats returned to power in October 1982 (second vertical line).

In our four case studies, stock market indices typically, but not always, move in the same direction as the capital share. For France and West Germany, for which we have continuous time series available, the correlations are 0.72 and 0.61, respectively.

2.2.2 Additional international evidence

How general are the four case studies that we just discussed? Table 2 summarizes the data for OECD countries that display similar patterns during the post-war period. It shows that across ten different policy changes in seven different countries, the median absolute change in the capital share was 5.2 percentage points within two years of the policy change. This increases to 8.2 percentage points within five years, measured across eight episodes.[2]

Table 2: Political events and changes in capital shares and real GDP: OECD countries

	Date		Change in gross business capital share				Change in detrended GDP			
			2 year change		5 year change		2 years		5 years	
OECD data	Year	Qtr	p.p.	%	p.p.	%	%	Sign	%	Sign
France: Mitterrand's election	1981	5	-.8	-3.5	3.2		-.9	y		
France: Mitterrand's reversal	1984	7	4.2	17.7	7.4	31.2	-.8		2.1	y
Mexico: Debt crisis	1982	8	12	23.5	12.3	24	-8.3		-18.6	
Mexico: NAFTA+	1994	1	8.6	14.5	-25.5		-7.7		2.1	
Portugal: Carnation Revolution	1974	4	-15	-34.9	-3.8	-8.8	-12.4	y	-12.9	y
S Korea: free election	1987	12	-5.4	-10.8	-8.9	-17.9	2.9		5.5	
Turkey: free election	1987	10	-6.1	-7.4	-24.2	-29.5	-6	y	-2.2	y
UK: (Failed) miners' strike	1985	3	.8	3.1	.6	2.6	2.6	y	7	y
W Germany: Brandt election	1969	10	-4.9	-14	-9.4	-26.7	-.9	y	-2.4	y
W Germany: Kohl goverment	1982	10	4.1	17.1	4.3	17.9	.8	y	.6	y
Absolute change: 25th percentile			4.1	7.4	3.8	13.35	.9		2.1	
Absolute change: Median			5.15	14.25	8.15	20.95	2.75		2.4	
Absolute change: 75th percentile			8.6	17.7	12.3	28.1	7.7		7	

Data: The data covers the gross capital share in the business sector. Detrended GDP is real and in per capita terms.

Our finding that political changes are followed significant changes in capital shares also holds up in Latin American and Caribbean countries. This data in Table 3 includes the capital share in 15 of these countries. Within two years of large political events, the median absolute change in the

[2]Note that we do not claim that factor shares will move after all political events. Instead, we have the much more circumspect claim that some important political events lead to the implementations of policies that move factor shares in significant ways.

net capital share was 3.0 percentage points across 23 episodes. For the 19 episodes that we can follow for five years, the median absolute change rises to 5.9 percentage points. Since Table 2 and Table 3 both include Mexico, we can also compare the joint effect of different data sources and the difference between the gross capital share in the business sector and the net overall capital shares. The change in the gross capital share is larger - a gross increase of 12.0 percentage points compared to a net increase of 8.1 percentage points after the 1982 debt crisis. Similarly, after the 1994 events that include the start of NAFTA, the *Ejercito Zapatista de Liberación Nacional* uprising, and a tumultuous presidential election, the gross increase was 8.6 percentage points relative to a net increase of 3.0 percentage points. This is unsurprising both because the gross capital share is higher and since here it covers only the business sector.

Table 3: Political events and changes in capital shares and real GDP: Latin American & Caribbean countries

	Date	Change in net overall capital share				Change in detrended GDP			
		2 year change		5 year change		2 years		5 years	
ECLAC data	Year	p.p.	%	p.p.	%	%	Sign	%	Sign
Bolivia: Democratic transition	2006	2.8	4.4	5	7.9				
Chile: Allende election	1970	-13.1	-25.5			4.6			
Chile: Pinochet coup	1973	11.9	31.9	9.5	25.4	-11.6		-23.1	
Chile: Democratic election	1990	-2.8	-4.8	-6	-10.2	1.7		10.9	
Chile: Democratic transition	2006	4	7.9						
Columbia: National Front gov ends	1974	-.4	-.8	-4	-6.7	.2		6.6	
Columbia: FARC peace deal	1984	2.5	4.8	5.2	10	-1.4		3	y
Costa Rica: New presidency/Austerity	1982	-.9	-2	-2.5	-5.1				
Ecuador: Democratic transition	1979	-4.3	-6.6	4.2	6.3				
Ecuador: War/President killed	1981	2.8	4.6	11.2	18.2				
Honduras: US deployment	1988	2.1	5.3	1.2	3.1				
Honduras: Democratic transition	1990	.3	.6	5	12.3				
Mexico: Debt crisis	1982	8.1	14.7	8.2	14.8	-12.5		-21.6	
Mexico: NAFTA+	1994	3	5.2	4.2	7.2	-7.7		2.1	y
Mexico: Democratic transition	2000	-1.9	-3.1			2.8		5.2	
Panama: US invasion	1989	2.3	6.8	8.6	25.1				
Paraguay: Democratic elections	1993	-4.8	-9	-15.5	-29.2				
Peru: Democratic election	2001	-.6	-.9	1.6	2.2	4.5		19.5	y
Suriname: Military coup	1980	-5.1	-13.2	-19.5	-50.6				
Suriname: Free elections	1987	13.8	68.6	20.9	104.3				
Trin. & Tob.: Democratic transition	1986	-3.3	-9.6	5.9	17.1				
Uruguay: Democratic elections	1984	-5.4	-9	-1.7	-2.9	-4.4	y	8.6	
Venezuela: Democratic transition	1999	5.3	9.4	7.6	13.4	-3.3		-17.7	
Absolute change: 25th percentile		2.1	4.4	4.1	6.5	1.7		5.2	
Absolute change: Median		3	6.6	5.55	11.25	4.4		9.75	
Absolute change: 75th percentile		5.3	9.6	9.05	21.65	7.7		19.5	

Data: Net capital share in the overall economy. Detrended GDP is real and in per capita terms.

An important point about the four case studies and Tables 2 and 3 is that the lead timing of policy changes make reverse causation concerns (i.e., political changes are triggered by changes in factor shares) less salient. But even when this reverse causality may operate (past changes in factor shares lead to current policy changes), for our argument we only need to assert that these policy changes revert the previous movement in the factor shares.

Having documented the potential distributional effect that policy changes can have, we gather data on the accompanying real and financial effects. In particular, we use data on real per capita GDP from Barro (2009) and we collect data for individual countries on the value of stock indices, deflated by consumer prices (see Appendix A for details).

Tables 2 and 3 already show the information on detrended real GDP around the political events. As Table 2 shows, there is mild evidence for comovement of real GDP with the capital share among OECD countries, with positive comovement in six out of ten episodes. For the Latin American and Caribbean countries in Table 3, the comovement is mostly negative. This may be because of costs of transition or movements in commodity prices at the time of these events.[3]

In contrast to the ambiguous correlation of real GDP changes with capital share changes, financial markets comove with the capital share in 9 out of 14 cases (see Table 4). In France, we find a drop by 0.13 log points in the industrials index within two years after Mitterrand's election, and an increase of 0.56 log points following his policy turnaround. The German stock index drop 0.19 log points in the two years after Brandt's election victory and an increase of 29 log points after Kohl ascended to power.

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

The radical policy changes that we have documented for other OECD countries and, particularly, for Latin America have been rare in the U.S. post-world war II history. At the state level, however, there is the arguably the most direct evidence on the effect of policy changes on the labor share. Right-to-work legislation was aimed at hurting unions and their bargaining power. 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 have enacted legislation between 1963 and 2013, the period where we have data on their private-industry labor share. Two states, Indiana and Michigan, were late adopters in 2012.

The data on the four states that adopted earlier indicates 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 3). For Indiana and Michiga, their capital share increased in 2013, both in absolute terms and relative to that in the U.S. as a whole, but with only one observation, we must be most cautious.

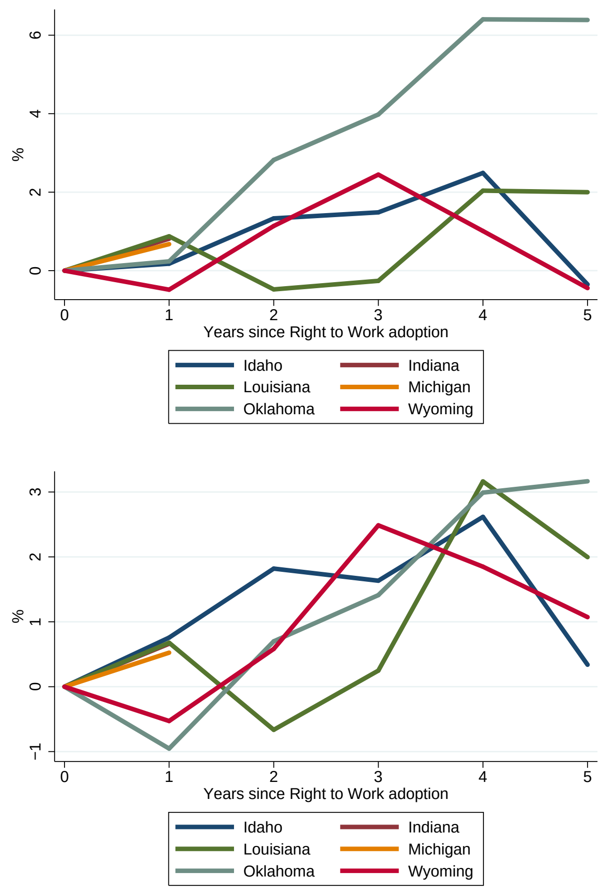
[3] For example, the price of West Texas Intermediate rose from \$12.01 in 02/1999, when Hugo Chávez became the Venezuelan president, to \$29.61 two years later and \$34.69 five years later. In the year prior to his inauguration, the oil price had declined from \$16.06. This does not explain the decline in the Barro-GDP, but it does line up much better with the increase in GDP according to the Penn World Tables. See Table A.1 in the Appendix.

Table 4: Political events and stock index changes

	Date of event		Change within 2 years			Change within 5 years		
	Year	Month	cap-sh (ln%)	stocks (ln%)	same sign?	cap-sh (ln%)	stocks (ln%)	same sign?
Chile: Allende election⋆	1970	11	-25.5	-110.1	y			
Chile: Pinochet coup⋆	1973	9	31.9	-15.9		25.4	255.5	y
Chile: Democratic election⋆	1990	3	-4.8	108.7		-10.2	172.1	
Chile: Democratic transition⋆	2006	3	7.9	15.1	y	16.8	-284.2	
France: Mitterrand's election	1981	5	-3.5	-12.8	y			
France: Mitterrand's policy change	1984	7	17.7	55.3	y	31.2	76.5	y
Mexico: Debt crisis	1982	8	23.5	-91075.2		24	-91075.2	
Mexico: NAFTA+	1994	1	14.5	-31.7			-25.5	
Portugal: Carnation Revolution	1974	4	-34.9	-545.3	y	-8.8	-313.5	y
S Korea: free election	1987	12	-10.8	54.1		-17.9	-29.4	y
Turkey: free election	1987	10	-7.4	-85.8	y	-29.5	-58.8	y
UK: (Failed) miners' strike	1985	3	3.1	21.8	y	2.6	44.9	y
W Germany: Brandt election	1969	10	-14	-18.5	y	-26.7	-55.2	y
W Germany: Kohl administration	1982	10	17.1	28.7	y	17.9	89.5	y
Absolute change: 25th percentile			7.4	21.8		10.2	55.2	
Absolute change: Median			14.25	48.4		17.9	96.4	
Absolute change: 75th percentile			25.5	108.7		25.4	285	

Note: Results are based on gross business sector capital shares and the "Industrials" stock price index, deflated by the CPI. Chile, marked with ⋆, is exception: Here we use net net overall capital share and the "Financials" stock index. This matters only for the Pinochet coup, that would otherwise show as a permanent level drop of 1,000 ln%. At monthly/quarterly frequency the changes are computed three months before to 21 or 57 months after the event.

Cumulative change in capital shares and change relative to U.S.



Note: Capital shares are computed as the one minus the share of employees' compensation in state GDP net of taxes and subsidies.

Figure 3: Change in state private industry capital shares after right to work adoption.

While the evidence on differences in private sector real GDP growth is less pronounced, GDP growth also weakly increased three to five years after a state adopts right-to-work legislation (see Figure A.5 in the appendix). This is consistent with Holmes (1998), who analyzes the effects of right-to-work legislation on the location of manufacturing and finds positive effects on manufacturing activity.

So far, we have presented evidence that policies can have large effects on how income is distributed among capital and labor. For advanced economies also economic activity and the stock market tend to move in the same direction as the capital share. Since we have identified only a few episodes, it is hard to separate policy-induced changes from endogenous changes to other shocks or events. Thus, we now present some more formal evidence through a VAR analysis.

3 Factor shares: VAR evidence

In this section, we estimate a structural VAR for the U.S. economy that includes information on the capital share, the real economy, the labor market, and the stock market valuation covering 1951Q2 to 2014Q2. This VAR will uncover the dynamic response of the economy to exogenous shocks to factor shares.

Specifically, we include the following eight variables: (1) gross domestic product, defined as the sum of consumption and investment, (2) consumption, (3) real output per hour, (4) real compensation per hour, (5) the gross capital share of income in the corporate non-financial business sector, (6) labor market tightness, defined as the Help-Wanted index by Barnichon (2010) relative to the unemployment rate, (7) the unemployment rate, and (8) the real stock market value. We construct the latter following Greenwald, Lettau, and Ludvigson (2014) as the cumulative total real return. To ensure that our results are not driven by low-frequency components, we run the VAR in levels both with and without a linear-quadratic trend.

In terms of identification, we implement the strategy outlined by Uhlig (2004) (also followed by Barsky and Sims, 2011, to analyze news shocks). In the spirit of the calibration exercise in Section 5, we define a productivity shock as the shock that explains the largest fraction of the forecast error variance of real output per hour over some horizon $[\underline{h}, \overline{h}]$. Second, we compute the residual forecast error variance after stripping out the productivity shock from all endogenous variables. Then, we find the shock that explains the most of the remaining forecast error variance of the gross capital share over the same horizon $[\underline{h}, \overline{h}]$. By construction, this shock is orthogonal to the productivity shock. When $\underline{h} = \bar{h} = 0$, this procedure corresponds to identification by Cholesky-ordering.[4]

3.1 Implementation

Technically, let $J\Phi^h \operatorname{chol}(\Sigma)$ be the reduced-form impulse-response of the n-dimensional VAR(p), written in companion form as

$$Y_t = \Phi Y_{t-1} + u_t, u_t \overset{iid}{\sim} \mathcal{N}(0, \Sigma),$$

where J is a selection matrix that picks the first n columns. Identifying shocks is equivalent to finding an orthonormal rotation matrix Q associated with the structural impulse-response $J\Phi^h \operatorname{chol}(\Sigma)Q$. We choose Q to maximize the cumulative forecast error variance of forecast errors. The forecast error variance associated with a single structural shock q is given by:

$$\Omega_{h,i}(q) = \sum_{\ell=0}^{h} e_i' J\Phi^h \operatorname{chol}(\Sigma) q (e_i' J\Phi^h \operatorname{chol}(\Sigma) q)'.$$

[4]In the exploratory analysis, we also tried a sign restrictions strategy did not yield any significant results beyond the restrictions themselves.

Uhlig (2004) demonstrates that we can choose q to maximize the cumulative forecast error variance from $\underline{h}$ to $\bar{h}$ by solving:

$$\max_q qS(i, \underline{h}, \bar{h})q \text{ s.t. } ||q|| = 1, \tag{3.1}$$

where

$$S(i, \underline{h}, \bar{h}) \equiv \sum_{\ell=0}^{\bar{h}} (\bar{h} + 1 - \max\{\underline{h}, \ell\})(J\Phi^h \operatorname{chol}(\Sigma))' e_i e_i' (J\Phi^h \operatorname{chol}(\Sigma)).$$

Taking first order conditions shows that the solution to (3.1) is the same as finding the principal components of $S(\circ)$. Note that for $\underline{h} = \bar{h} = 0$, $S(i, 0, 0) = \operatorname{chol}(\Sigma)' J' e_i e_i' J \operatorname{chol}(\Sigma)$ and the maximizing q yields the first column of a Cholesky-factorization with variable i ordered first.

To identify a second shock that maximizes the FEVD for a variable $j \neq i$, we solve

$$\max_{\tilde{q}} \tilde{q}\tilde{S}(j, \underline{h}, \bar{h}; q)\tilde{q} \text{ s.t. } ||\tilde{q}|| = 1,$$

where

$$\tilde{S}(j, \underline{h}, \bar{h}; q) \equiv \sum_{\ell=0}^{\bar{h}} (\bar{h} + 1 - \max\{\underline{k}, \ell\})(J\Phi^h \operatorname{chol}(\Sigma)[\mathbf{0}, Q_{\perp q}])' e_j e_j' (J\Phi^h \operatorname{chol}(\Sigma)[\mathbf{0}, Q_{\perp q}]),$$

that is, we subtract the first shock associated with q before repeating the procedure. $Q_{\perp q}$ is the $n \times (n-1)$ dimensional matrix formed by the eigenvectors other than q associated with the $n-1$ smallest eigenvalues of the principal components problem implied by (3.1). $\tilde{q}$ is then the eigenvector associated with the eigenvalue of $\tilde{S}(\circ)$.

3.2 Results

Figure 4 plots the IRFs of productivity shock (blue) and redistribution shock (orange) in the VAR(4) estimated from 1951Q2 to 2014Q2. We identify shocks over the horizon $\underline{h} = 0, \bar{h} = 12$.

Both after a negative productivity shock and after a redistribution shock in favor of labor, GDP falls and unemployment rises. But whereas the the gross capital share falls only insignificantly in response to a negative TFP shock, its falls is, by construction, large in response to the redistribution shock. Real wages are procyclical in response to a productivity shock, but countercyclical in response to a redistribution shock. Redistribution shocks also cause the level of the stock market to fall, with most of the effect one to three years after the initial shock. In comparison, there is no significant response in the stock market after a negative productivity shock (although the point estimates are slightly negative).

Figure 5 reports the IRFs of output, capital share, real wage, and the stock market valuation for different choices of $\underline{h}, \bar{h}$, and trend specification. Clearly, the patterns documented by these IRFs are independent of the details of the identification scheme. We repeat the same exercise in Figure 6, where we compare the results from measure of labor productivity with the results obtained from using Fernald's measure of TFP (Fernald, 2014).

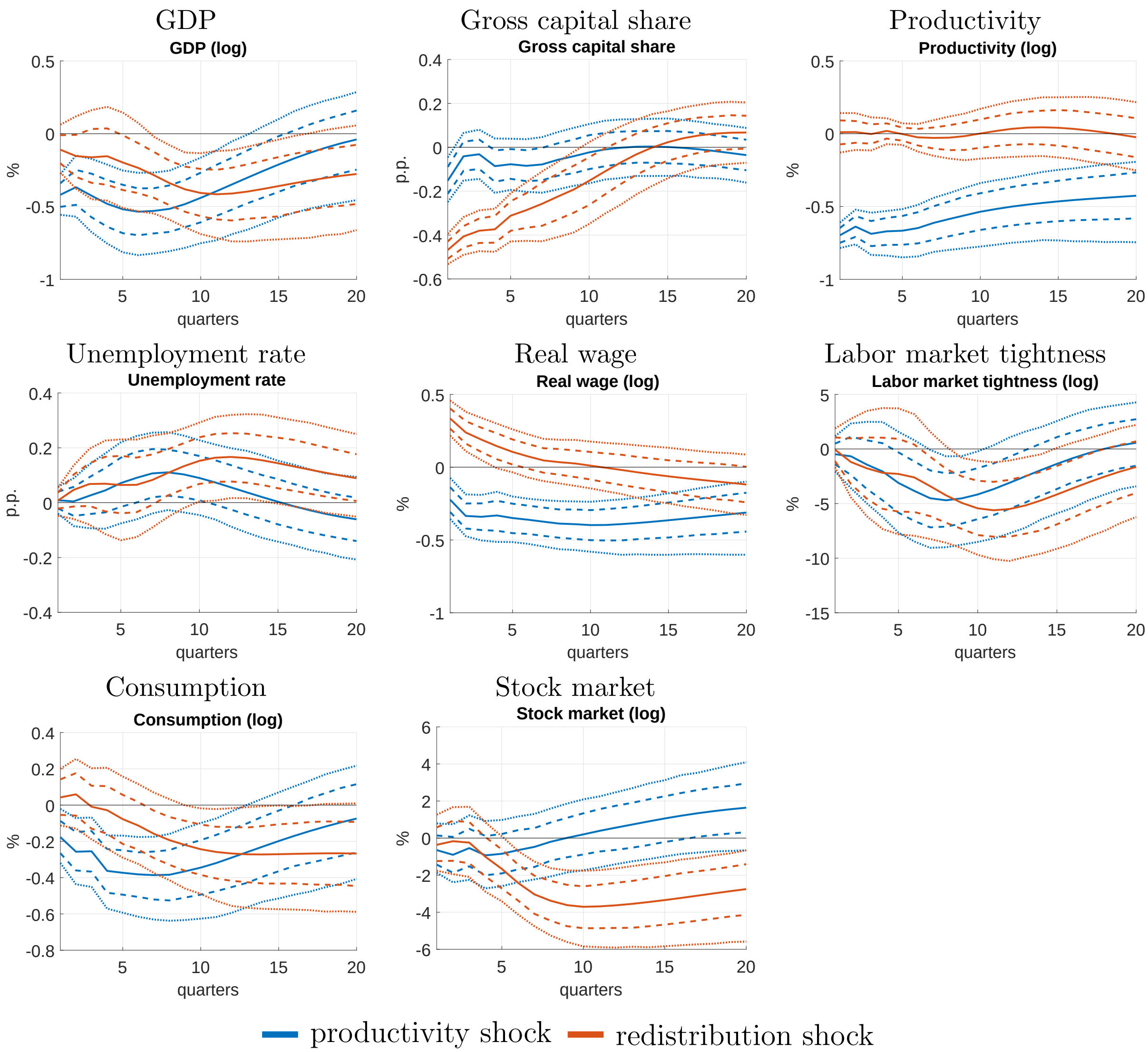


Figure 4: VAR-implied IRFs of productivity shock (blue) and redistribution shock (orange) in VAR(4) estimated from 1951Q2 to 2014Q2. Shown are the (pointwise) posterior median along with 68% and 90% credible sets. The model is estimated with a flat prior. We identify shocks by maximizing the forecast error variance from $\underline{h} = 0$ to $\bar{h} = 12$.

Identifying shocks via forecast error variance maximization avoids imposing zero restrictions as the traditional Cholesky-identification, as done in this context by Greenwald, Lettau, and Ludvigson (2014). This zero restrictions may be difficult to justify with respect to economic theory.[5] However, the results of our VAR analysis are robust to this traditional approach of pure short-run identification, as Figure 7 shows for the IRFs.

[5]Greenwald, Lettau, and Ludvigson (2014) use a model with a constant input of capital and labor to motivate their restrictions.

The qualitative responses of the VAR match those of the calibrated model in Figure 9: Redistribution to labor causes a quantities to fall and the stock market to decline, but wage to rise. However, the VAR implies stronger responses of the capital share and the stock market than our calibrated model.

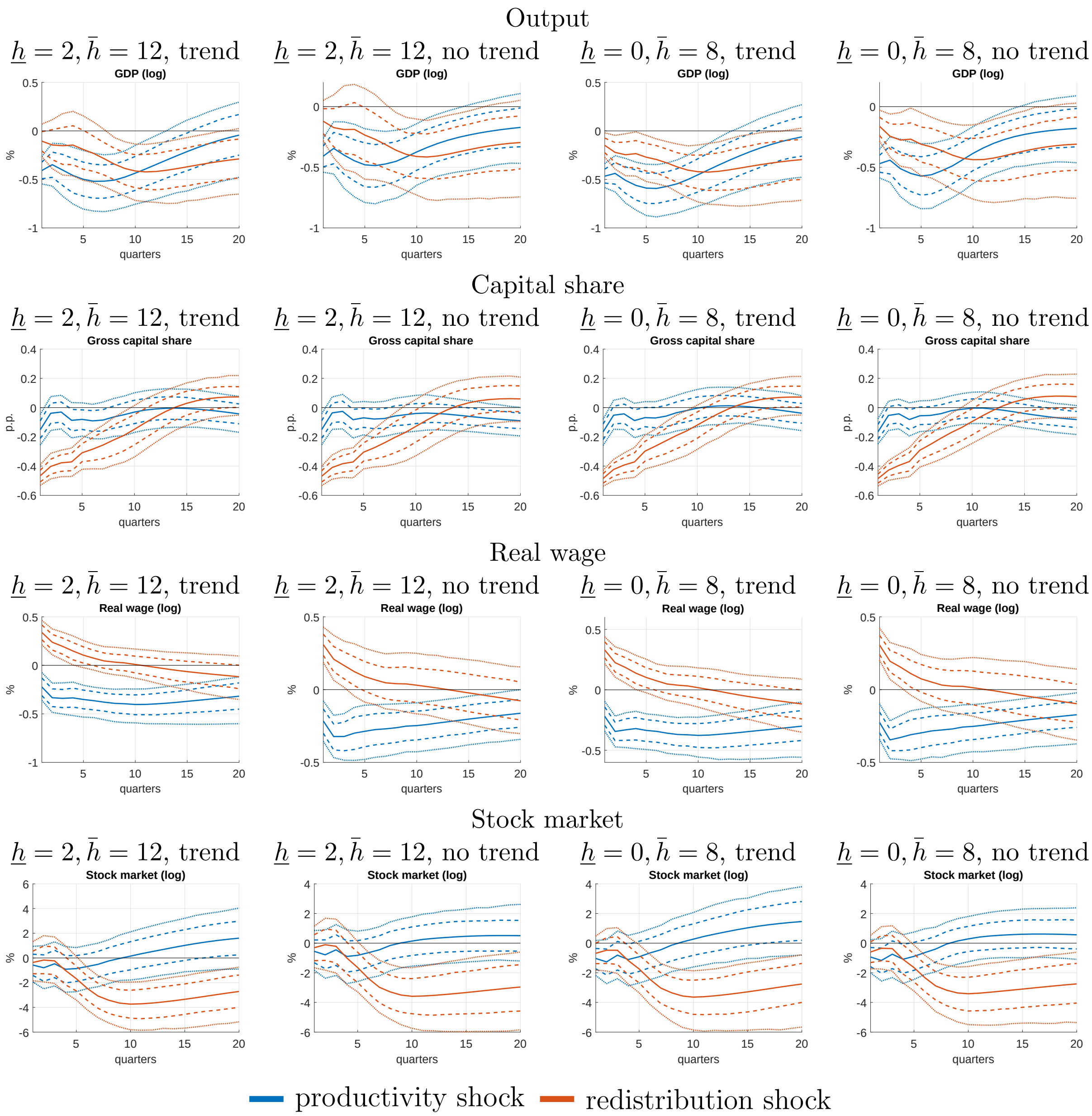


Figure 5: IRF of output, gross capital share, real wage, and the stock market for different VAR specifications: identification at two to three year horizons, with and without trend

The forecast error variance decomposition in Table 5, and its Cholesky-counterpart in Table 7, reveals that redistribution shocks account for about half of the variation in the gross capital share at five year horizons, slightly above 10% of the variation in GDP, and slightly less than 10% of the variation in the unemployment rate. Redistribution shocks also account for more than 20% of the

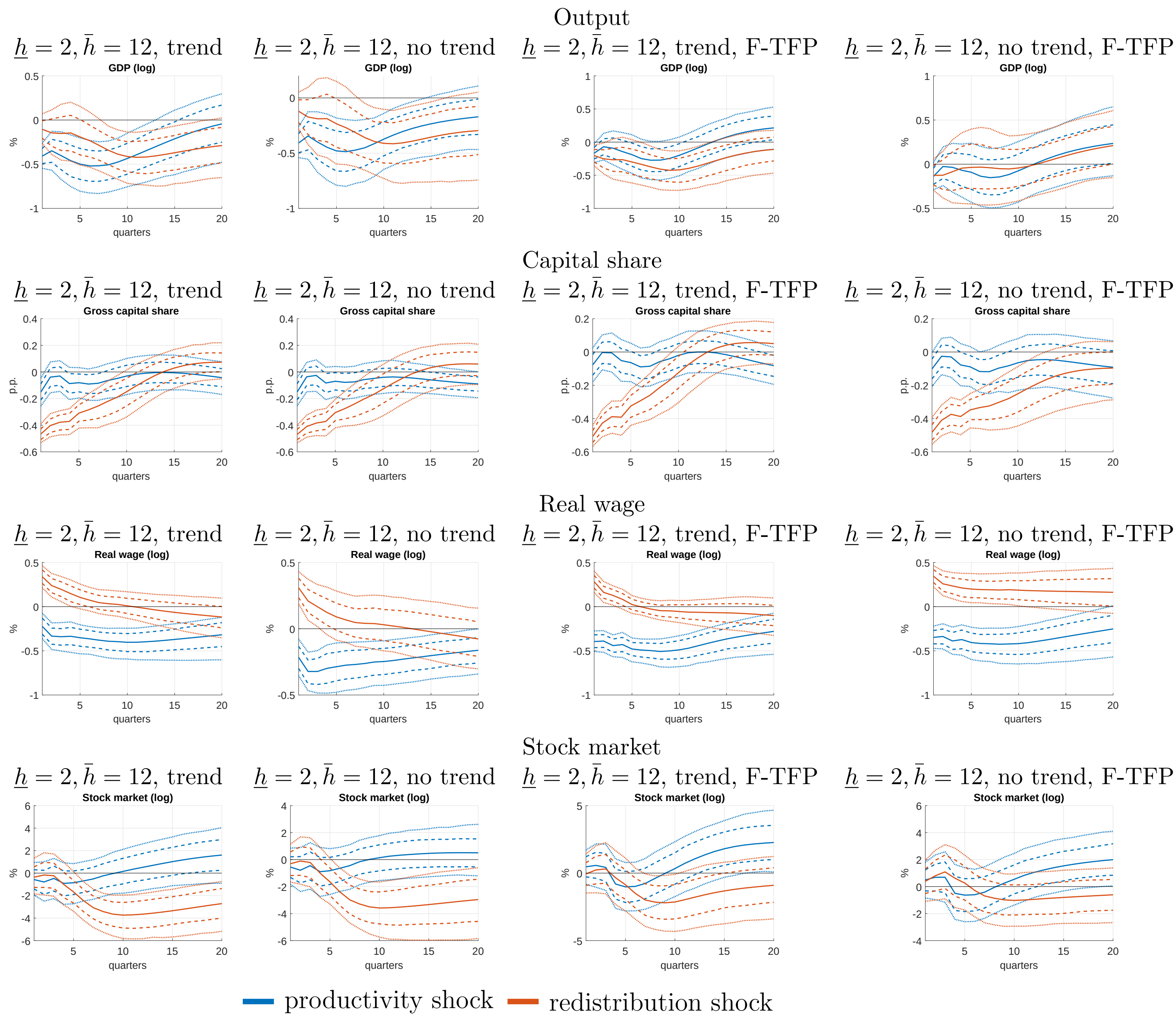


Figure 6: IRF of output, gross capital share, real wage, and the stock market for different VAR specifications: identification at three year horizons, with and without trend, with two different productivity measures. Unless otherwise noted, we use real output per hour. F-TFP: Fernald's overall TFP measure, adjusted for capacity utilization.

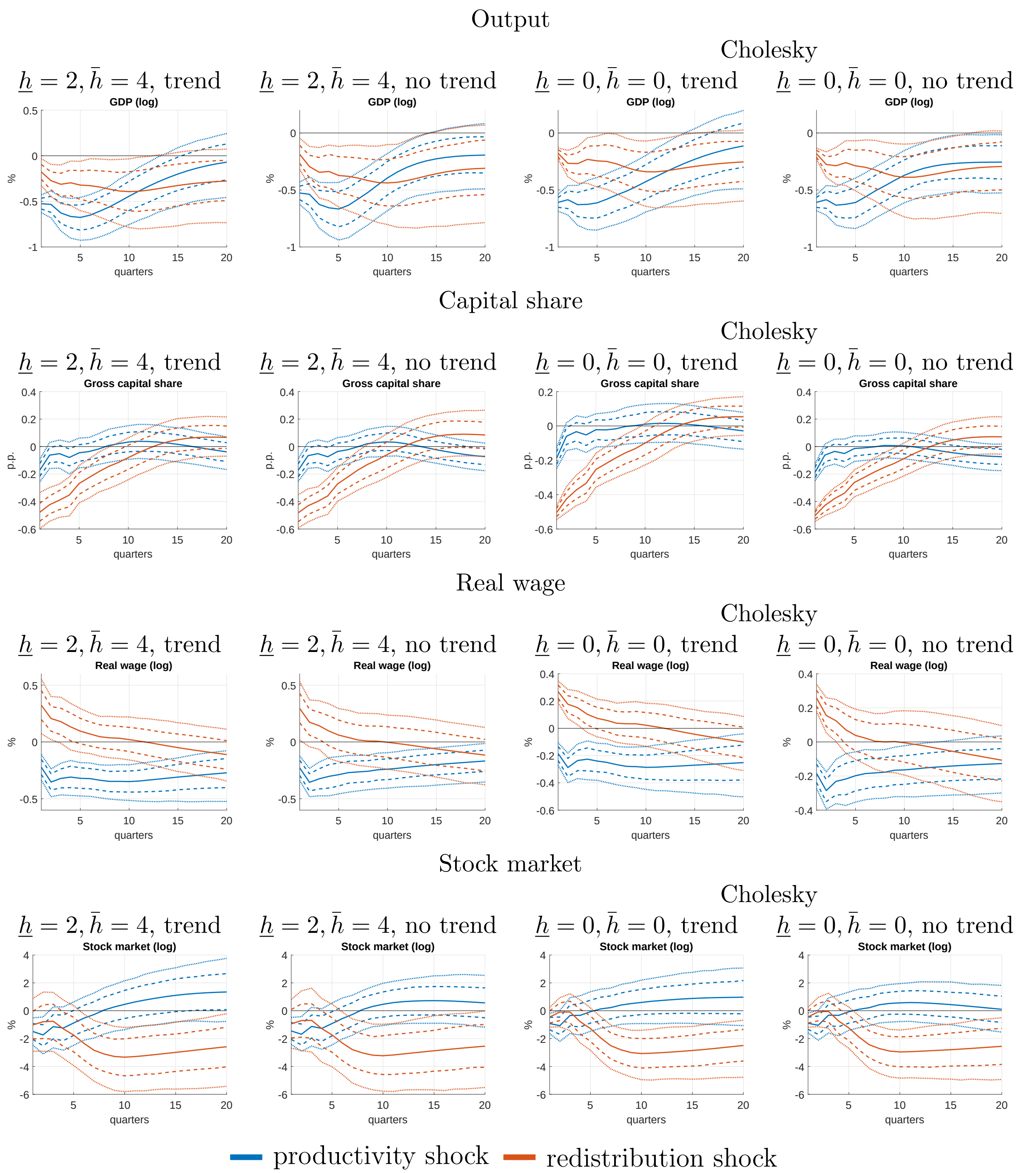


Figure 7: IRF of output, gross capital share, real wage, and the stock market for different VAR specifications: identification at zero to one year horizons, with and without trend

variation in the stock market in our baseline VAR, and 15% when identified via Cholesky-ordering. In contrast, the productivity shock accounts for about one quarter to one third of the variation in GDP at the five year horizon, but only less than 5% of the variation in the stock market valuation. For completeness, we also report the results in Table 6 when using Fernald's TFP measure.

Table 5: VAR-implied FEVD for the productivity shock (top) and redistribution shock (bottom) in VAR(4) estimated from 1951Q1 to 2014Q2 by horizon: $\underline{h} = 0, \bar{h} = 12$, trend

Productivity shock: Cumulative variance contribution up to horizon $\bar{h}$					
Variable	$\bar{h} = 0$ quarters	$\bar{h} = 4$ quarters	$\bar{h} = 12$ quarters	$\bar{h} = 20$ quarters	$\bar{h} = 40$ quarters
Unemployment rate	0.8 (0.1, 3.5)	1.6 (0.4, 5.1)	3.8 (1.1, 9.9)	4.7 (1.8,10.7)	7.6 (3.7,14.1)
GDP (log)	30.3(20.2,41.1)	21.7(12.2,31.2)	24.8(15.0,35.1)	23.3(14.2,33.6)	20.2(13.2,29.3)
Consumption (log)	5.4 (1.4,11.9)	12.0 (5.1,20.9)	18.7 (9.5,29.2)	18.3 (9.3,29.8)	15.7 (9.1,25.8)
Gross capital share	8.3 (2.8,15.4)	5.3 (2.2,10.4)	5.1 (2.4,10.5)	5.2 (2.5,10.4)	6.9 (3.9,12.6)
Real wage (log)	9.1 (3.5,16.9)	21.5(12.7,31.3)	33.5(23.2,44.6)	38.8(28.2,50.6)	36.9(26.0,49.3)
Labor market tightness (log)	1.1 (0.1, 4.2)	2.0 (0.5, 6.6)	6.5 (2.2,13.7)	7.6 (2.9,15.4)	8.8 (4.1,16.2)
Productivity (log)	82.1(73.5,88.6)	85.2(79.4,89.3)	84.7(79.9,88.9)	81.7(75.4,86.8)	70.4(60.5,78.4)
Stock market (log)	1.4 (0.1, 5.4)	2.2 (0.5, 6.4)	3.0 (1.0, 7.0)	4.1 (1.7, 8.8)	8.3 (3.1,16.9)

Redistribution shock: Cumulative variance contribution up to horizon $\bar{h}$					
Variable	$\bar{h} = 0$ quarters	$\bar{h} = 4$ quarters	$\bar{h} = 12$ quarters	$\bar{h} = 20$ quarters	$\bar{h} = 40$ quarters
Unemployment rate	0.9 (0.1, 3.5)	2.9 (0.6, 9.1)	6.2 (2.3,13.7)	10.1 (4.0,18.7)	12.1 (5.0,22.0)
GDP (log)	2.4 (0.3, 7.5)	3.6 (0.8, 9.6)	8.5 (3.8,16.0)	12.4 (5.8,21.1)	14.7 (6.7,25.6)
Consumption (log)	0.9 (0.1, 3.8)	1.6 (0.5, 4.5)	4.6 (1.8, 9.6)	7.5 (2.9,15.1)	12.4 (4.8,22.8)
Gross capital share	78.1(66.0,86.4)	80.4(70.7,86.1)	67.0(60.0,73.9)	57.8(49.7,65.6)	47.5(38.7,56.6)
Real wage (log)	20.5(13.4,29.7)	14.8 (8.8,22.5)	9.8 (5.9,16.0)	8.6 (5.2,13.8)	10.3 (5.4,17.2)
Labor market tightness (log)	1.1 (0.1, 4.4)	2.9 (0.5, 9.1)	7.8 (3.2,15.5)	11.6 (5.3,20.2)	13.6 (6.3,22.7)
Productivity (log)	0.5 (0.0, 2.2)	0.7 (0.2, 1.7)	0.8 (0.3, 2.1)	1.4 (0.5, 3.3)	3.7 (1.7, 8.2)
Stock market (log)	1.2 (0.1, 4.5)	2.4 (0.8, 5.9)	14.6 (7.9,22.7)	22.0(12.9,32.8)	24.4(14.3,36.8)

Shown are the (pointwise) posterior median along with 68% credible sets. The model is estimated with a flat prior.

Table 6: VAR-implied FEVD for the productivity shock (top) and redistribution shock (bottom) in VAR(4) estimated from 1951Q1 to 2014Q2 by horizon: $\underline{h} = 0, \bar{h} = 12$, trend, using F-TFP.

	Productivity shock: Cumulative variance contribution up to horizon $\bar{h}$				
Variable	$\bar{h} = 0$ quarters	$\bar{h} = 4$ quarters	$\bar{h} = 12$ quarters	$\bar{h} = 20$ quarters	$\bar{h} = 40$ quarters
Unemployment rate	1.1 (0.1, 4.2)	2.2 (0.5, 6.4)	3.0 (1.2, 6.8)	4.2 (2.1, 8.3)	8.4 (4.0,15.3)
GDP (log)	4.9 (1.2,10.9)	2.7 (1.0, 7.1)	4.7 (1.5,11.4)	5.6 (2.5,11.8)	9.6 (4.9,17.0)
Consumption (log)	3.2 (0.6, 8.5)	5.4 (1.7,12.2)	7.8 (2.5,16.4)	7.5 (3.3,15.5)	11.1 (5.7,19.1)
Gross capital share	2.0 (0.2, 6.1)	2.1 (0.9, 5.1)	3.2 (1.3, 7.3)	3.7 (1.7, 7.8)	7.3 (3.8,13.1)
Real wage (log)	29.9(20.5,38.8)	44.3(35.2,53.0)	58.2(50.2,66.1)	57.9(49.1,66.2)	45.7(34.6,56.6)
Labor market tightness (log)	1.2 (0.1, 4.3)	1.7 (0.4, 5.5)	3.7 (1.5, 7.6)	4.5 (2.2, 8.7)	6.3 (3.2,11.7)
Productivity (log)	88.1(81.7,92.5)	90.9(87.8,93.3)	88.2(84.3,91.5)	82.4(76.8,87.4)	66.7(55.0,76.3)
Stock market (log)	0.8 (0.1, 3.6)	1.9 (0.8, 4.3)	2.9 (1.4, 6.0)	4.9 (2.6, 9.1)	10.3 (4.5,19.5)

	Redistribution shock: Cumulative variance contribution up to horizon $\bar{h}$				
Variable	$\bar{h} = 0$ quarters	$\bar{h} = 4$ quarters	$\bar{h} = 12$ quarters	$\bar{h} = 20$ quarters	$\bar{h} = 40$ quarters
Unemployment rate	1.3 (0.1, 4.8)	4.7 (0.9,12.2)	8.4 (3.1,18.2)	10.9 (4.3,20.5)	11.2 (4.7,20.3)
GDP (log)	8.3 (2.7,15.7)	8.7 (2.6,17.0)	13.2 (5.4,23.0)	14.6 (6.2,24.4)	12.7 (5.8,22.3)
Consumption (log)	0.6 (0.1, 2.9)	1.6 (0.5, 4.8)	4.3 (1.4,10.8)	5.3 (1.7,12.9)	5.4 (2.0,12.6)
Gross capital share	87.1(78.5,92.9)	86.4(80.2,90.7)	71.3(64.3,77.8)	60.1(52.2,68.4)	48.5(40.0,57.8)
Real wage (log)	15.0 (8.5,22.5)	9.6 (5.5,15.2)	5.8 (3.4, 9.2)	5.0 (2.8, 8.7)	5.2 (2.6,10.6)
Labor market tightness (log)	2.2 (0.2, 7.0)	5.9 (1.2,14.3)	13.3 (5.7,24.0)	16.7 (8.2,27.4)	17.3 (8.9,27.6)
Productivity (log)	0.4 (0.0, 1.9)	0.7 (0.3, 1.6)	1.0 (0.4, 2.1)	1.5 (0.7, 3.1)	2.8 (1.1, 6.9)
Stock market (log)	0.8 (0.1, 3.3)	1.4 (0.5, 4.4)	5.3 (2.0,11.0)	6.7 (2.3,14.0)	6.6 (2.3,14.4)

Shown are the (pointwise) posterior median along with 68% credible sets. The model is estimated with a flat prior.

Table 7: VAR-implied FEVD for the productivity shock (top) and redistribution shock (bottom) in VAR(4) estimated from 1951Q1 to 2014Q2 by horizon: Cholesky, trend

	Productivity shock: Cumulative variance contribution up to horizon $\bar{h}$				
Variable	$\bar{h} = 0$ quarters	$\bar{h} = 4$ quarters	$\bar{h} = 12$ quarters	$\bar{h} = 20$ quarters	$\bar{h} = 40$ quarters
Unemployment rate	11.1 (7.2, 15.5)	10.5 (5.9,16.0)	10.1 (5.1,17.6)	9.6 (4.9,16.6)	10.1 (5.7,16.8)
GDP (log)	63.4 (59.3, 67.5)	43.6(36.5,50.7)	37.5(29.0,46.8)	32.7(24.0,42.8)	25.7(17.8,35.3)
Consumption (log)	5.4 (2.7, 8.7)	10.2 (5.3,15.4)	12.9 (6.7,20.7)	12.5 (6.2,21.0)	10.7 (5.5,18.5)
Gross capital share	12.2 (8.1, 16.6)	6.7 (4.1,10.1)	4.7 (2.9, 7.4)	4.5 (2.7, 7.3)	5.3 (3.2, 8.9)
Real wage (log)	6.3 (3.4, 10.2)	13.2 (8.2,19.2)	18.5(11.4,26.8)	21.6(13.1,31.8)	22.0(12.6,34.0)
Labor market tightness (log)	12.9 (8.6, 17.5)	11.2 (6.4,16.7)	12.2 (6.6,19.5)	11.9 (6.4,19.3)	11.6 (6.6,19.2)
Productivity (log)	100.0(100.0,100.0)	86.8(82.6,90.4)	70.7(62.3,78.0)	64.3(54.2,73.4)	54.2(42.3,65.1)
Stock market (log)	2.0 (0.5, 4.4)	1.9 (0.8, 4.2)	2.3 (1.0, 4.6)	2.9 (1.2, 6.0)	4.5 (1.7,11.0)

	Redistribution shock: Cumulative variance contribution up to horizon $\bar{h}$				
Variable	$\bar{h} = 0$ quarters	$\bar{h} = 4$ quarters	$\bar{h} = 12$ quarters	$\bar{h} = 20$ quarters	$\bar{h} = 40$ quarters
Unemployment rate	2.9 (1.2, 5.5)	6.8 (3.6,11.5)	7.6 (3.4,13.7)	9.0 (4.1,16.7)	10.1 (4.4,18.4)
GDP (log)	5.4 (3.8, 7.4)	6.6 (3.7,10.4)	8.7 (3.9,15.2)	10.5 (4.6,18.4)	12.1 (5.2,21.4)
Consumption (log)	0.2 (0.0, 0.9)	0.8 (0.3, 2.0)	2.3 (0.7, 6.5)	4.2 (1.2,10.7)	8.5 (2.9,17.5)
Gross capital share	87.8(83.4,91.9)	82.5(77.6,86.5)	61.1(52.9,68.6)	50.6(42.0,59.0)	40.4(32.1,49.0)
Real wage (log)	13.2 (9.3,17.7)	9.1 (5.9,13.4)	6.4 (3.9,10.4)	5.9 (3.5, 9.5)	7.6 (3.9,13.4)
Labor market tightness (log)	4.3 (2.1, 7.3)	7.1 (3.6,11.9)	8.9 (4.2,15.5)	10.5 (5.1,18.1)	11.0 (5.6,19.0)
Productivity (log)	0.0 (0.0, 0.0)	0.5 (0.2, 1.3)	1.2 (0.4, 3.1)	1.7 (0.6, 4.4)	3.8 (1.7, 8.3)
Stock market (log)	0.5 (0.0, 1.9)	1.2 (0.5, 2.9)	9.6 (4.8,15.8)	15.4 (8.1,23.6)	18.2 (9.8,28.3)

Shown are the (pointwise) posterior median along with 68% credible sets. The model is estimated with a flat prior.

4 Model

In this section, we propose a quantitative, discrete-time stochastic neoclassical growth model with labor search and matching in the tradition of Andolfatto (1996) and Merz (1995). Specifically, we build on the formulation in Shimer (2010). In the model, there is a representative household and a final good producer. To make the model closer to the data along important dimensions for our exercise, we add taxes on 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, Rubinstein, and Wolinsky (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 momentarily, the capital income share at the steady state is mostly pinned down by other deep parameters 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 B the description of the full model and its detailed analysis.

4.1 Households

There is a representative household formed by a continuum of individuals of measure 1. Each individual 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:

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

and budget constraint:

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

Let us describe each of these two expressions. 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 that are employed at time t, fraction that, as we will explain below, it 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 let us transform net income in each period into present valuations (with $m_0 = 1$). Net income is given by consumption less after-tax labor income and T_t, the net result of lump-sum transfers and profits from the ownership of firms (capital is owned directly by the firm). Labor income is determined by the wage w_t and it is taxed at a rate τ.

When making her decisions, the household considers that workers lose their jobs at rate x and find new jobs at rate $f_t(\theta_t)$, where θ_t is the labor market tightness that the representative household takes as given. Thus, the fraction of household members employed next period will be:

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

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

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

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

For an investment i_t, capital k_t evolves as:

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

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:

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

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

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

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:

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

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

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 (i.e., an administration that appoints more union-friendly board members at the NLRB or a major decision regarding labor relations at the Supreme Court of the United States), as well as potentially other shocks (for example, structural change in the economy such as a move from manufacturing factories to decentralized services that difficult workers collective action).[6]

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 $\tilde{w}_t$. 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. Total factor productivity z_t follows an AR(1) process with deterministic gross trend growth $g_z > 1$. In the appendix, we also allow for permanent shocks to labor productivity. ϕ_t follows a stationary AR(1) processes. All shocks are Gaussian and *iid*. The persistence is given by ρ_i and the standard deviation by ω_i, for $i \in \{z, \phi\}$. In contrast with other papers in the literature, we hold the matching efficiency ξ constant. This helps us to isolate more transparently the effects of innovations to bargaining power.

4.5 Market clearing

Aggregate employment must follow the law of of motion for the representative household (B.3), where the recruiter-unemployment ratio satisfies:

$$\theta_t = \frac{n_{t-1}}{1 - n_{t-1}} \nu_t. \tag{4.8}$$

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

$$y_t = c_t + i_t. \tag{4.9}$$

[6] Binmore, Rubinstein, and Wolinsky (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 microfoundation for how policies that change the bargaining procedure induce changes in ϕ_t if the parties to the bargain have impatience for the outcomes.

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

4.6 Equilibrium

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

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

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.

5 Taking the model to the 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 in our model to be the sum of final goods production and the cost of recruiting:

$$yr_t \equiv y_t + \nu_t n_{t-1} w_t. \tag{5.1}$$

The cost of recruiting is not accounted in 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:

$$cs_t \equiv 1 - \frac{n_{t-1}w_t}{yr_t}, \tag{5.2a}$$

$$ncs_t \equiv 1 - \frac{n_{t-1}w_t}{yr_t} - \bar{\delta}\frac{k_{t-1}}{yr_t}. \tag{5.2b}$$

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.

We calibrate our model to U.S. data. We focus on three sets of variables. First, we match characteristics of the nonfinancial corporate business sector - such as the share of capital and the return to capital. Second, we match the moments of GDP, consumption, and investment, as is customary in the business cycle literature. Third, we match some labor market statistics.

We choose the rate of time preference, 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 percent, (2) the ratio of depreciation to gross value added of 12.7 percent, and (3) the (annualized) ratio of capital to gross value added of 2.3. We calibrate the average corporate tax rate to 30 percent, the average observed in the data. The implied annual depreciation rate is 5.5 percent and the annualized discount rate, given a growth rate of labor productivity of 1.6 percent per year (Cooley and Prescott, 1995), is 0.976. The corresponding capital share α depends on the elasticity of substitution, but is simply 0.31 in the Cobb-Douglas case.

Regarding the productivity process in the baseline model, we calibrate the monthly process for labor productivity to match the quarterly process for TFP in Cooley and Prescott (1995). At a quarterly frequency, they find an autocorrelation of 0.95 and a standard deviation of shocks of 0.73 percent. Averaging monthly observations within quarters, their values correspond to a monthly autocorrelation of $0.95^{1/3}$ and a standard deviation of TFP of 0.73 percent. Because in our model TFP varies only due to labor-augmenting productivity growth, we scale the TFP standard deviation by the one over the share of labor in final goods production.[7]

With respect to the persistence of the bargaining shock, we use the same value than for the persistence of the productivity shock, $0.95^{1/3}$. This implies a half-life of 41 months, a duration slightly below that of a presidential term and slightly above the time it would take to replace three out five members on the NLRB. Thus, besides its parsimony, this parameter value fits the persistence of political appointments.[8]

Given all the parameter values above, we calibrate the volatility of the bargaining power shock and the investment adjustment cost to target the overall volatility of GDP and the relative volatility of investment to GDP, after HP-filtering. This yields a monthly standard deviation of the bargaining power shock of 3.4 percent.[9] Setting the elasticity of utilization with respect to the marginal product of capital to $\frac{1}{2}$ (i.e., $\delta_2 = 2\delta_1$), we find that $\kappa = 0.08/\delta_0^2$ matches the relative volatility of investment and consumption after productivity shocks given the volatility of the bargaining power shock.

We calibrate the labor market following Shimer (2010, p. 80f.). The exogenous separation rate x is 3.3 percent per month, the average unemployment rate is 5 percent, 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 bargaining power ϕ to 0.5.[10] As in Prescott (2004), the labor income

[7] $\frac{d \ln Y}{d \ln z} = \overline{MPL}^{1-\epsilon}(1-\alpha)$ equals the labor share because firms choose production workers such that $\bar{w} = \overline{MPL}$ and, from the production function, $\frac{\bar{n}(1-\bar{\nu})}{\bar{Y}} = \overline{MPL}^{-\epsilon}(1-\alpha)^{-1}$.

[8] Appendix B.12 considers different half-lives for the bargaining power shock. The output effects of the shock are largely invariant to the persistence, but the effects on the capital share are higher when persistence is lower, in line with our steady state analysis below.

[9] We define per capita consumption as the sum of real consumer nondurables 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 Appendix A.

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

tax rate combines the consumption taxes and the actual labor tax rate and is set at 40 percent. Choosing a risk aversion of $\sigma = 2$ implies that consumption complements labor moderately and that the employed consume 30 percent more than the unemployed.

Our baseline production function features a unitary elasticity of substitution between capital and labor, as in Cooley and Prescott (1995) and many others. Alternatively, we consider a values of $\varepsilon = 1 \pm 0.25$, reflecting the recent estimates of Karabarbounis and Neiman (2014) and Oberfield and Raval (2014). Oberfield and Raval (2014) 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. Karabarbounis and Neiman (2014) estimate the elasticity of substitution of 1.25 using long-run differences across countries.

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 inv. $\bar{\chi}$	1
Avg detrended TFP $\tilde{z}$	1
Trend productivity growth g_z	$1.016^{1/12}$
Investment adjustment cost κ	$0.08 \times (\delta_0)^{-2}$
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
Income tax rate τ_n	0.4
Corporate tax rate τ_k	0.3
Shock persistences ρ_ϕ, ρ_z	$0.95^{1/3}$
Bargaining power s.d. $\approx 0.22 \times \omega_\phi$ *	3.40%
TFP s.d. ω_z	0.73%
Implied gross capital share $\overline{cs}$	31.2%
Implied net capital share $\overline{ncs}$	16.9%

* The bargaining power ϕ_t is transformed to levels via $x \equiv \frac{\bar{e}^{\tilde{x}}}{1+\bar{e}^{\tilde{x}}}$. The multiplier is $\frac{dx}{d\tilde{x}}$.

Table 8: Calibrated parameters

Note that the capital shares are completely independent of the bargaining power parameter when we re-calibrate the disutility of working to keep employment constant. The matching efficiency ξ is calibrated for any given average employment level $\bar{n}$ to ensure that the recruiter-employment ratio along the balanced-growth path $\bar{\theta}$ 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.

6 Solution

To solve our model, we detrend all variables as needed and use perturbation methods to solve for the equilibrium of the detrended economy. In the next section, to compute business cycle statistics, we add the trend to all trending variables before HP-filtering. In the model, labor productivity grows at gross rate g_z. Capital, consumption, investment, the marginal value of employment, the marginal product of labor, and wages grow at rate g_z, while all other variables are stationary. Because we are interested in non-linear dynamics, we use a third-order approximation. To ensure stability, we apply the pruning method developed by Andreasen, Fernandez-Villaverde, and Rubio-Ramirez (2013). Unlike the partial equilibrium search model in Petrosky-Nadeau and Zhang (2013), we document in Appendix B.9 that the perturbation method performs well in terms of accuracy. For example, the mean Euler equation errors are below 0.5 percent of consumption and the 99th percentile of Euler errors is around 1.5 percent.[11]

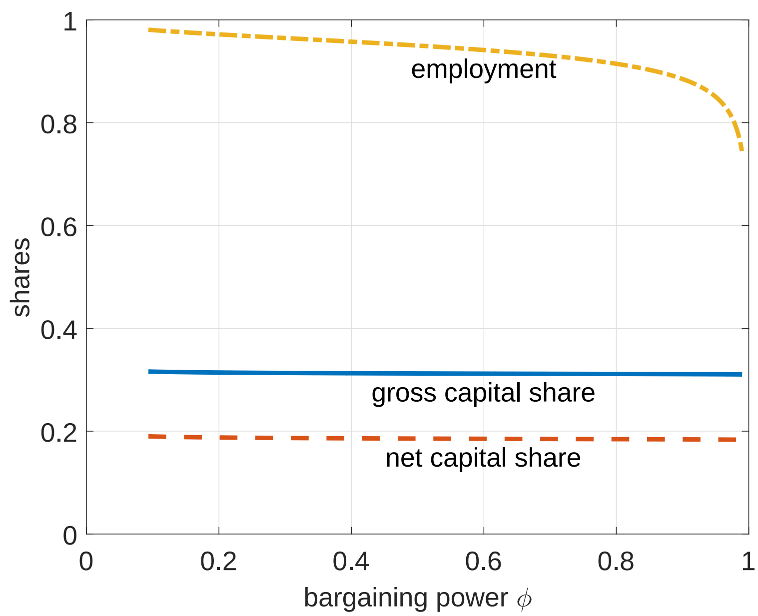


Figure 8: Deterministic steady state capital shares and employment as a function of bargaining power for given disutility of working . Note: Missing values indicate that no solution could be found.

Figure 8 shows how, in the neighborhood of the calibrated (detrended) steady state, the capital share is almost invariant to the bargaining power. This is because in the long-run, the capital share is overwhelmingly determined by technology and preferences. In our baseline calibration, 31 out of the 31.2 percentage points of the gross capital share are compensation for depreciation,

[11] Petrosky-Nadeau and Zhang (2013) argue that the DMP exhibits non-linearities that first- and second-order perturbations do not capture adequately. Their model has an inequality constraint on vacancies that can be occasionally binding. The analog in our model is the fraction of recruiters ν_t. We find that both the capital and the recruiting Euler equation are well approximated in our calibration because, along the equilibrium path, the fraction of recruiters ν_t does not get to zero. We conjecture that the perturbation method does better in our model because, in general equilibrium, prices move to keep agents away from corners.

impatience, and growth. For our benchmark risk aversion, the capital share is almost constant. Instead, employment moves to equate the marginal product of labor to the varying wage rate (adjusted for recruiting costs). Because of the same reasoning, 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.

Finally, before we enter into the results section, let us mention that we formulate and calibrate, using the same criteria than for our baseline economy, a real business cycle *à la* Hansen-Rogerson where we eliminate the search and matching frictions. In that way, we can benchmark our search and matching 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 B.11 and its quantitative properties are reported at the rows "RBC model" in Table 9.

7 Quantitative results I: business cycle statistics

Table 9 compares U.S. business cycle statistics to those of our search and matching (S&M) model (with and without bargaining shocks) and its real business cycle (RBC) counterpart. We focus on statistics that describe the volatility, persistence, and cyclicality of our model variables. All business cycle statistics are based on HP-filtered quarterly variables. 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, both the gross and the net capital share are pro-cyclical, but much less so than consumption and investment. The net capital share is more cyclical than the gross capital share, with a correlation of 0.57 compared to 0.36. Investment is about 3.3 times as volatile as GDP, whereas consumption is only about 0.6 times as volatile. With correlations of 0.91 and 0.83, both investment and consumption are highly pro-cyclical. The volatility of (log) GDP is slightly less than 2.0 percent per quarter. All variables are very persistent, with quarterly autocorrelations of 0.68 to 0.87 (Table 9).

How does our model compare to the data? Recall that we calibrated the capital adjustment cost to match the relative volatility of investment (3.29) and consumption (0.59) in the data. The baseline model delivers 3.23 and 0.58 (see the rows "S&M model" with "baseline" and "US data" in Table 9). If we eliminate the bargaining shock (but keep all the other parameters, including adjustment costs, at their baseline value), the volatility of output drops 39 percent (1.19 versus 1.96 in the data; see the row "No bargaining shocks"). Without these bargaining shocks, the performance of the model in terms of the relative volatility of investment and consumption is still satisfactory.[12]

[12] As a robustness check, we tried a different strategy. In this alternative exercise, 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, bargaining shocks accounted for 40 percent of fluctuations, instead of 39 percent as in our baseline exercise.

Table 9: Business cycle statistics: 1947Q1–2015Q2

	Y [%]	$\frac{\text{std(I)}}{\text{std(Y)}}$	$\frac{\text{std(C)}}{\text{std(Y)}}$	std(ncs) [%]	std(cs) [%]	std(w) [%]	
US data	1.96	3.29	0.59	1.07	0.86	0.95	
				Models			
S&M model	1.95	3.23	0.58	0.39	0.22	1.29	Baseline
S&M model	1.19	3.49	0.53	0.16	0.01	1.05	No bargaining shock
RBC model	1.92	3.51	0.56	0.25	0.00	0.83	Hansen-Rogerson

	Y	I	C	ncs	cs	w	
Output corr.	1.00	0.91	0.83	0.57	0.36	0.19	
				Models			
S&M model, output corr.	1.00	0.97	0.99	0.82	0.33	0.08	Baseline
S&M model, output corr.	1.00	0.99	0.99	0.98	0.88	1.00	No bargaining shock
RBC model, output corr.	1.00	0.98	0.99	0.98	NaN	0.96	Hansen-Rogerson

	Y	I	C	ncs	cs	w	
Auto-corr.	0.87	0.82	0.78	0.76	0.74	0.68	
				Models			
S&M model, auto-corr.	0.82	0.80	0.83	0.76	0.65	0.79	Baseline
S&M model, auto-corr.	0.79	0.80	0.80	0.78	0.57	0.78	No bargaining shock
RBC model, auto-corr.	0.80	0.80	0.80	0.82	NaN	0.76	Hansen-Rogerson

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

The model with "no bargaining shock" fails, however, to generate any meaningful fluctuations in the gross capital share and only around 16 percent of the fluctuations in the net capital share. Instead, with bargaining shocks, the model can account for slightly less than 26 percent of the volatility of the gross and 36 percent of the volatility of the net capital share in the data.

The search model with bargaining shocks also captures the cyclicality and persistence of the capital shares well. With respect to cyclicality, the model overstates a bit the cyclicality of the net capital share and understates that of the gross capital share. In comparison, the model with "no bargaining shock" does considerably worse in terms of correlations of the gross and net capital shares with the data, with correlations close to 1. This is not a surprise: in the absence of bargaining shocks, the only moves in these shares come from changes in depreciation 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 0.65, understates the empirical autocorrelation of the gross capital share of 0.74 only slightly. The model with "no bargaining shock" does a worse job matching these autocorrelations.

Finally, the search model does a fair job in generating a nearly acyclical wage: the correlation of output and wages is 0.08 in the model versus 0.19 in the data. The procyclicality of wages in productivity-driven models (higher productivity increases 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 of wages and output.

7.1 Comparison with a real business cycle model

Could a standard real business cycle model account for the same features of the data than our search and matching model with bargaining shocks? To answer this question, we report in the rows "RBC model" in Table 9 the quantitative properties of the real business cycle model *à la* Hansen-Rogerson introduced at the end of section 6.[13]

While this model does very well for the standard business cycle moments, it generates less than half as much fluctuation in the net capital share than our baseline model. Plus, the net capital share is too cyclical and the wage is too procyclical (correlation of 0.96 with output). By construction, this real business cycle model cannot generate any volatility in the gross capital share. This is, of course, because we assumed a unitary elasticity of substitution between capital and labor. We relax this assumption in the next subsection.

[13]See, also, Figures B.12 for the full set of impulse response functions with unitary elasticity of substitution and Figures B.13 and B.14 for the corresponding figures with elasticities of $\varepsilon = 1 \pm 0.25$.

7.2 The role of the elasticity of substitution

Could the search and matching model without bargaining shocks or the real business cycle version of our model match the data when the elasticity of substitution is different from one? In Table 10 we provide the model moments for elasticities of substitution between capital and labor of $\varepsilon = 1 \pm 0.25$. This range includes both the estimates in Oberfield and Raval (2014) and Karabarbounis and Neiman (2014) than we described in section 5.

When we depart from $\varepsilon = 1$, even the real business cycle model produces fluctuations in the capital share, but it cannot match the low but positive cyclicality of the gross capital share. For example, with $\varepsilon = 0.75$, the real business cycle generates a correlation of the gross capital share with output of -0.93 vs. 0.36 in the data. For $\varepsilon = 1.25$, the same correlation is 0.97. 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 cyclicality of capital shares, either getting the sign wrong ($\varepsilon = 0.75$) or considerably overstating them ($\varepsilon = 1.25$).

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 (0.00 vs. 0.36). With $\varepsilon = 1.25$, the result flips, the model can match the gross capital share (0.37 vs. 0.36 in the data), but not the net share (0.79 vs. 0.57 in the data). In both cases the bargaining shock accounts for between 36 and 41 percent of fluctuations.

7.3 Alternative calibration: matching unemployment volatility

Interestingly, our baseline models yields excess volatility of unemployment. The HP-filtered average quarterly unemployment rate has a standard deviation of 0.81 percent in the data, but of 1.94 percent in our calibration. This excess volatility is in stark contrast with 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 in half, however, almost exactly 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. As Table 11 shows, in this case our model explains slightly less than 10 percent of the volatility of the gross capital share, almost fully because of bargaining power shocks. 80 percent of employment fluctuations are due to fluctuations in the bargaining power, as well as 7 percent and 9 percent of output and consumption volatility, respectively.

While the contribution of bargaining power shocks to unemployment, output, and consumption are robust to departures from the Cobb-Douglas assumption, the contribution to the explained capital share is not. When we cut the volatility of the bargaining power shocks in half and ε is different from 1, the alternative calibrations imply a counterfactual cyclicality of the capital share, whereas the Cobb-Douglas specification matches it exactly.

Table 10: Elasticity of substitution and business cycle statistics: 1947Q1-2015Q2.

	Y [%]	$\frac{\text{std(I)}}{\text{std(Y)}}$	$\frac{\text{std(C)}}{\text{std(Y)}}$	std(ncs) [%]	std(cs) [%]	std(w) [%]	
US data	1.96	3.29	0.59	1.07	0.86	0.95	
			$\varepsilon = .75$				
S&M model	2.03	3.30	0.56	0.44	0.35	1.64	Baseline
S&M model	1.30	3.50	0.53	0.08	0.23	1.41	No bargaining shock
RBC model	2.42	3.58	0.57	0.18	0.17	1.01	Hansen-Rogerson
			$\varepsilon = 1.25$				
S&M model	1.91	3.24	0.58	0.43	0.27	1.08	Baseline
S&M model	1.13	3.50	0.53	0.30	0.15	0.84	No bargaining shock
RBC model	1.61	3.53	0.55	0.33	0.12	0.72	Hansen-Rogerson

	Y	I	C	ncs	cs	w	
Output corr.	1.00	0.91	0.83	0.57	0.36	0.19	
			$\varepsilon = 0.75$				
S&M model, output corr.	1.00	0.98	0.99	0.58	0.00	0.17	Baseline
S&M model, output corr.	1.00	0.99	0.99	-0.82	-1.00	1.00	No bargaining shock
RBC model, output corr.	1.00	0.97	0.99	0.83	-0.93	0.93	Hansen-Rogerson
			$\varepsilon = 1.25$				
S&M model, output corr.	1.00	0.97	0.99	0.79	0.37	-0.00	Baseline
S&M model, output corr.	1.00	0.99	0.99	0.99	1.00	1.00	No bargaining shock
RBC model, output corr.	1.00	0.99	0.99	0.99	0.97	0.97	Hansen-Rogerson

	Y	I	C	ncs	cs	w	
Auto-corr.	0.87	0.82	0.78	0.76	0.74	0.68	
			$\varepsilon = 0.75$				
S&M model, auto-corr.	0.82	0.80	0.83	0.75	0.73	0.78	Baseline
S&M model, auto-corr.	0.80	0.80	0.80	0.64	0.79	0.78	No bargaining shock
RBC model, auto-corr.	0.80	0.80	0.80	0.30	0.74	0.74	Hansen-Rogerson
			$\varepsilon = 1.25$				
S&M model, auto-corr.	0.82	0.80	0.83	0.76	0.71	0.79	Baseline
S&M model, auto-corr.	0.79	0.79	0.79	0.79	0.78	0.78	No bargaining shock
RBC model, auto-corr.	0.80	0.80	0.80	0.80	0.77	0.77	Hansen-Rogerson

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

	std(Y) [%]	$\frac{\text{std(I)}}{\text{std(Y)}}$	$\frac{\text{std(C)}}{\text{std(Y)}}$	std(cs) [%]	std(w) [%]	std(N) [%]	
US data	1.96	3.29	0.59	0.86	0.95	0.81	
			$\varepsilon = 0.75$				
S&M model	1.44	3.40	0.54	0.25	1.45	0.80	50% lower volatility of ϕ_t
S&M model	1.30	3.50	0.53	0.23	1.41	0.24	No bargaining shock
RBC model	2.42	3.58	0.57	0.17	1.01	3.36	Hansen-Rogerson
			$\varepsilon = 1.00$				
S&M model	1.33	3.36	0.55	0.08	1.09	0.78	50% lower volatility of ϕ_t
S&M model	1.19	3.49	0.53	0.01	1.05	0.13	No bargaining shock
RBC model	1.92	3.51	0.56	0.00	0.83	1.18	Hansen-Rogerson
			$\varepsilon = 1.25$				
S&M model	1.28	3.35	0.55	0.17	0.88	0.78	50% lower volatility of ϕ_t
S&M model	1.13	3.50	0.53	0.15	0.84	0.07	No bargaining shock
RBC model	1.61	3.53	0.55	0.12	0.72	0.74	Hansen-Rogerson

	Y	I	C	cs	w	N	
Output corr.	1.00	0.91	0.83	0.36	0.19	-0.76	
			$\varepsilon = 0.75$				
S&M model, output corr.	1.00	0.98	0.99	-0.66	0.78	-0.65	50% lower volatility of ϕ_t
S&M model, output corr.	1.00	0.99	0.99	-1.00	1.00	-0.95	No bargaining shock
RBC model, output corr.	1.00	0.97	0.99	-0.93	0.93	-0.72	Hansen-Rogerson
			$\varepsilon = 1.00$				
S&M model, output corr.	1.00	0.98	0.99	0.38	0.74	-0.57	50% lower volatility of ϕ_t
S&M model, output corr.	1.00	0.99	0.99	0.88	1.00	-0.97	No bargaining shock
RBC model, output corr.	1.00	0.98	0.99	NaN	0.96	-0.95	Hansen-Rogerson
			$\varepsilon = 1.25$				
S&M model, output corr.	1.00	0.98	0.99	0.85	0.70	-0.53	50% lower volatility of ϕ_t
S&M model, output corr.	1.00	0.99	0.99	1.00	1.00	-0.96	No bargaining shock
RBC model, output corr.	1.00	0.99	0.99	0.97	0.97	-0.96	Hansen-Rogerson

	Y	I	C	cs	w	N	
Auto-corr.	0.87	0.82	0.78	0.74	0.68	0.90	
			$\varepsilon = 0.75$				
S&M model, auto-corr.	0.81	0.80	0.81	0.77	0.78	0.82	50% lower volatility of ϕ_t
S&M model, auto-corr.	0.80	0.80	0.80	0.79	0.78	0.82	No bargaining shock
RBC model, auto-corr.	0.80	0.80	0.80	0.74	0.74	0.79	Hansen-Rogerson
			$\varepsilon = 1.00$				
S&M model, auto-corr.	0.80	0.79	0.81	0.56	0.78	0.82	50% lower volatility of ϕ_t
S&M model, auto-corr.	0.79	0.80	0.80	0.57	0.78	0.82	No bargaining shock
RBC model, auto-corr.	0.80	0.80	0.80	NaN	0.76	0.79	Hansen-Rogerson
			$\varepsilon = 1.25$				
S&M model, auto-corr.	0.82	0.80	0.83	0.71	0.79	0.82	50% lower volatility of ϕ_t
S&M model, auto-corr.	0.79	0.79	0.79	0.78	0.78	0.81	No bargaining shock
RBC model, auto-corr.	0.80	0.80	0.80	0.77	0.77	0.79	Hansen-Rogerson

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

7.4 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 percent per year from 1929 to 1949 to 0.81 percent 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 percent (0.31/0.81) higher than that in the USA (Table 1(a)). Controlling for industry composition, this difference amounts to 60 percent (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 increase the volatility by 40 percent, U.S. output would become 30 percent more volatile. Consumption volatility increases 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 by lowering the ergodic mean of consumption.

Table 12: Welfare effects of increased or reduced political distribution risk

Specification	std(Y) [%]	$\frac{\text{Std(C)}}{\text{StdY}}$	Std(cs) [%]	Std(n) [%]	Welfare: Δ baseline Consumption units
Baseline	1.95	0.58	0.22	1.88	0
40% higher capital share volatility	2.40	0.58	0.31	2.52	–0.6%
100% higher capital share volatility	3.07	0.58	0.44	3.42	–1.3%
No redistribution risk	1.19	0.53	0.01	0.13	+1.4%

We find sizable welfare effects of redistribution risk (Table 12). Welfare, expressed in consumption units, drops by 0.6 percent when we increase the volatility of political redistribution risk to make the capital share 40 percent 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 1.3 percent of consumption. Eliminating all redistribution risk would increase the welfare of the representative household by 1.4 percent of consumption. Redistribution risk, thus, makes the economy significantly more volatile and lowers welfare.

8 Quantitative results II: 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 9 shows the response to a bargaining shock that strengthens workers' bargaining power. In particular, we plot generalized impulse-responses following the procedure outlined in Andreasen, Fernandez-Villaverde, and Rubio-Ramirez (2013).

First, after this shock, the capital share falls, irrespective of whether we focus on the gross or the net capital shares. 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 firms values and an increase in labor income share.

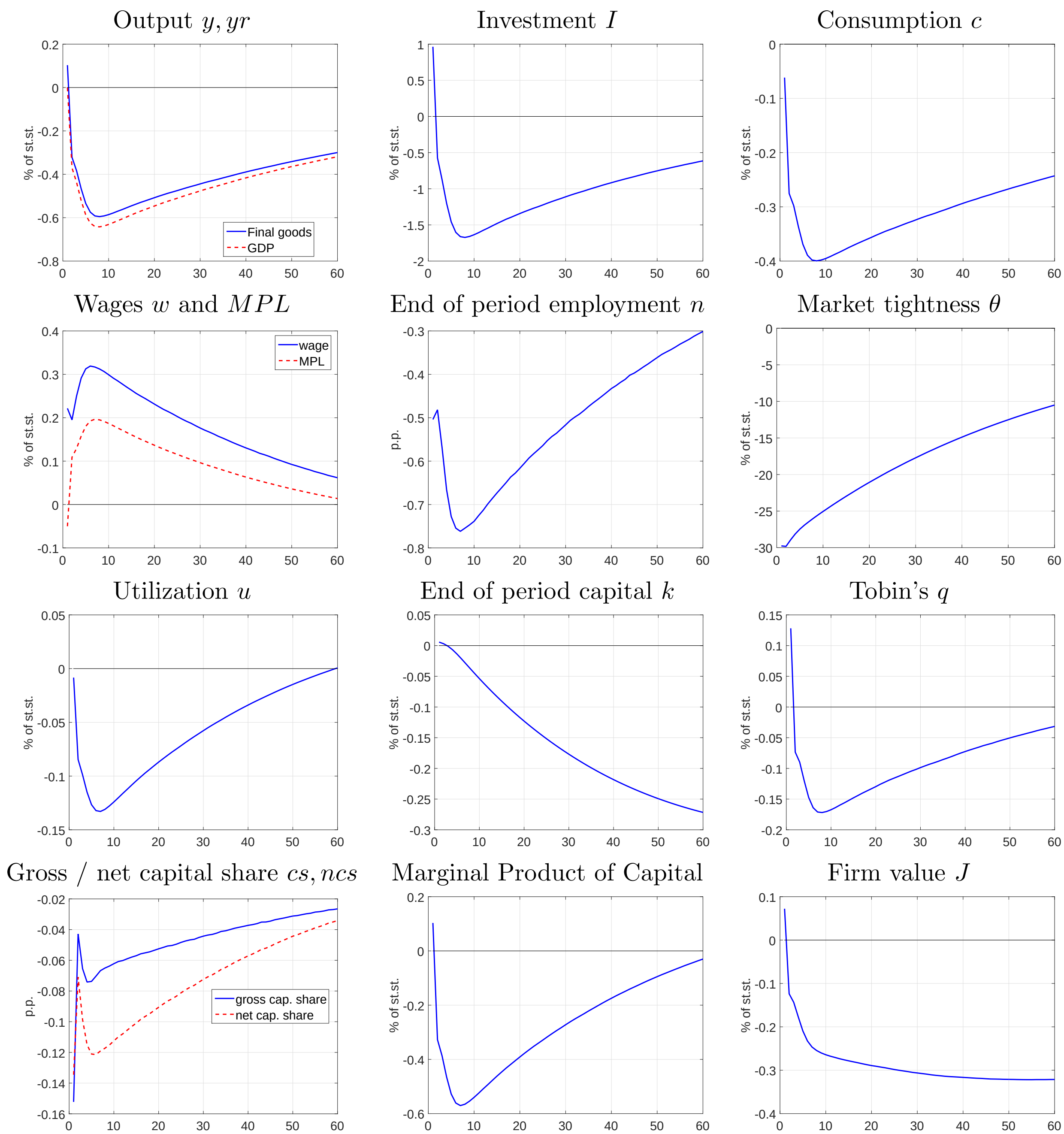
It is interesting to analyze the details of the response of the economy after the shock. The value of the firm rises initially, if slightly, as firms shift workers from recruiting to production to raise output of final goods to take advantage of the existing stocks of workers and capital (this movement 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.

While our baseline calibration matches the qualitative features of redistribution in advances economies, the response of output is stronger than what we found in the data. Two years after the redistribution shock, output is around 0.5 percent down, but the gross capital share only about 0.05 percentage points. In contrast to this 10-1 ratio, in Germany we found movements of about 1-5. The Brandt redistribution to labor happened when the capital share was high, and the Kohl redistribution to capital when the capital share was very low.

Fortunately, the non-linearities in our model make the response to a bargaining shock state-dependent. In particular, the prevailing capital share at the moment of the shock matters. Figure 10 shows that a given shock to the 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 capital share is small, further reduction in its bargaining cost have a higher marginal cost to the firm but 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 much muted when the capital share is already high. Thus, the non-linearity in our model can partly explain why we can observe at times relatively large redistributions with relatively small effects on quantities.[14]

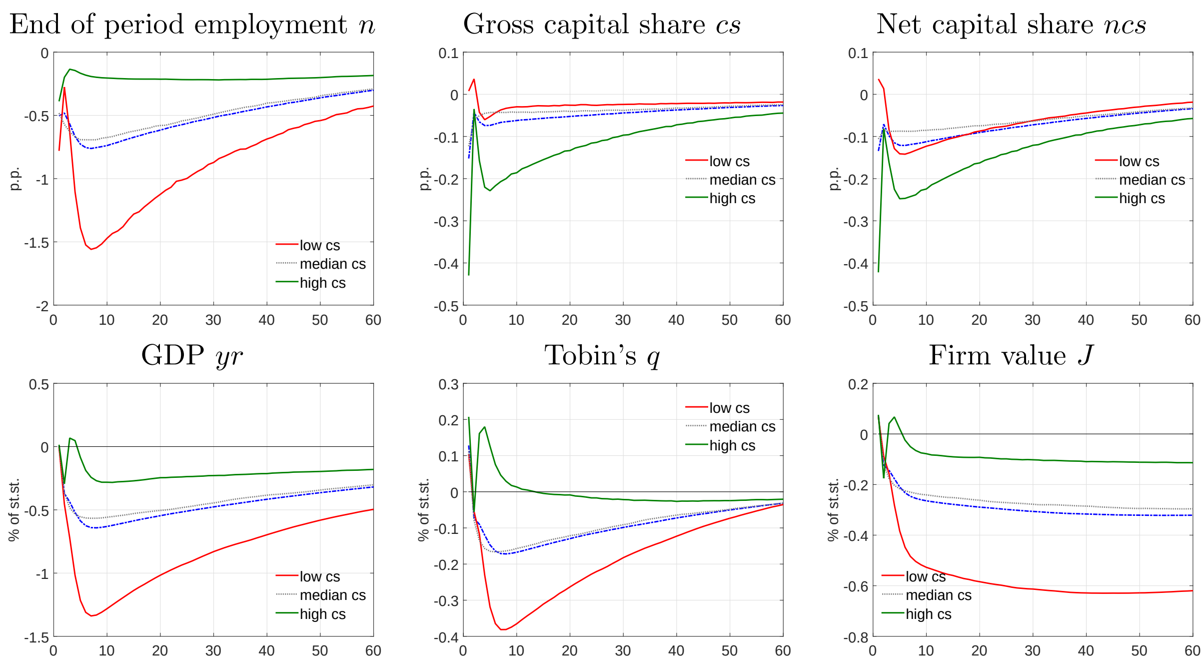
How do our results change if firms would substitute capital for labor more or less elastically?

[14] We conjecture that our model currently also generates relatively large movements in output relative to those in the bargaining power because the match surplus is small. If the surplus included product market markups 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 generalized IRFs based on third order approximation methods following Andreasen, Fernandez-Villaverde, and Rubio-Ramirez (2013).

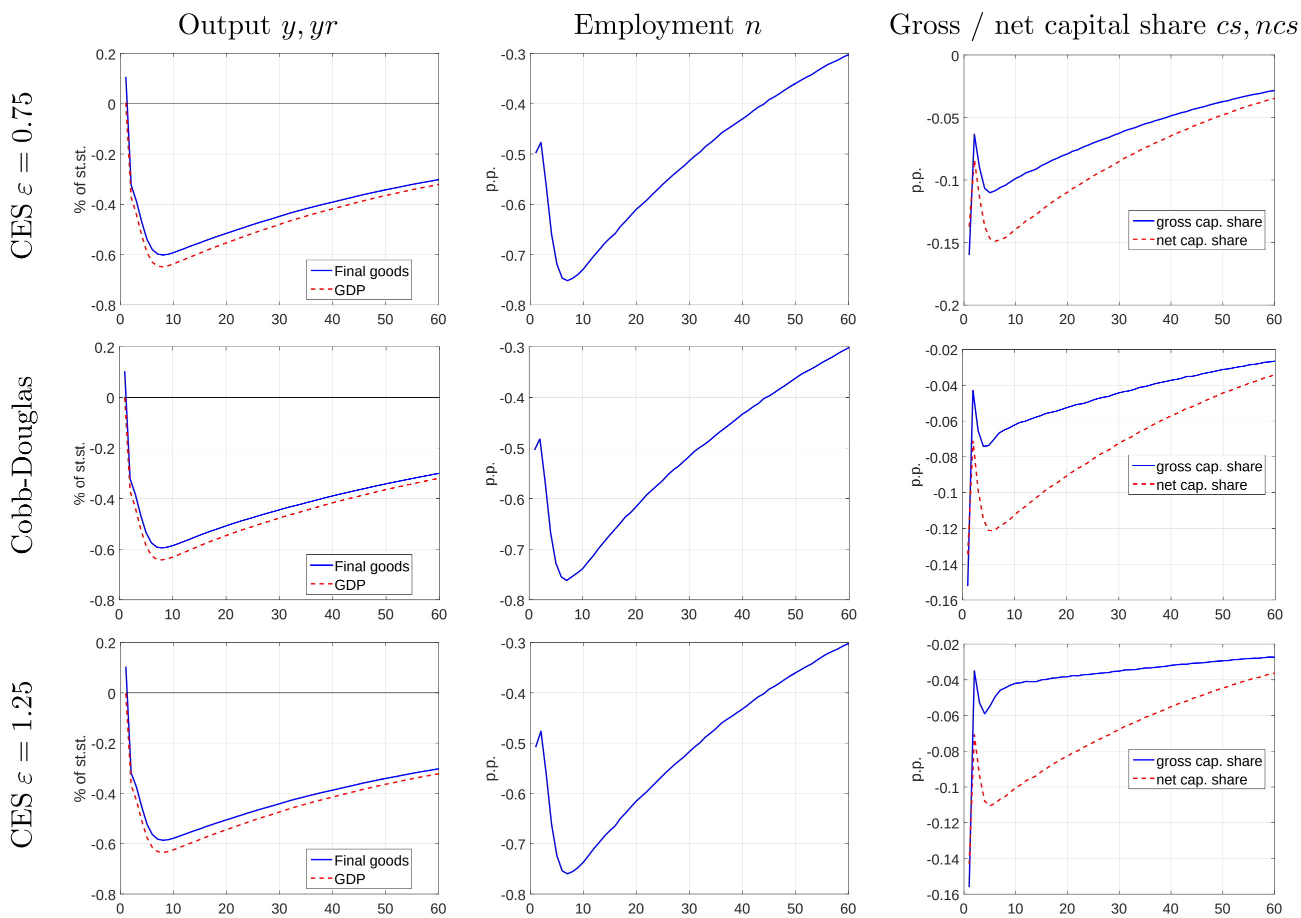
Figure 9: IRFs to one standard deviation shock raising workers' bargaining power



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 or bottom 10 percent of the ergodic distribution.

Figure 10: State dependence in IRFs to one standard deviation bargaining power shock with high vs low initial capital share

For the bargaining shock not much. Figure 11 shows the responses of output, employment, and the capital shares to a bargaining power shock for three different elasticities of substitution: The baseline Cobb-Douglas case ($\varepsilon = 1$), and a low elasticity of substitution of $\varepsilon = 0.75$ consistent with U.S. manufacturing estimates (Oberfield and Raval, 2014), and a high elasticity of substitution of $\varepsilon = 1.25$, consistent with cross-country estimates (Karabarbounis and Neiman, 2014). 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. The impact response, however, changes little because physical capital and overall labor are fixed.

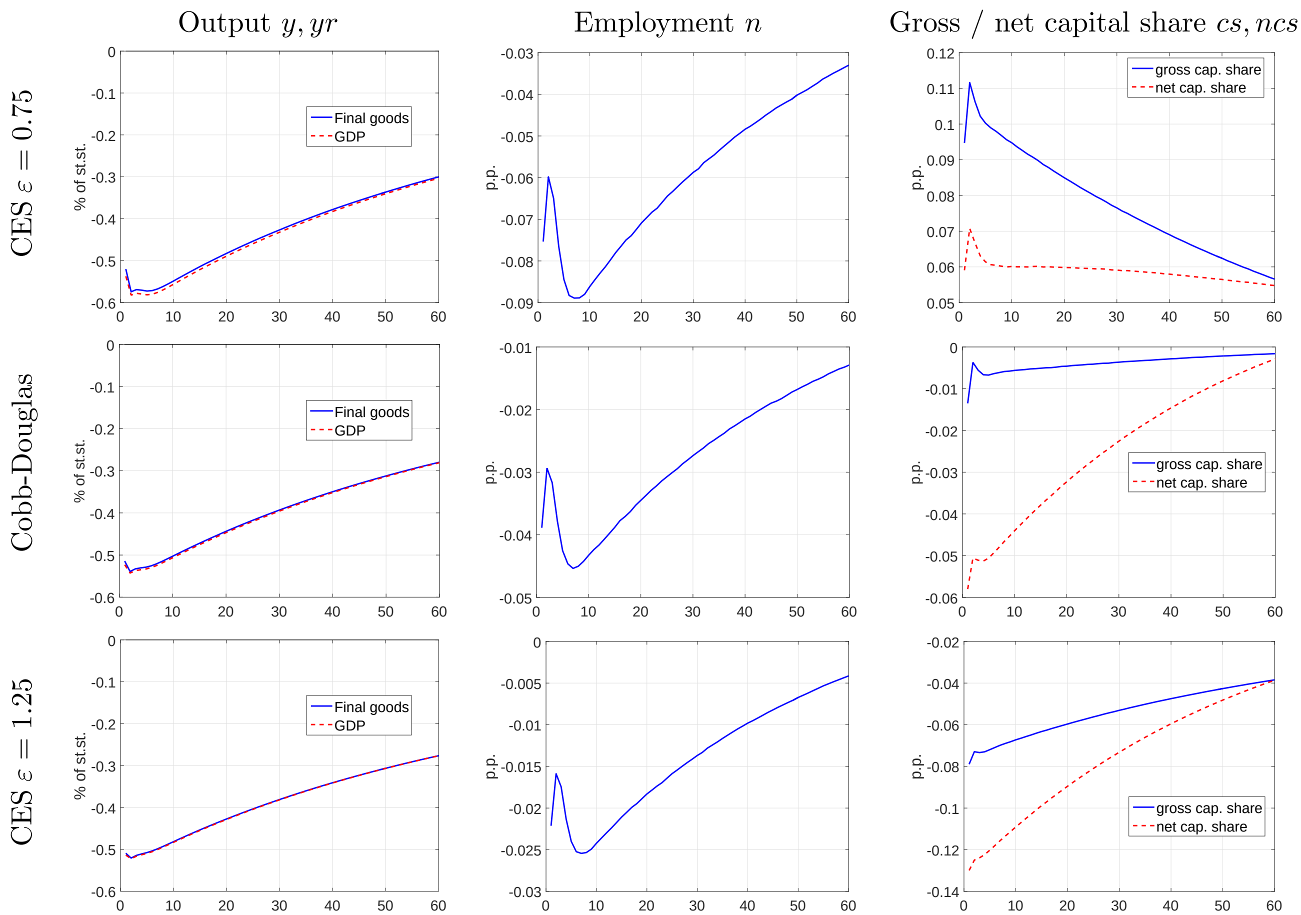


Note: The responses are shown for the 60 months following a shock. We compute generalized IRFs based on third order approximation methods following Andreasen, Fernandez-Villaverde, and Rubio-Ramirez (2013).

Figure 11: 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 12 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 Santaeulàlia-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. We compute generalized IRFs based on third order approximation methods following Andreasen, Fernandez-Villaverde, and Rubio-Ramirez (2013).

Figure 12: 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. The three countries for which we have long historic 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 differs also significantly 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 change of 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 which 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. Our model matches the standard US business cycle moments and the cyclicality 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 with a non-unitary elasticity of substitution between capital and labor cannot replicate the observed cyclicality of the capital share.

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 almost 25%. 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%. Welfare of the representative household would drop in these cases, by 0.7% and 1.5% of consumption, respectively. In contrast, eliminating political redistribution risk in the U.S. would raise welfare by 1.6%.

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 by 0.15 percentage point, but output drops by 0.6% at its trough. Firm value drops by 0.3%. The effects are, however, non-linear: We show that conditional on an already high capital share, the response of of output and the firm value is much more muted, whereas the capital share responds more strongly.

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A Capital share data

A.1 U.S. business cycle data

We construct the net capital share in the corporate business sector as from BEA Table 1.14. "Gross Value Added of Domestic Corporate Business in Current Dollars and Gross Value Added of Nonfinancial Domestic Corporate Business in Current and Chained Dollars" and focus on the data on nonfinancial 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).

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, Inklaar, and Timmer, 2013).

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

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

We compute consumption as the sum of real services and nondurable consumption, divided by the civilian non-institutionalized population above 16. Specifically:

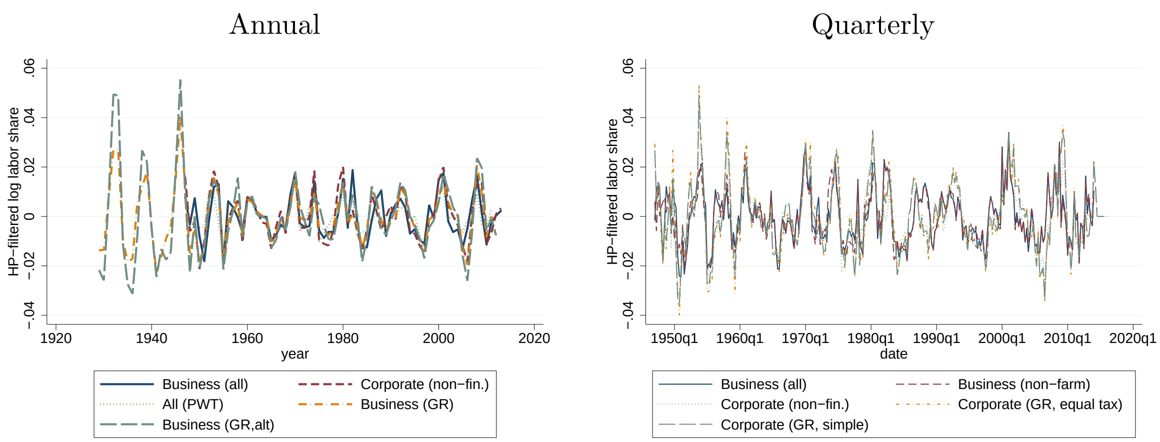
$$C_t = \frac{\frac{\text{DSERRA3Q086SBEA}_t}{\text{DSERRA3Q086SBEA in 2009}} \times \text{PCESVC96 in 2009} + \frac{\text{DGOERA3Q086SBEA}_t}{\text{DGOERA3Q086SBEA in 2009}} \times \text{PCNDGC96 in 2009}}{\text{CN16OV}_t}$$

Note that 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.

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

$$Y_t = C_t + I_t.$$

Figure A.3 compares the different measure of the labor share which are available in levels. The left panel shows the annual time series, the right panel shows the shorter quarterly series. In both annual and 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



We detrend the data using the HP filter with the smoothing parameter recommended by Ravn and Uhlig (2002). Two facts stand out: First, there is significant variation in capital shares at business cycle frequency. Second, the different measures of the labor share move together.

Figure A.1: Detrended labor shares in the U.S..

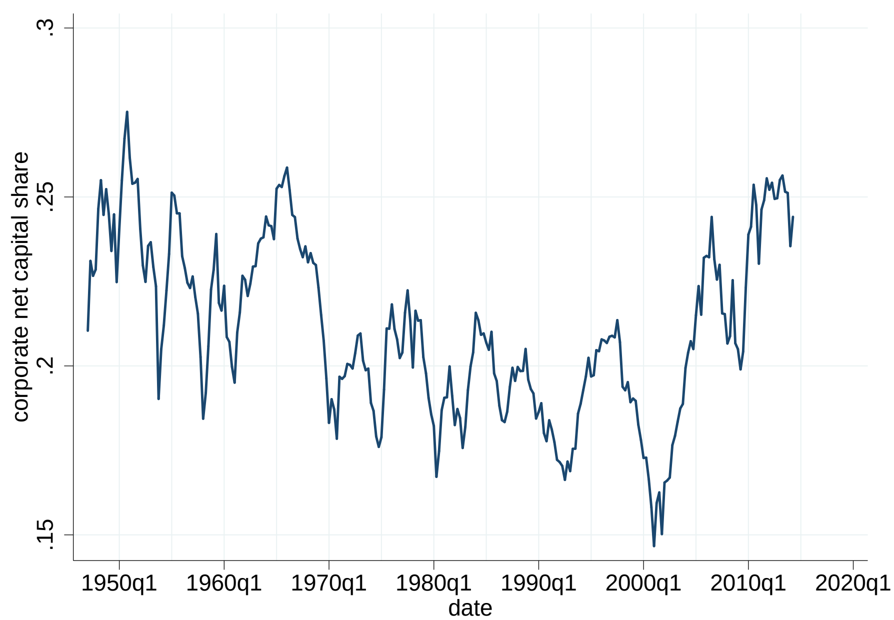


Figure A.2: Net capital share levels: quarterly U.S. data

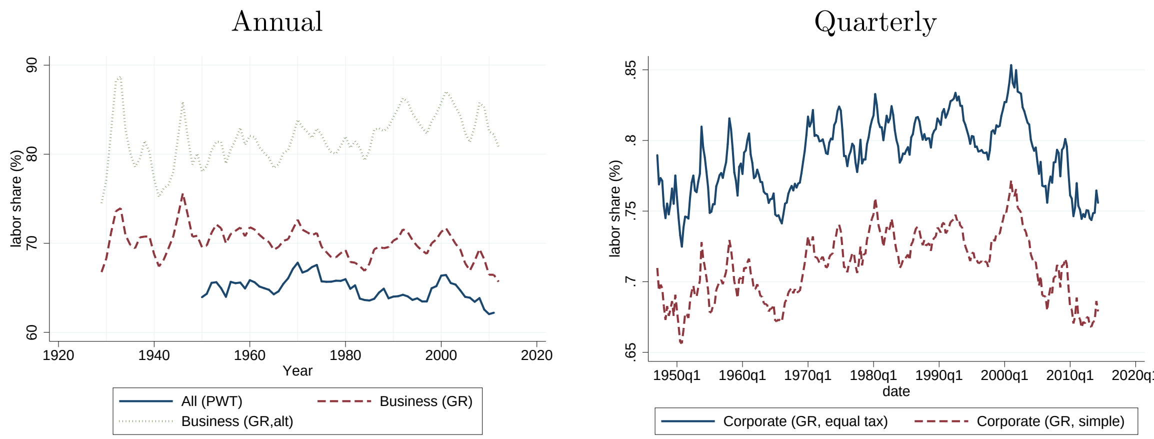


Figure A.3: Labor share levels data: Annual and quarterly

government production in the annual series change the trend behavior. The different labor shares average between about 65 percent and 80 percent.

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, seems to correlate positively at higher frequencies, but may exhibit different time trends. Figure A.1 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 exhibit sometimes low correlations, but filtered correlations are above 0.6 for annual data and above 0.7 for quarterly data with the exception of correlations between manufacturing sectors and broader measures.

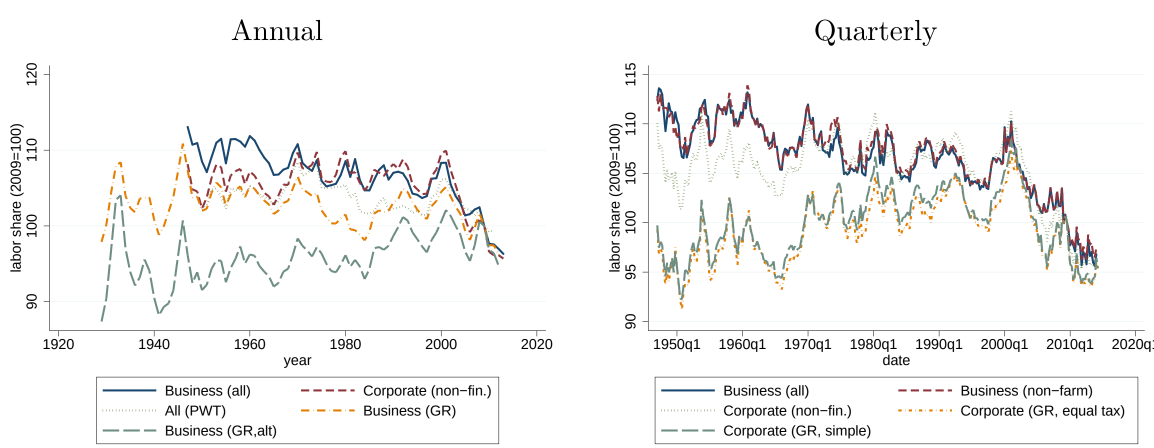


Figure A.4: Raw indexed labor shares: Annual and quarterly

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.

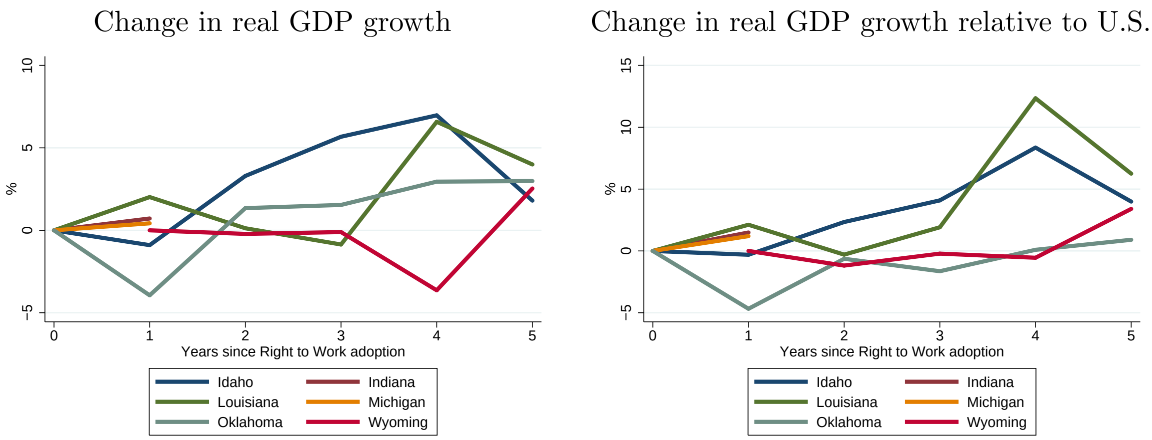
- U.S. state capital share and GDP data: We use the Bureau of Economic Analysis Regional Accounts, section "Annual Gross Domestic Product By State" from http://www.bea.gov/regional/ to obtain data on "compensation of employees", "taxes on production and imports less subsidies" and "GDP in current dollars" to compute the gross capital share as one minus the compensation of employees over GDP minus taxes net of subsidies. All data is confined to (total) "private industry". Since the five year periods in the states we are studying does not include 1997, when the BEA switches from SIC to NAICS, we simply 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, Inklaar, and Timmer, 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:
  - Chile (financials): "Chile BEC Finance Index", ticker symbol "_FINANCD"
  - Chile (industrials): "Chile BEC Industrials Index (w/GFD extension)", ticker symbol "_INDUSTD"
  - France: "France SBF Industrials", ticker symbol "_FISID"
  - Mexico: "Mexico SE Return Index", ticker symbol "_IRTD"
  - Portugal: "Portugal Industrials", ticker symbol "PTINDUSM"
  - South Korea: "Korea SE Stock Price Index (KOSPI)", ticker symbol "_KS11D"
  - Turkey: "Turkey ISE-100 Total Return Index", ticker symbol "TRRBILED"
  - U.K.: "FTSE 100 – Historical Prices" from https://uk.finance.yahoo.com/q/hp?s=^FTSE
  - Western Germany: "Germany CDAX Industrials Price Index", ticker symbol "_CXKNXD"

- Price indices: We use consumer price indices to deflatre the stock market indices. Except for Chile, we downloaded the data from http://research.stlouisfed.org/fred2/:
  - Chile: "Índice de Precios al Consumidor - Antecedentes históricos" from http://www.ine.cl/canales/chile_estadistico/estadisticas_precios/ipc/series_antecedentes_historicos/index.php
  - France: Ticker symbol "FRACPIALLMINMEI"
  - Mexico: Ticker symbol "MEXCPIALLMINMEI"
  - Portugal: Ticker symbol "PRTCPIALLMINMEI"
  - South Korea: Ticker symbol "KORCPIALLMINMEI"

– Turkey: Ticker symbol “TURCPIALLMINMEI”
– U.K.: Ticker symbol “GBRCPIALLMINMEI”
– Western Germany: Ticker symbol “DEUCPIALLMINMEI”



Note: Real GDP growth is computed using the change in state total private sector GDP deflated by the national GDP deflator. Since the data starts only in 1963, the year Wyoming adopted the new legislation, the GDP growth in Wyoming is normalizes to zero for the first year after adoption.

Figure A.5: Change in real state private industry GDP growth after right to work adoption.

Table A.1: Political events and changes in capital shares & real GDP in PPP: Latin American & Caribbean countries

	Date	Change in net overall capital share				Change in detrended per cap. GDP			
		Change within 2 years		Change within 5 years		2 years		5 years	
ECLAC data	Year	p.p.	%	p.p.	%	%	Sign	%	Sign
Bolivia: Democratic transition	2006	2.8	4.4	5	7.9				
Chile: Allende election	1970	-13.1	-25.5			6.7			
Chile: Pinochet coup	1973	11.9	31.9	9.5	25.4	-14.5		-27	
Chile: Democratic election	1990	-2.8	-4.8	-6	-10.2	1.7		15	
Chile: Democratic transition	2006	4	7.9			6.4	y	1.5	
Columbia: National Front gov ends	1974	-.4	-.8	-4	-6.7	4.5		11.3	
Columbia: FARC peace deal	1984	2.5	4.8	5.2	10	-5.4		-5.2	
Costa Rica: New presidency/Austerity	1982	-.9	-2	-2.5	-5.1	-13.5	y	-5.1	y
Ecuador: Democratic transition	1979	-4.3	-6.6	4.2	6.3	-5	y	-14.2	
Ecuador: War/President killed	1981	2.8	4.6	11.2	18.2	-2.4		-10.7	
Honduras: US deployment	1988	2.1	5.3	1.2	3.1	-.2		-.2	
Honduras: Democratic transition	1990	.3	.6	5	12.3	.9	y	-.3	
Mexico: Debt crisis	1982	8.1	14.7	8.2	14.8	-15.6		-27.5	
Mexico: NAFTA+	1994	3	5.2	4.2	7.2	-11.3		-3.9	
Mexico: Democratic transition	2000	-1.9	-3.1			8.4		10.8	
Panama: US invasion	1989	2.3	6.8	8.6	25.1				
Paraguay: Democratic elections	1993	-4.8	-9	-15.5	-29.2	2.8		-1.5	y
Peru: Democratic election	2001	-.6	-.9	1.6	2.2	-1.2	y	12	y
Suriname: Military coup	1980	-5.1	-13.2	-19.5	-50.6	-6.4	y	-10	y
Suriname: Free elections	1987	13.8	68.6	20.9	104.3	-7.2		-2.6	
Trinidad and Tobago: Democratic transition	1986	-3.3	-9.6	5.9	17.1				
Uruguay: Democratic elections	1984	-5.4	-9	-1.7	-2.9	-4	y	12.7	
Venezuela: Democratic transition	1999	5.3	9.4	7.6	13.4	9.1	y	-2.4	
Absolute change: 25th percentile		2.1	4.4	4.1	6.5	2.6		2.4	
Absolute change: Median		3	6.6	5.55	11.25	5.9		10	
Absolute change: 75th percentile		5.3	9.6	9.05	21.65	8.75		12.7	

Data: Net capital share in the overall economy. Detrended real GDP per capita in constant purchasing power parity.

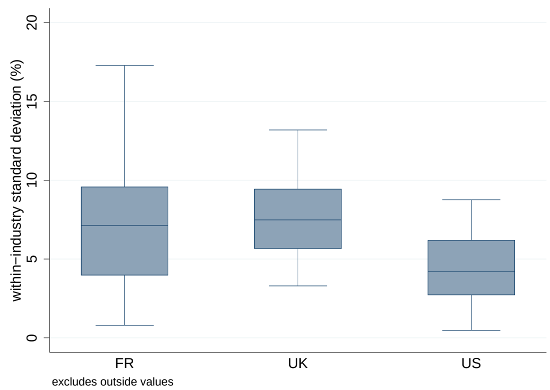
A.3 Controlling for industry composition

To control for industry composition in France, the U.K., and the U.S. , 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:

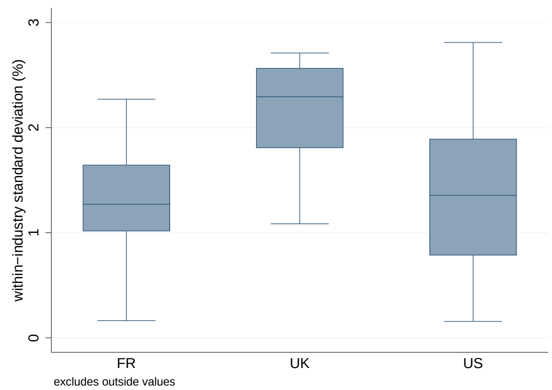
- Agriculture (code: "AtB")
- Mining (code: "C")
- Government (code: "L")
- Financial intermediation (code: "J")

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

(a) Volatility in raw data



(b) Volatility in HP-filtered data



Income shares in the U.K. are significantly more volatile than in the U.S., controlling for industry composition. For France, the results depend on whether we HP-filter the data or not. Data: EU KLEMS for private industries excluding agriculture, mining, and finance.

Figure A.6: Within-industry volatility of the gross labor share

A.4 Historical narrative

> "A popular framework for thinking about labor law is to consider a pendulum that can range from strong bargaining power for labor on one side to strong bargaining power for companies on the other side." (Budd, 2012, p. 126)

Since the birth of U.S. labor law in the 1930s, legislation has actively sought to balance the rights of organized labor with the property rights of firms. Before the 1930s, labor relations were subject only to general common and business Law that focused on guaranteeing a widely construed freedom of contract. Since the 1960s, the regulation of organized labor through labor law has been complemented by employment law that establishes minimum standards for individual workers. We illustrate this point with the following overview, based on Budd (2012, ch. 4) unless otherwise noted.

Before Labor Law was established, organized labor was subject only to Common Law and general Business Law and thus largely shaped by court rulings. Under Common Law, unions could be treated as criminal conspiracies to infringe firm owners' property rights: The Philadelphia shoemakers who formed the first union in the US were also the first that was found to be a criminal conspiracy. Legal doctrine evolved, however, and in 1842 the Massachusetts Supreme Court ruled that only some union actions, but not unions per se constituted illegal conspiracies. Towards the end of the 19th century, firms, therefore, largely used injunctions to limit picketing and sometimes strikes more generally. During the 1900s, firms could also use "yellow dog" contracts with their workers and injunctions to limit unions. These contracts include the worker's commitment not to unionize. Injunctions could then limit union organizing as a third party attempt to breach the binding contract. The Sherman Antitrust Act of 1890 introduced Business Law that regulated business by outlawing monopolies – but was also applied to unions: In 1908, the Supreme Court ruled that union boycotts constituted an illegal restraint of commerce. The legal standing of organized labor started to improve with the Clayton Act of 1914. While some aspects of the act facilitated injunctions against unions, it did give unions the legal right to exist. Economy-wide labor law was, however, not passed until the 1930s.

Given the background of the role of courts in limiting unions and in the face of the Great Depression, Congress assessed in the Norris-LaGuardia Act of 1932 that:

> "[T]he individual unorganized worker is commonly helpless to exercise actual liberty of contract and to protect his freedom of labor, and thereby to obtain acceptable terms and conditions of employment wherefore [...] it is necessary that he have full freedom of association, self-organization, and designation of representatives of his own choosing, to negotiate the terms and conditions of his employment" (29 U.S. Code §102).

The body of the act seeks to implement this principle of protecting unions by limiting the authority of U.S. courts. Already in 1926, Congress had enshrined the right of railroad workers to form unions in the Railway Labor Act. Congress went on to establish economy wide"the right to organize and bargain collectively" (National Industrial Recovery Act §7(a)), but it was ineffective for lack of enforcement mechanisms and later ruled unconstitutional. Congress reacted by passing the Wagner Act.

The Wagner Act (or National Labor Relations Act) of 1935 goes beyond protecting unions from federal courts. The IWW union states that its philosophy "[...] is that government must help labor to organize into unions, after which labor will be strong enough to bargain collectively."[15] Similarly, Budd (2012) notes that its underlying belief is that of "an imbalance of bargaining power" (p. 119) between labor and management. In its substance, the act has three main elements. First, majority-status unions have the right to exclusive representation of employees in bargaining over wage and other bargaining. Second, it defines illegal employer actions that could undermine union activity, such as firing employees trying to form a union. Third, it establishes the National Labor Relations Board (NLRB) and awards it enforcement powers. Besides overseeing union certification, the NLRB has a board of presidential appointees that issues rulings on which labor practices are unfair.[16]

The NLRA was seen as effective: Union membership grew and in the twelve months after WWII, the U.S. was hit by the Great Strike Wave. The 1947 Taft-Hartley Act amended the NLRA by introducing important changes: First, it restricted union actions, matching the unfair employer actions of the NLRA. Second, it separated prosecution and judicial functions of the NLRB, expanded its board from three to five members, and introduced a voluntary mediation mechanism. Third, it allowed for right-to-works legislation by states that allows states to ban arrangements that forces all hires to join unions or pay union dues.

[15] http://www.iww.org/organize/laborlaw/Lynd/Lynd3.shtml, retrieved 9/22/2016.

[16] Unlike its predecessor established under the NIRA, the NLRB also has limited enforcement powers.

While Budd (2012) characterizes the statutes underlying U.S. Labor Law as "quite static" (p. 138), the presidentially appointed NLRB committee has created a second strand of labor law, that "is much more dynamic and voluminous" (ibid.). Through the interpretation of the statutes, the NLRB has created its own body of case law, whose evolution the U.S. President can influence by appointing members for five year terms.

While this account shows the historical intent of Congress to influence the bargaining power of firms and workers, statistical inference about the effects of Labor Law in determining bargaining power is limited both by the Great Depression and its aftermath and concurrent move by Congress limit competition between firms. This raised profits at the same time that Congress acted to improve workers' bargaining position.[17] We therefore focus on the post-war era for evidence. This era features variation in the roll-out of right-to-work legislation.

[17] In addition, the 1935 NLRA was initially ignored by corporations according to (Budd, 2012, p. 125f.) and only upheld by the Supreme Court in 1937, two years after its passage. In 1938, when the Fair Labor Standards Act first established minimum wages, the Supreme Court also established the so-called "MacKay Doctrine" that affirmed the rights of firms to hire strike breakers (Budd, 2012, p. 278f).

B 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.

B.1 Households

B.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:

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

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

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

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.

As mentioned in the main text, when making her 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 labor market tightness that the household takes as given. Thus, the fraction of household members employed next period will be:

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

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

B.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:

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

If $h = 0$ or given the initial condition that $c^a_{e,t-1} = c^a_{u,t-1}(1+(\sigma-1)\gamma)$, 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:

$$
U_0 = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t - hc^a_{t-1}\frac{1+(\sigma-1)\gamma n_{t-1}}{1+(\sigma-1)\gamma n^a_{t-2}}\right)^{1-\sigma}(1+(\sigma-1)\gamma n_{t-1})^{\sigma} - 1}{1-\sigma}, \tag{B.4}
$$

and the budget constraint becomes:

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

Note that with $h > 0$, the household partially internalizes that increasing employment changes the size of habit one period ahead.

B.1.3 Equilibrium conditions

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

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

subject to:

$$
\begin{aligned}
n &= (1-x)n_{-1} + f(\theta)(1-n_{-1}) && \text{(B.6)} \\
c &= a_{-1} + (1-\tau_n)w_t n_{-1} + T_t - \mathbb{E}[m(S')a(S')|S] && \text{(B.7)}
\end{aligned}
$$

and where:

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

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:

$$
\begin{aligned}
\lambda &= (c - \hat{h}(n_{-1})c^a_{-1})^{-\sigma}(1+(\sigma-1)\gamma n_{-1})^{\sigma} && \text{(B.8)} \\
\lambda m(S') &= \beta V_a(a(S'), n; S') = \beta\lambda(S') = \beta(c(S') - \hat{h}(n)c^a)^{-\sigma}(1+(\sigma-1)\gamma n)^{\sigma}. && \text{(B.9)}
\end{aligned}
$$

Thus, the stochastic discount factor of the economy is simply:

$$m(S') = \beta \frac{(c(S') - \hat{h}(n)c^a)^{-\sigma}(1 + (\sigma-1)\gamma n)^{\sigma}}{(c - \hat{h}(n_{-1})c^a_{-1})^{-\sigma}(1 + (\sigma-1)\gamma n_{-1})^{\sigma}}. \tag{B.10}$$

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

The marginal value of employment is given by:

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

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:

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

$\tilde{V}_n$ 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.

B.2 Firms

B.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 firms produces a homogeneous output with production function:

$$y_t = \left(\alpha^{1/\varepsilon} (u_t k_{t-1})^{1-1/\varepsilon} + (1-\alpha)^{1/\varepsilon} (z_t n_{t-1}(1-\nu_t))^{1-1/\varepsilon} \right)^{\frac{\varepsilon}{\varepsilon-1}} \equiv \psi(u_t k_{t-1}, z_t n_{t-1}(1-\nu_t)). \tag{B.13}$$

ε is the constant elasticity of substitution between effective capital and labor in production. z_t is labor-augmenting technology.

The law of motion for capital is:

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

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

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

The firm's value is given by:

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

where production and capital follow from equations (B.72) and (B.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:

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

B.2.2 Firm optimality

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

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

Thus, the marginal value of employment is given by:

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

using equation (B.17) to substitute for $\mathbb{E}\left[m_{t+1}J_n(n_t,k_t)\right]$. Note that 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:

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

The optimality condition for the utilization rate is:

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

and for investment:

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

The optimality condition for capital k' is given by:

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

where the marginal product of physical capital is:

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

B.3 Wage determination

Under Nash bargaining, the equilibrium wage solves:

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

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

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

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

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

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

$$\begin{aligned} &\phi_t(1-\tau_n)J_{n,t} \\ =&(1-\phi_t)(1-\tau_k)(1-\tau_n)w_t-(1-\phi_t)(1-\tau_k)\left(\frac{c_t-\hat{h}_{t-1}c^a_{t-1}}{1+(\sigma-1)\gamma n_{t-1}}\right)\gamma\left(\sigma+(\sigma-1)\frac{\hat{h}_{t-1}c^a_{t-1}}{c_t-\hat{h}_{t-1}c^a_{t-1}}\right) \end{aligned}$$

$$+ (1 - x - f_t(\theta_t))\mathbb{E}_t \left[\frac{1-\phi_t}{1-\phi_{t+1}} m_{t+1}\phi_{t+1}(1-\tau_n)J_{n,t+1}) \right]$$

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

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

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

B.4 Market clearing

Market clearing involves the following equations. First, the resource constraint of the economy:

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

Second, the law of motion of capital:

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

Third, the law of motion for employment:

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

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

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

B.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 than the equilibrium allocation, but that recognizes the externalities embodied in the matching function. Because external habit would introduce an additional externality we would need to consider, we set habit $h = 0$ in this section to derive a cleaner result.

The planner solves:

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

subject to:

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

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

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

Let λ_b be the multiplier on the budget constraint (B.31a), λ_k the multiplier on the law of motion for capital (B.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:

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

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

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

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

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

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

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

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

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

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:

$$q \equiv \frac{\lambda_k}{\lambda_b} \tag{B.34a}$$

$$m \equiv \beta\frac{\lambda_b'}{\lambda_b} \tag{B.34b}$$

$$J_n \equiv \eta^{-1}\frac{W_n}{\lambda_b'} \tag{B.34c}$$

$$\phi \equiv 1 - \eta. \tag{B.34d}$$

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

$$q\delta'(u) = \frac{mpk}{u}(1-\tau_k) \tag{B.32b'}$$

$$(1-\tau_k)mpl = \mathbb{E}\left[m'\frac{W_n'}{\lambda_b'}\Big|S\right]\eta\mu(\theta) = \mathbb{E}[m'J_n'|S]\mu(\theta) \tag{B.32c'}$$

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

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

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 (B.32c'):

$$\begin{aligned}\eta^{-1}J_n = &\left(\left(1+\frac{1-x}{\mu(\theta)}\right)mpn - w\right)(1-\tau_k) + (1-x-f(\theta))\mathbb{E}[m'J_n'|S]\frac{1-\eta}{\eta} \\ &(1-\tau_n)w + -\frac{\gamma\sigma c}{1+(\sigma-1)\gamma n_{-1}}.\end{aligned} \tag{B.33a'}$$

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

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

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

$$\begin{aligned}&\frac{\phi}{1-\phi}J_n\frac{1-\tau_n}{1-\tau_k} \\ =&(1-\tau_n)w - \left(\frac{c}{1+(\sigma-1)\gamma n_{t-1}}\right)\gamma\sigma + (1-x-f(\theta))\mathbb{E}\left[m'J_n'|S\right]\frac{\phi}{1-\phi}\frac{1-\tau_n}{1-\tau_k}.\end{aligned} \tag{B.25'}$$

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

B.6 Detrended economy

In this subsection, we augment the model by allowing for a stochastic trend in labor-augmenting productivity:

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

where $\epsilon_{p,t}$ is the permanent shock to productivity.

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:

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

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

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

$$n_{t-1} - \nu_{t-1} n_{t-1} = n_{t-1} - \theta_{t-1}(1-n_{t-1}). \tag{B.39}$$

Similarly, for the capital law of motion:

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

the resource constraint

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

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

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

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

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

We also have the marginal value of employment

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

the recruiting optimality condition:

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

and wage setting:

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

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

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

Other equilibrium conditions are optimal utilization:

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

optimal capital:

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

optimal investment:

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

and the stochastic discount factor:

$$m_{t+1}=\beta_t g_{z,t+1}^{-\sigma}\left(\frac{\tilde{c}_t-\tilde{h}_{t-1}\tilde{c}^a_{t-1}}{\tilde{c}_{t+1}-\tilde{h}_t\tilde{c}^a_t}\frac{1+(\sigma-1)\gamma n_t}{1+(\sigma-1)\gamma n_{t-1}}\right)^{\sigma}. \tag{B.50}$$

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

1. Detrended capital $\tilde{k}_t$ from equation(B.40).
2. Detrended consumption $\tilde{c}_t$ from the resource constraint (B.41).
3. Detrended firm value $\tilde{J}$ from the Bellman equation (B.42).
4. Detrended marginal value of employment $\tilde{J}_n$ from the envelope condition (B.43).
5. Recruiting intensity ν_t from equation (B.44).
6. Detrended wages $\tilde{w}_t$ from Nash bargaining equation (B.45).
7. The utilization rate u_t from the utilization equation (B.47).
8. The shadow price of capital q_t from the capital equation (B.48).
9. Detrended investment $\tilde{i}_t$ from the investment equation (B.49).

10. The stochastic discount factor m_{t+1} from equation(B.50).

In addition, the following variables and equations matter:

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

And, for completeness, we can add a few definitions:

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

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

16. GDP including recruiting services $\widetilde{yr}_t$ from equation (B.52):

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

17. The Gross capital share cs_t from equation (B.53):

$$cs_t \equiv 1 - \frac{n_{t-1}w_t}{\widetilde{yr}_t}. \tag{B.53}$$

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

$$ncs_t \equiv 1 - \frac{n_{t-1}w_t}{\widetilde{yr}_t} - \delta_t\frac{\tilde{k}_{t-1}}{\widetilde{yr}_t g_{z,t}}. \tag{B.54}$$

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

19. The bargaining power

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

20. Stationary TFP

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

21. Permanent TFP

$$\log(g_{z,t}) = \log(g_z) + \epsilon_{p,t}. \tag{B.57}$$

B.7 Balanced growth path and calibration

Along the balanced growth path, the discount factor becomes:

$$\bar{m} = \beta g_z^{-\sigma} \tag{B.58}$$

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

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

We can normalize capacity utilization to be 1 along the balanced growth path to get:

$$\bar{u} = 1 \tag{B.60}$$
$$\delta_1 = (1-\tau_k)\overline{mpk}. \tag{B.61}$$

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

$$1 = \bar{m}\left((1-\tau_k)\left(\alpha\frac{\bar{y}}{\bar{k}}g_z\right)^{1/\varepsilon} + 1 - (1-\tau_k)\delta_0\right) \quad \Leftrightarrow \quad \frac{\bar{m}^{-1} - (1-(1-\tau_k)\delta_0)}{1-\tau_k} = \overline{mpk}. \tag{B.62}$$

Investment along the balanced growth path is given by:

$$\bar{I} = \left(1-(1-\delta_0)g_z^{-1}\right)\bar{k}. \tag{B.63}$$

The steady state price of capital is given by:

$$\bar{q} = 1. \tag{B.64}$$

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

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

Because $1-\tau_k$ cancels and using that $f(\theta_t) \equiv \theta_t\mu(\theta_t)$:[18]

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

Thus, after detrending there are two equivalent useful expressions:

$$\begin{aligned}
\bar{w} &= \bar{\phi}\overline{mpl}(1+\bar{\theta}) + \frac{1-\bar{\phi}}{1-\tau_n}\left(\frac{\bar{c}(1-\tilde{h})}{1+(\sigma-1)\gamma\bar{n}}\right)\gamma\left(\sigma+(\sigma-1)\frac{\tilde{h}}{1-\tilde{h}}\right) \\
&= \bar{\phi}\overline{mpl}(1+\bar{\theta}) + \frac{1-\bar{\phi}}{1-\tau_n}\left(\frac{\bar{c}}{1+(\sigma-1)\gamma\bar{n}}\right)\gamma(\sigma-\tilde{h}) \qquad \text{(B.65a)}
\end{aligned}$$

$$\gamma \equiv \frac{RHS}{1-(\sigma-1)\bar{n}\times RHS}, \quad RHS \equiv \frac{1-\tau_n}{(1-\phi)\bar{c}(\sigma-\tilde{h})}\left(\bar{w}-\phi\overline{mpl}(1+\bar{\theta})\right), \tag{B.65b}$$

[18]Recall that $\mu_t(\theta) = \bar{\xi}\times\theta^{\eta-1}$.

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:

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

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

$$\bar{y} = \left(\alpha^{1/\varepsilon}(u_t\tilde{k}_{t-1}g_z^{-1})^{1/\varepsilon} + (1-\alpha)^{1/\varepsilon}(\tilde{z}_t n_{t-1}(1-\nu_t))^{1-1/\varepsilon}\right)^{\frac{\varepsilon}{\varepsilon-1}} \quad \Leftrightarrow$$

$$\bar{y} = \frac{(\overline{mpk})^{\varepsilon}}{\alpha}\frac{\bar{k}}{g_z} = \bar{n}(1-\bar{\nu})\frac{(\overline{mpk})^{\varepsilon}}{\alpha}\left(\left(\frac{\alpha}{1-\alpha}\right)^{1/\varepsilon}\left(\frac{\overline{mpk}^{\varepsilon-1}}{\alpha}-1\right)\right)^{-\frac{\varepsilon}{\varepsilon-1}}. \tag{B.66}$$

The law of motion for capital gives us:

$$\frac{\bar{c}}{\bar{y}} = 1-\left(1-\frac{1-\delta_0}{g_z}\right)\frac{\bar{k}}{\bar{y}g_z} = 1-\left(1-\frac{1-\delta_0}{g_z}\right)\frac{\bar{k}g_z}{\bar{y}g_z}\frac{\alpha}{\overline{mpk}^{\varepsilon}}. \tag{B.67}$$

The law of motion for employment implies:

$$\bar{n} = \frac{f(\bar{\theta})}{x+f(\bar{\theta})}. \tag{B.68}$$

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

$$\bar{w} = \overline{mpl}\left(1-\frac{1-(1-x)\bar{m}g_z}{\bar{m}g_z\mu(\bar{\theta})}\right) \tag{B.69}$$

Per definition:

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

In general, we have the following unknowns and equations:

1. Employment $\bar{n}$ from the law of motion (B.68).
2. Capital $\bar{k}$ from the first order condition (B.62).
3. Investment from the capital law of motion (B.67).
4. Capacity utilization follows, trivially, from equation(B.60).
5. The derivative of capacity utilization along the balanced growth path δ_1 from equation(B.61).
6. The price of capital follows, trivially, from equation(B.64).
7. Consumption $\bar{c}$ from the resource constraint (B.67).

8. Wages $\bar{w}$ from wage setting (B.65).
9. Number of recruiters $\bar{n}\bar{\nu}$ from the definition of market tightness (B.59).
10. The stochastic discount factor $\bar{m}$ from no arbitrage (B.58).
11. Production $\bar{y}$ per definition (B.66).
12. Market tightness $\bar{\theta}$ from the recruiting optimality condition (B.69).

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 (B.65b).
2. Tightness $\bar{\theta}$ from the law of motion (B.68)

$$\bar{\theta} = \left(\frac{\bar{n}x}{\xi \times (1-\bar{n})}\right)^{1/\eta}. \qquad \text{(B.68')}$$

3. Capital to production ratio $\frac{\bar{k}}{\bar{y}\bar{g}}$ from the first order condition (B.62).
4. Investment to production ration from the law of motion of capital (B.67).
5. Capacity utilization follows, trivially, from equation(B.60).
6. The derivative of capacity utilization along the balanced growth path δ_1 from equation(B.61).
7. The price of capital follows, trivially, from equation(B.64).
8. Consumption to production ratio $\frac{\bar{c}}{\bar{y}}$ from the resource constraint (B.67).
9. Wages to production $\frac{\bar{w}}{\bar{y}}$ from the recruiting optimality condition (B.69).
10. Number of recruiters $\bar{n}\bar{\nu}$ from the definition of market tightness (B.59).
11. The stochastic discount factor $\bar{m}$ from equation (B.58).
12. Production $\bar{y}$ per definition (B.66).

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

B.8 Variation: Product market power

To introduce market power, let us differentiate 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 $\zeta > 1$:

$$\bar{y}_t = \left(\int_0^1 y_t(i)^{1-1/\zeta} di \right) \frac{\zeta}{\zeta - 1}. \tag{B.70}$$

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:

$$y_t(i) = \bar{y}_t \left(\frac{p_t(i)}{\bar{p}_t} \right)^{-\zeta}.. \tag{B.71}$$

Each variety is produced according to the following production function:

$$\begin{aligned} y_t(i) &= \left(\alpha^{1/\varepsilon} (u_t(i) k_{t-1}(i))^{1-1/\varepsilon} + (1-\alpha)^{1/\varepsilon} (z_t n_{t-1}(i)(1-\nu_t(i)))^{1-1/\varepsilon} \right)^{\frac{\varepsilon}{\varepsilon-1}} - \Phi_t \\ &\equiv \psi(u_t(i) k_{t-1}(i), z_t n_{t-1}(i)(1-\nu_t(i)); \Phi_t), \end{aligned} \tag{B.72}$$

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 (B.71) 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 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.

B.8.1 Firm optimality

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 the marginal value of employment that enters it reflects the lower marginal revenue product, as (B.43) shows.

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

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

Thus, the marginal value of employment is given by:

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

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

The optimality condition for the utilization rate becomes:

$$\delta'(u_t)q_tk_{t-1} = \left(\delta_1 + \delta_2(u_t-1)\right)q_tk_{t-1} = (1-\tau_k)(1-1/\zeta)\left(\alpha\frac{y_t}{u_tk_{t-1}}\right)^{1/\varepsilon}k_{t-1} \equiv (1-\tau_k)\frac{mrpk_t}{u_t}. \tag{B.20'}$$

The optimality condition for capital k' becomes:

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

The marginal revenue product of physical capital is:

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

B.8.2 Calibration

Monopolistic competition is an extra source of profits in the economy: In the detrended economy, the flow profit is $\bar{y}/\zeta$ 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. We then 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 $1-(1-0.31)(1-1/\zeta)^{-1/\epsilon}$.

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: $\tilde{\Phi}_t = \bar{y}/\zeta$.

B.9 Euler equation errors

Our model has two Euler equations: (1) The recruiting FOC (B.44) and (2) the capital FOC (B.48). As is customary, we transform the Euler equation error to consumption units. To do so, take an a Euler equation with a generic return R^i_{t+1}. Following Fernandez-Villaverde and Rubio-Ramirez (2006), the Euler equation error in state s_t is:

$$EE(s_t) = \left|1 - \frac{u_c^{-1}\left(\mathbb{E}_t\left[\beta_t g_z^{-\sigma}u_c(c(s_{t+1});n(s_{t+1}))R^i(s_{t+1})\right];n(s_t)\right)}{c(s_t)}\right| \tag{B.73}$$

Here:

$$R^{\nu}_{t+1} \equiv \left(1-\tau_k)\widetilde{mpl}_t\right)^{-1} \mu(\theta_t) g_{z,t+1} \tilde{J}_{n,t+1}$$

$$R^{k}_{t+1} \equiv q_t^{-1} \left(\widetilde{mpk}_{t+1}(1-\tau_k) + \bar{\delta}\tau_k + \left((1-\delta(u_{t+1})) + \chi_{t+1}\left(\frac{\tilde{I}_{t+1}}{\tilde{k}_t} g_{z,t+1}\right)^2 \left(\frac{\tilde{I}_{t+1}}{\tilde{k}_t} g_{z,t+1} - \tilde{\delta}\right)\right) q_{t+1}\right)$$

$$u_c^{-1}(\tilde{u}_c; n) = \tilde{u}_c^{-\frac{1}{\sigma}} \times (1 + (\sigma - 1)\gamma n)$$

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 solution. Unlike Fernandez-Villaverde and Rubio-Ramirez (2006) we therefore resort to Monte Carlo integration as in Andreasen, Fernandez-Villaverde, and Rubio-Ramirez (2013). By discarding a burn-in of 1,000 simulations and before evaluating the state s_t we draw from the ergodic distribution. We then integrate out the shocks in the next period. We can use either Monte Carlo or Gaussian quadrature.

`Pseudo-code for Monte Carlo integration`

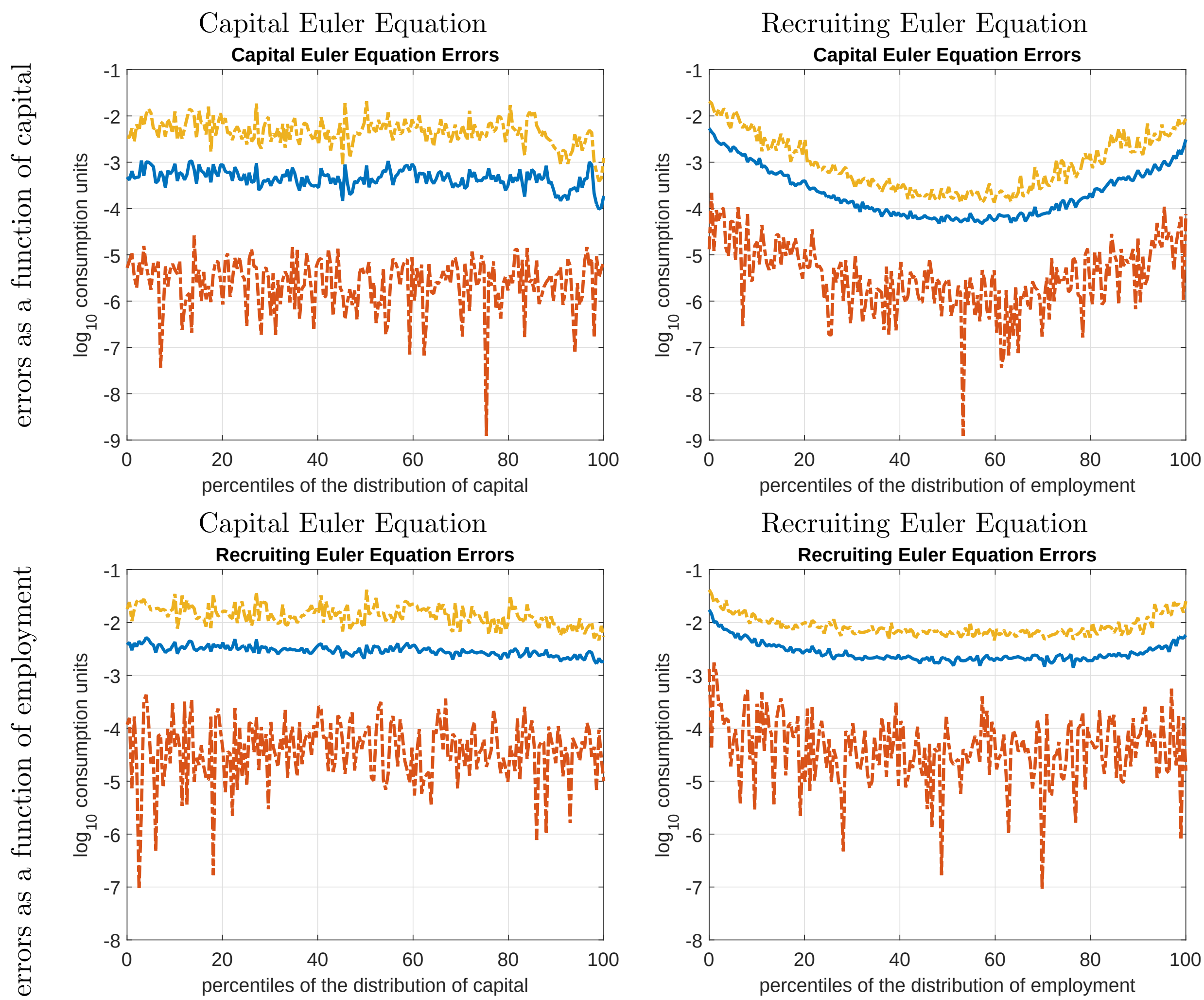
1. `Simulate the model for 6,000 periods.`
2. `Discard the first 1,000 periods and save the remaining 5,000 draws for the state` s_t `as` $\{s_t^{(\ell)}\}_\ell$.
3. `For` $\ell = 1, \ldots, 5,000$:
   (a) $s_t^{(\ell)}$, `compute the vector of current policies and stack it with the state vector:` $s_t^{+,(\ell)}$.
   (b) `For` $m = 1, \ldots, 1,000$:
      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:

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

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 equation: Table B.2(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 maximum approximation is only slightly above 2%. This is largely comparable to the real business cycle analogue of our search model, as panel (c) shows. Errors in the search and matching model with the same shock process in panel (b) are smaller than in the RBC model.

Figure B.7 shows the mean, minimum, and maximum Euler equation error also as a function of the endogenous state of the economy, i.e. capital and employment. It shows that while the approximation errors for the capital Euler equation are larger for extreme values of employment, they still average below 1% of consumption.



Mean and maximum Euler equation errors as a function of the two endogenous state variables, i.e. capital and employment, are in the order of 10^{-2} in consumption units. This error is largely independent of the value of capital or employment.

Figure B.7: Euler equation errors as a function of capital and employment: Mean, maximum, and minimum.

(a) Baseline search & matching model

Euler Equation	Mean	Min	p1	p5	Median	p95	p99	Max
Capital EE	-3.31	-8.91	-5.70	-5.01	-3.92	-2.65	-2.26	-1.68
Recruiting EE	-2.52	-7.05	-4.47	-3.71	-2.66	-2.08	-1.80	-1.38

(b) Search & matching model without bargaining shocks

Euler Equation	Mean	Min	p1	p5	Median	p95	p99	Max
Capital EE	-4.41	-9.35	-6.22	-5.54	-4.47	-4.02	-3.90	-3.68
Recruiting EE	-3.77	-8.38	-5.75	-4.92	-3.86	-3.36	-3.20	-2.88

(c) Hansen-Rogerson RBC model

Euler Equation	Mean	Min	p1	p5	Median	p95	p99	Max
Capital EE	-3.93	-7.70	-6.04	-5.33	-4.25	-3.36	-2.89	-2.34
Labor supply EE	-3.23	-7.49	-5.48	-4.83	-3.70	-2.59	-2.21	-1.66

Table B.2: Euler equation errors: Mean and distribution.

B.10 Search and matching model: All IRFs

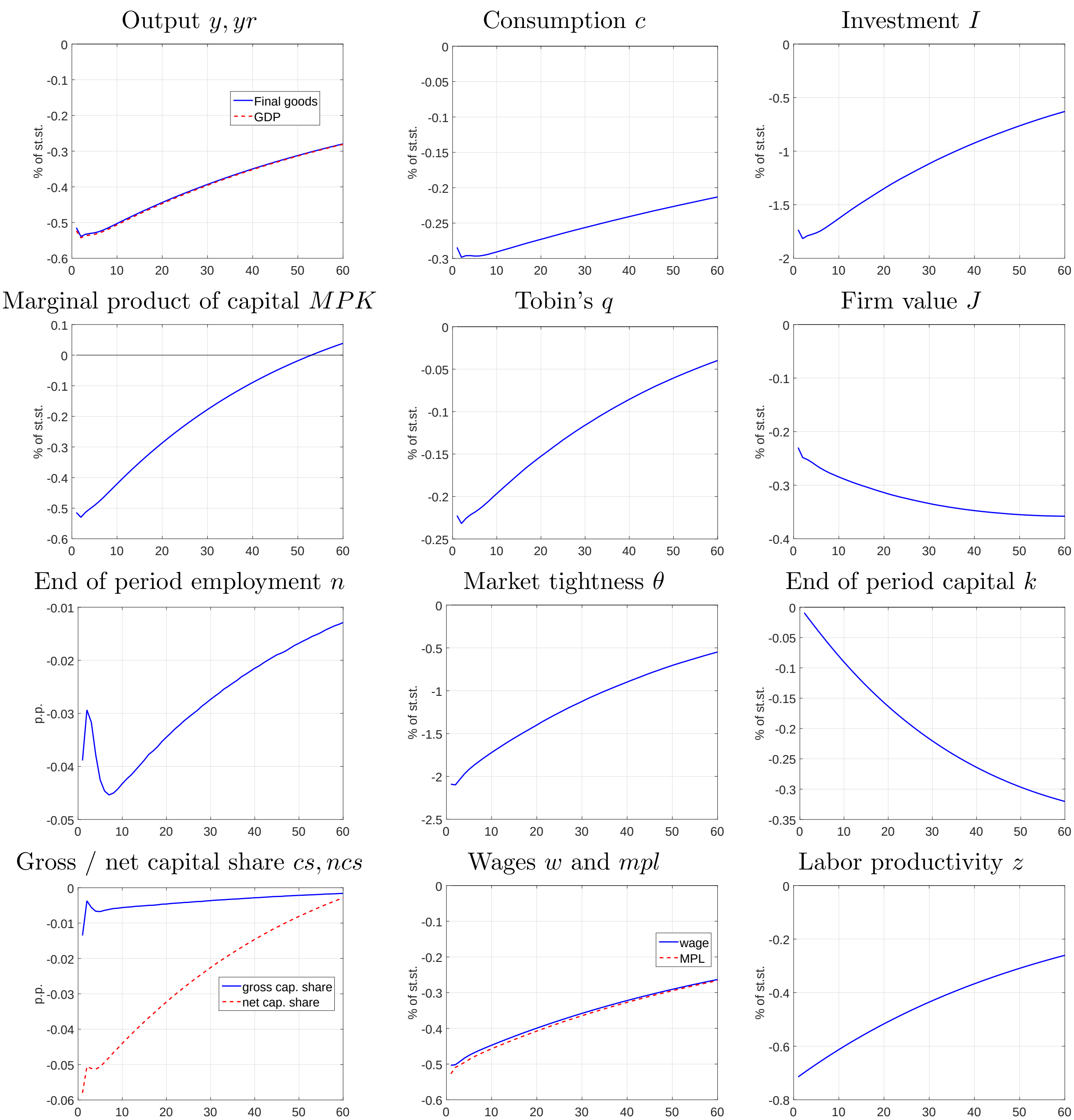


Figure B.8: IRFs to a negative one standard deviation shock to labor productivity with Cobb-Douglas technology

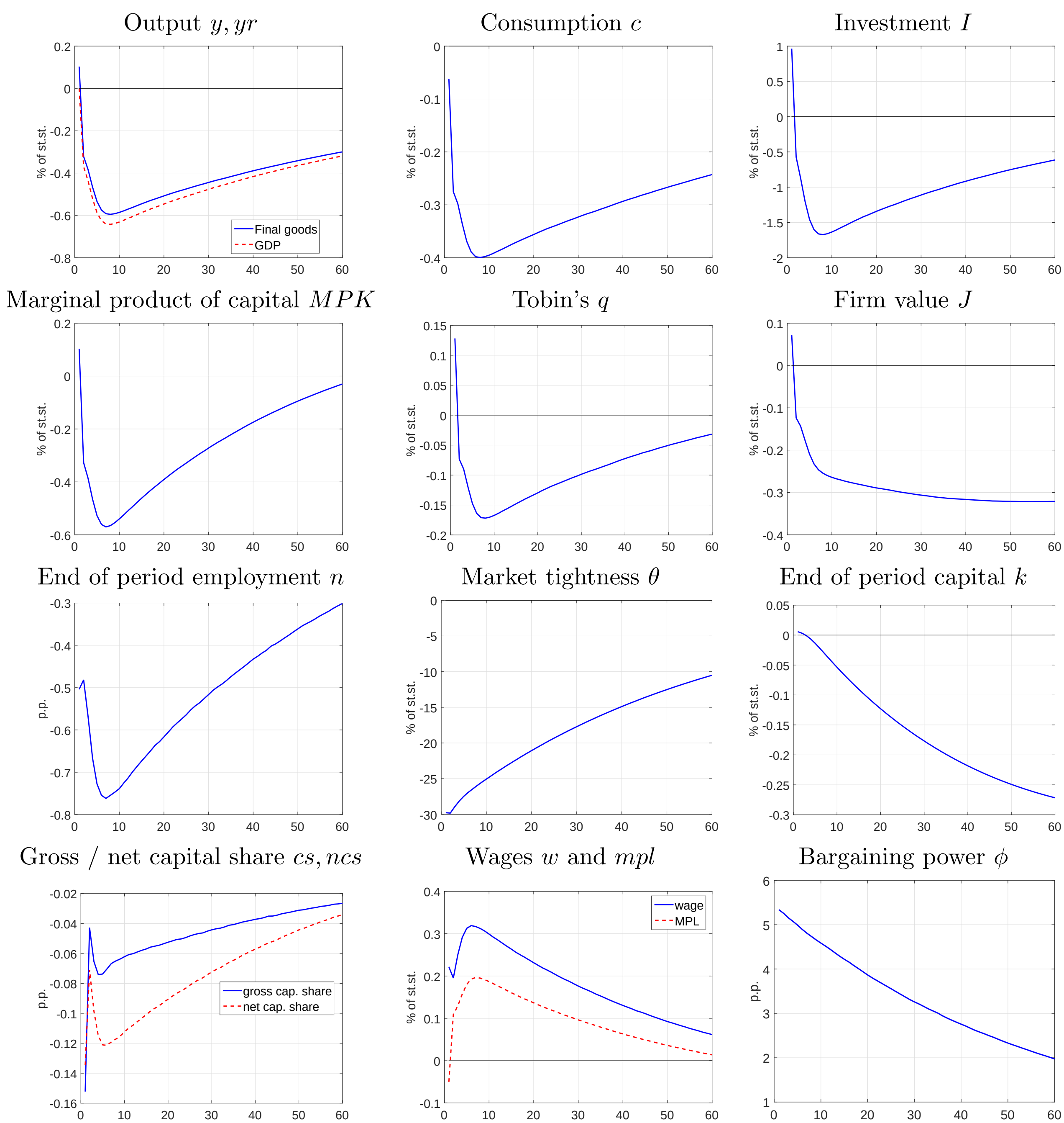


Figure B.9: IRFs to a one standard deviation shock to workers' bargaining power with Cobb-Douglas technology

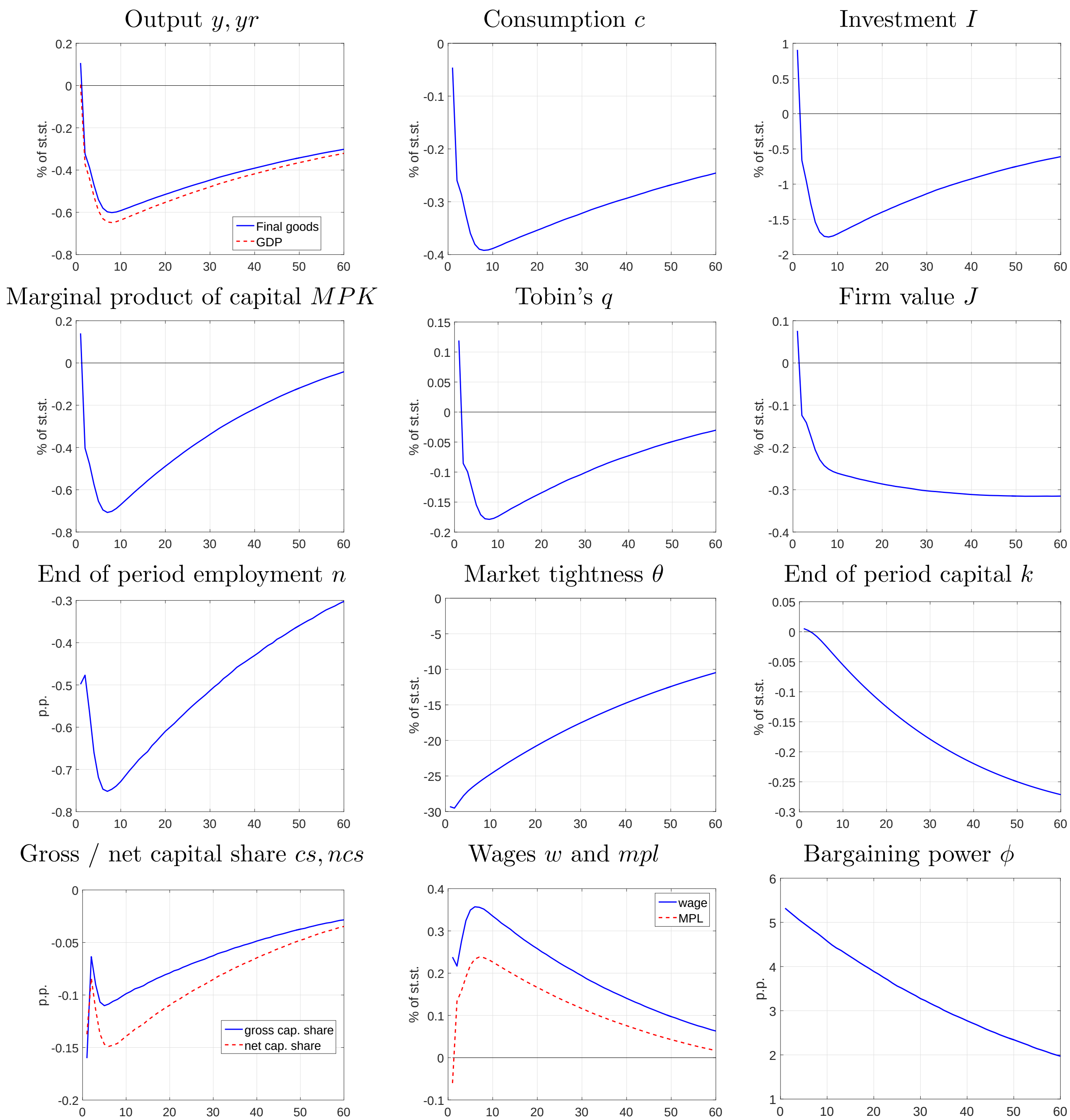


Figure B.10: IRFs to a one standard deviation shock to workers' bargaining power with CES $\varepsilon = 0.75$

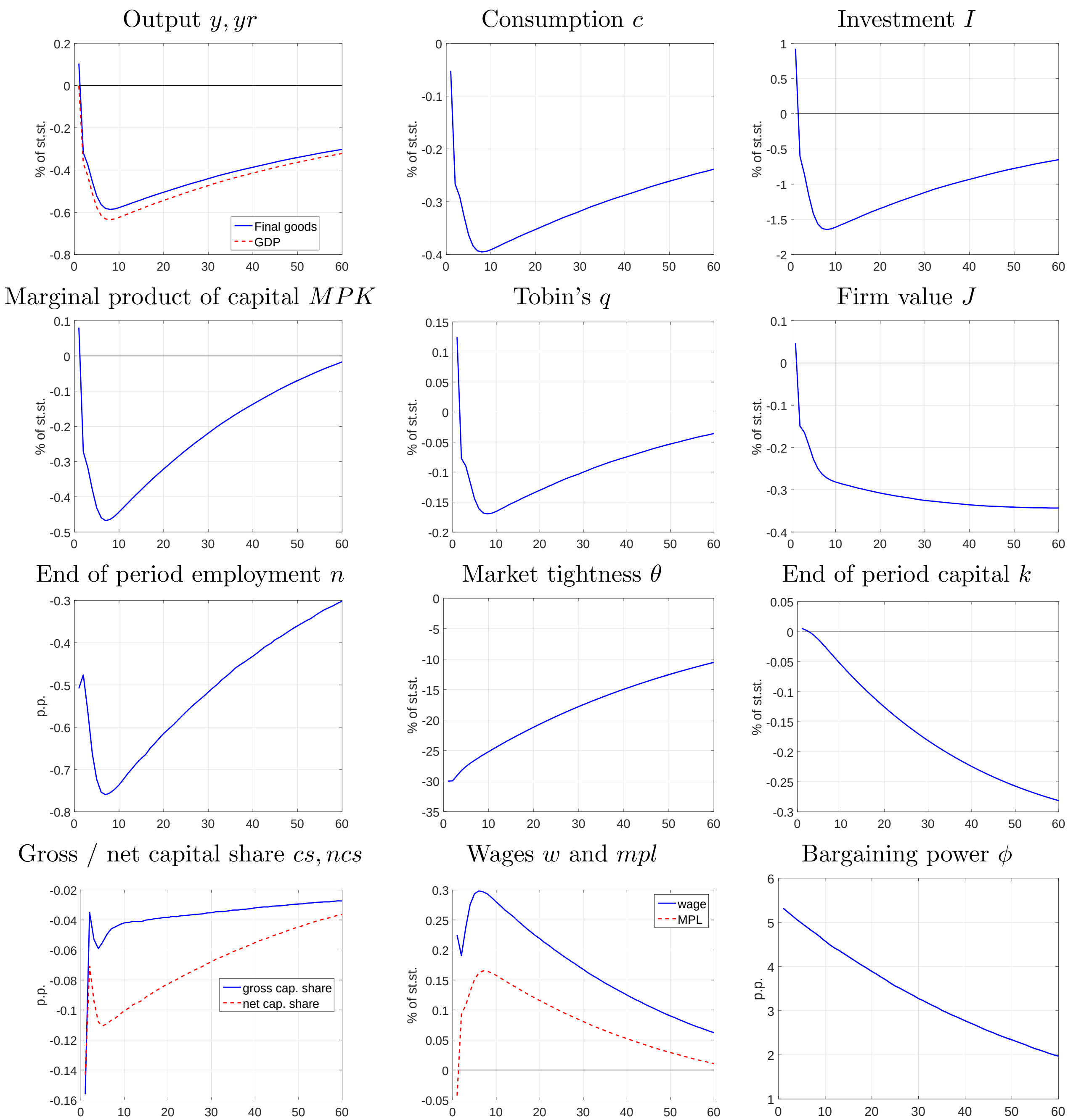


Figure B.11: IRFs to a one standard deviation shock to workers' bargaining power with CES $\varepsilon = 1.25$

B.11 IRF comparison: Search and matching vs. RBC model

We benchmark our model against a real business cycle analogue to our economy. Since our economy with search and matching friction 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:

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

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

- The detrended habit function $\tilde{h}(\cdot)$ in (B.46) is constant at $\tilde{h} = hg_z^{-\frac{1}{1-\alpha}}$.
- The law of motion for employment (**??**) drops out as well as the recruiting FOC (B.17) – the fraction of recruiter 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.

  Labor supply predetermined

  - The equation (B.43) for the marginal value of employment J_n is replaced by

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

    In words, the wage rate equals marginal product of labor state by state – keeping the labor share of income constant with a Cobb-Douglas production function.
  - The wage setting equation (B.65a) is replaced by a simple 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.

  Labor demand predetermined

  - The equation (B.43) for the marginal value of employment J_n is replaced by

    $$\mathbb{E}_t[m_{t+1}g^{\frac{1}{1-\alpha}}(\widetilde{mpl}_{t+1} - w_{t+1})] = 0$$

    When firms choose labor in advance, the present discounted wage rate has to equal the present discounted marginal product of labor.
  - The wage setting equation (B.65a) is replaced by a simple indifference condition for the household:

    $$(1-\tau_n)w_t = \sigma\gamma\frac{c_t - h\bar{c}_{t-1}}{1+(\sigma-1)\gamma n_t}$$

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.

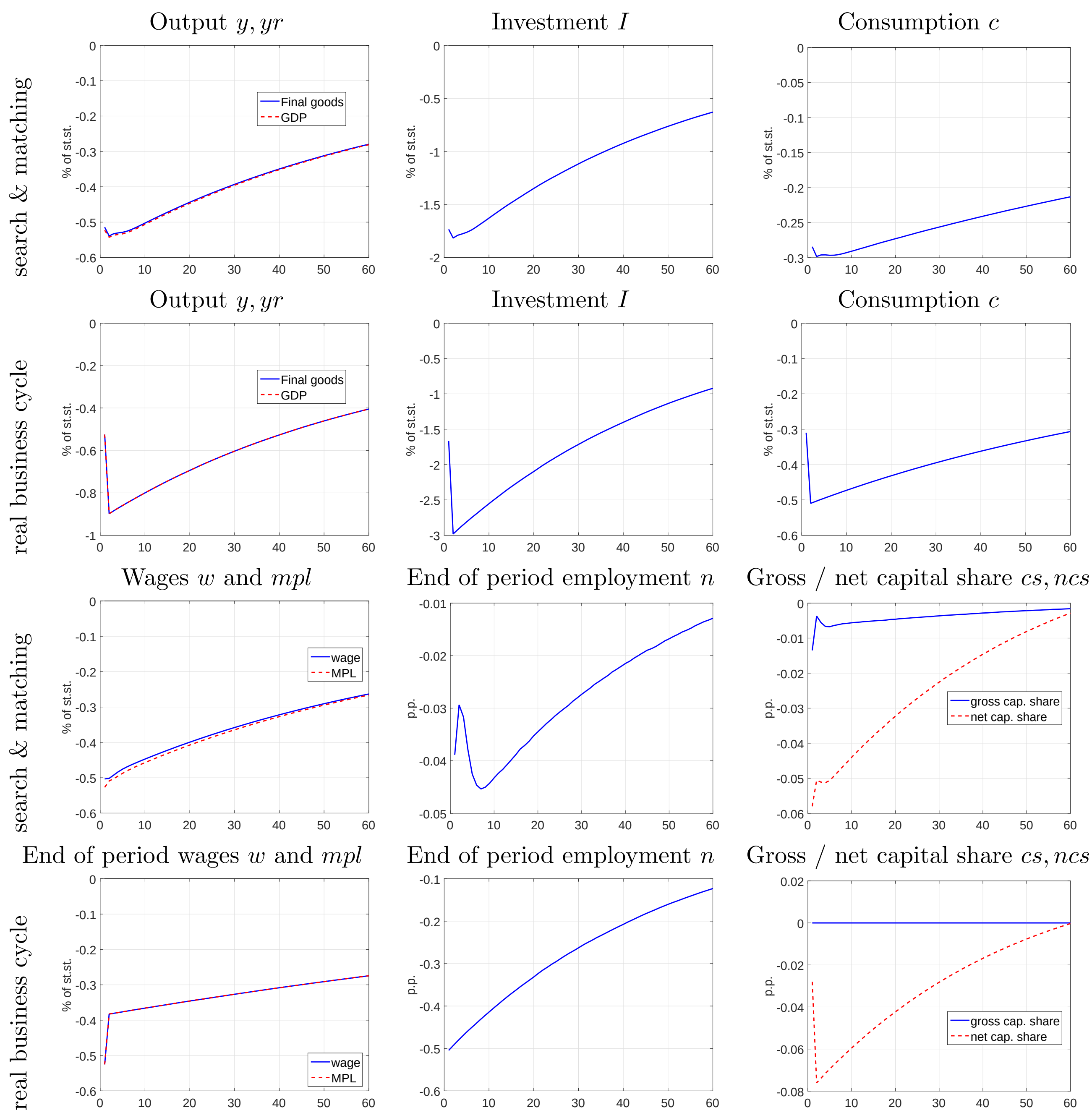


Figure B.12: IRFs to a negative one standard deviation TFP shock: Search & matching vs RBC model with Cobb-Douglas production function

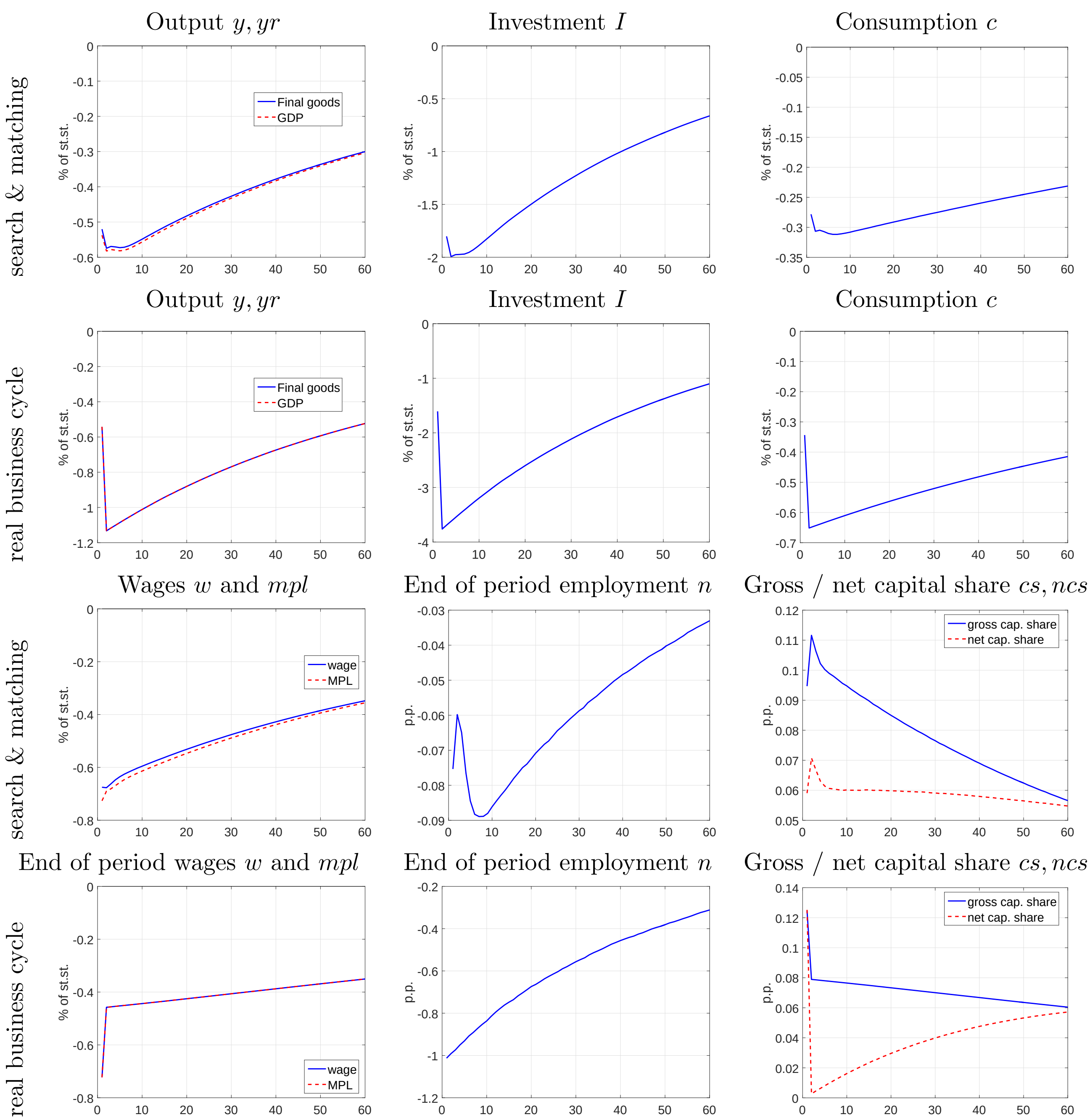


Figure B.13: IRFs to a negative one standard deviation TFP shock: Search & matching vs RBC model with CES $\varepsilon = 0.75$

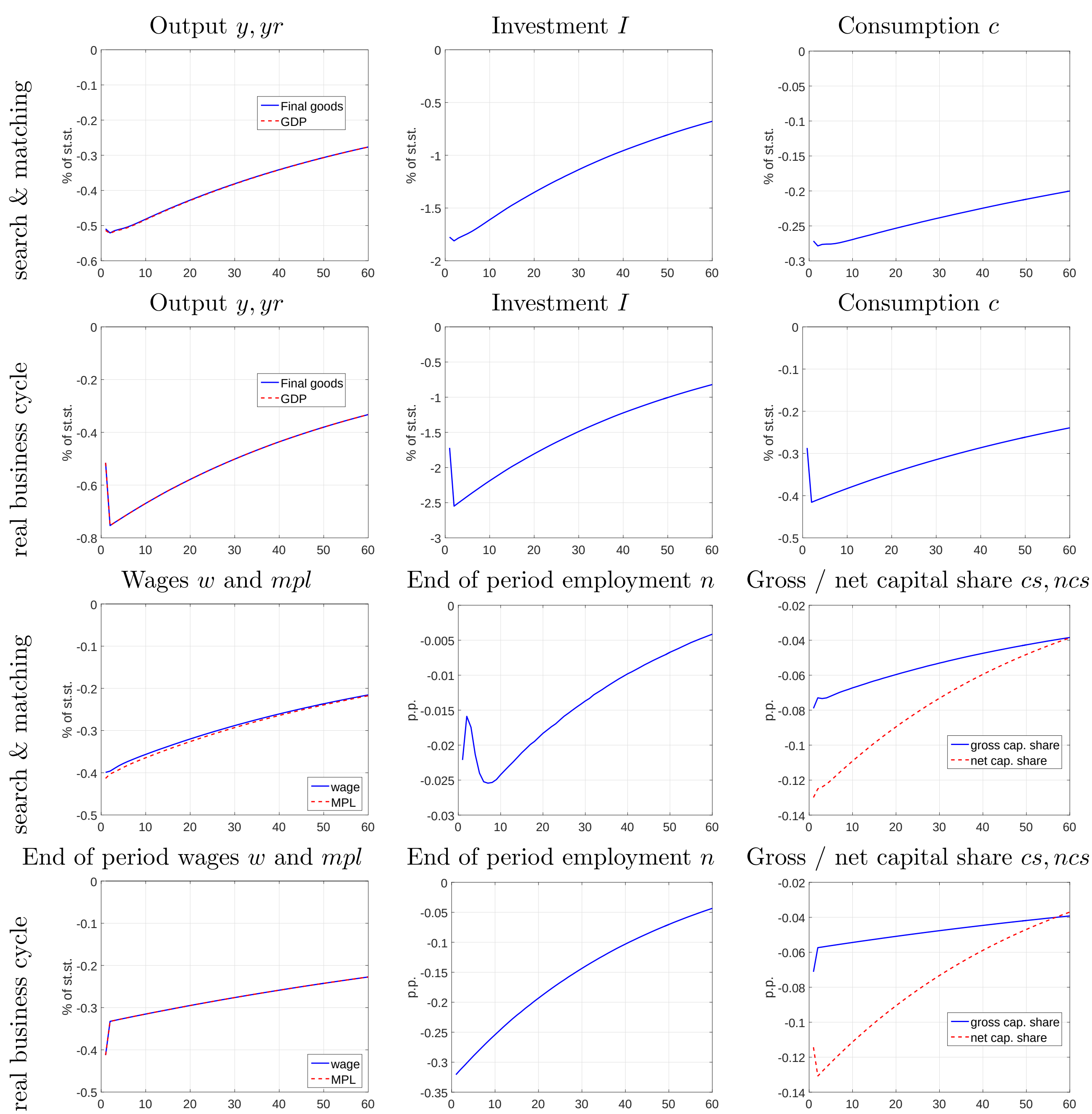


Figure B.14: IRFs to a negative one standard deviation TFP shock: Search & matching vs RBC model with CES $\varepsilon = 1.25$

B.12 Sensitivity analysis: Persistence

Here we consider different values of the persistence of the bargaining power shock in addition to the baseline value of $\rho_\phi = 0.95^{1/3}$. For the low persistence, we choose $\rho_\phi = 0.75^{1/3}$, yielding a half-life of about two quarters. For the high persistence, we choose $\rho_\phi = 0.99^{1/3}$, yielding a half-life of about 69 quarters: a semi-permanent shock. For each value, we re-calibrate the model.

Table B.3 and Figure B.15 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 we show in the main text (Figure 8) that steady state changes in the bargaining power have virtually no effects on capital shares.

Table B.3: Business cycle statistics with different persistence for the bargaining power shock and re-calibrated persistence and investment adjustment cost: 1947Q1–2015Q2

	Y [%]	$\frac{\text{std(I)}}{\text{std(Y)}}$	$\frac{\text{std(C)}}{\text{std(Y)}}$	std(ncs) [%]	std(cs) [%]	std(w) [%]	
US data	1.96	3.29	0.59	1.07	0.86	0.95	
				Models			
S&M model	1.95	3.23	0.58	0.39	0.22	1.29	Baseline: $\rho_\phi = 0.95^{1/3}$
S&M model	1.19	3.49	0.53	0.16	0.01	1.05	Baseline w/o bargaining shock
S&M model	1.95	3.25	0.61	0.34	0.14	1.22	High persistence: $\rho_\phi = 0.99^{1/3}$
S&M model	1.23	3.85	0.46	0.17	0.02	1.06	High persistence calibration, no barg. shock
S&M model	1.95	3.25	0.56	0.69	0.55	1.62	Low persistence: $\rho_\phi = 0.75^{1/3}$
S&M model	1.17	3.31	0.56	0.16	0.01	1.04	Low persistence calibration, no barg. shock

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

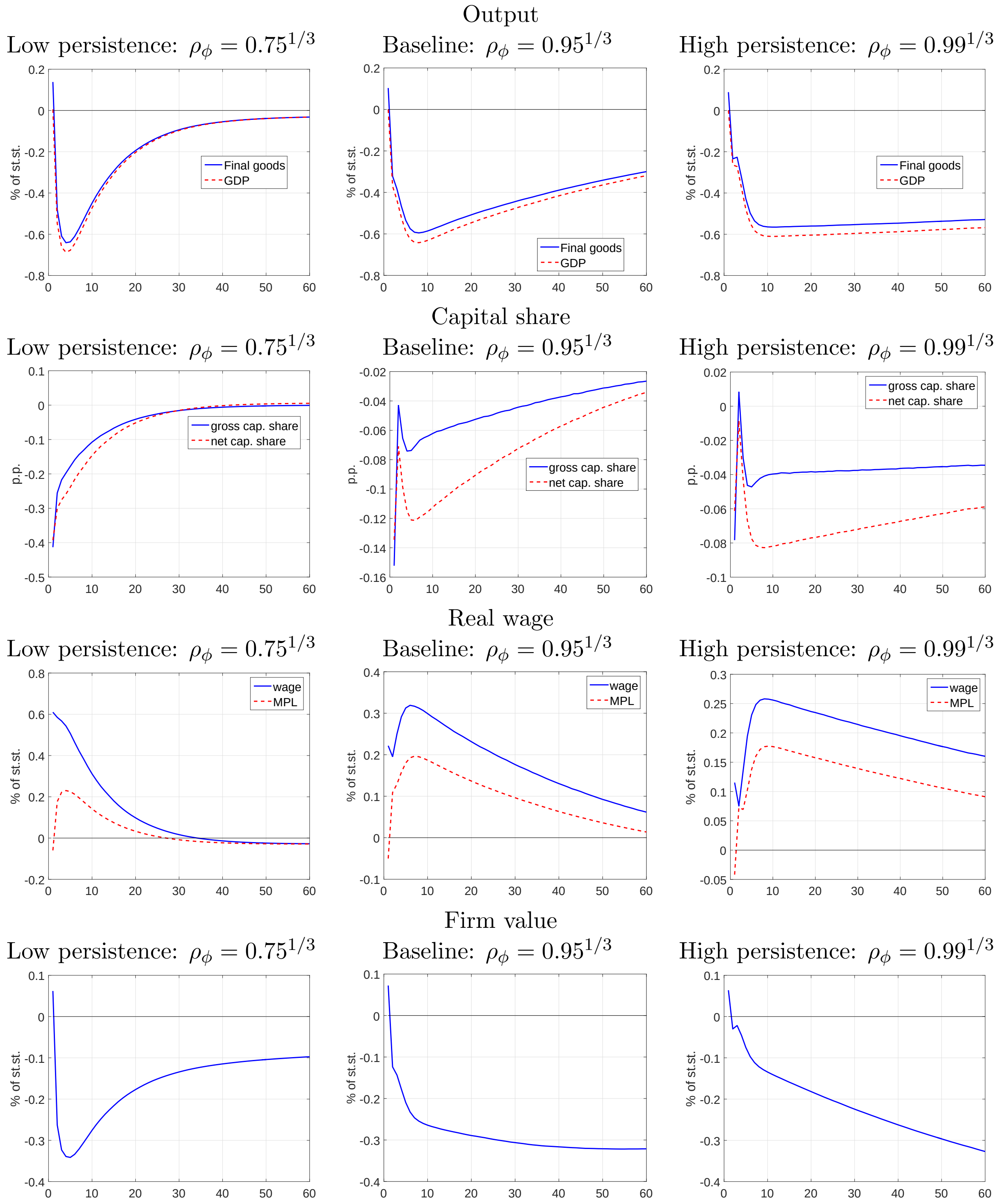


Figure B.15: IRF of output, capital share, real wage, and firm value with the model calibrated to different levels of persistence