

The Missing Link: Labor Share and Monetary Policy

C. Cantore¹ F. Ferroni² M. León-Ledesma³

¹Bank of England, CfM, and University of Surrey

²Federal Reserve Bank of Chicago

³University of Kent and CEPR

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The views expressed in this paper are those of the authors and are not necessarily reflective of views at the Bank of England, Federal Reserve Bank of Chicago or the Federal Reserve System.

Motivation and Results

- ▶ The textbook New-Keynesian (NK) model implies that the labor share is pro-cyclical conditional on a monetary policy (MP) shock.
- ▶ There is **no systematic empirical evidence** on the effect of monetary policy shocks on the share of output allocated to wages.
- ▶ Usually the labor share (observable) is used to proxy for the 'inverse' of mark-ups (unobservable).
- ▶ Using data for **five developed economies** we find that **the labor share is counter-cyclical** following a MP shock. (wages are pro-cyclical)
- ▶ We show that **standard models generate the wrong sign** for the labor share response and cannot be used to study the distributional effects of monetary policy.

Labor Share, the price mark-up and the Business Cycle

- ▶ MP shocks and SVAR evidence: [Christiano et al., 2005], [Olivei and Tenreyro, 2007] , [Ramey, 2016], [Basu and House, 2016].
- ▶ Labor Share and technology shocks: [Hansen and Prescott, 2005], [Choi and Ríos-Rull, 2009], and [León-Ledesma and Satchi, 2018].
- ▶ **The cyclicality of mark-ups:** [Bils, 1987], [Rotemberg and Woodford, 1999], [Galí et al., 2007], [Hall, 2012], [Nekarda and Ramey, 2019], [Karabarbounis, 2014] and [Bils et al., 2014].
- ▶ [Nekarda and Ramey, 2019]: Their conclusions, like ours, cast doubts on the standard transmission mechanism of NK models.
- ▶ The conditional correlation of the labor share to demand shocks is still empirically and theoretically an **open question**.

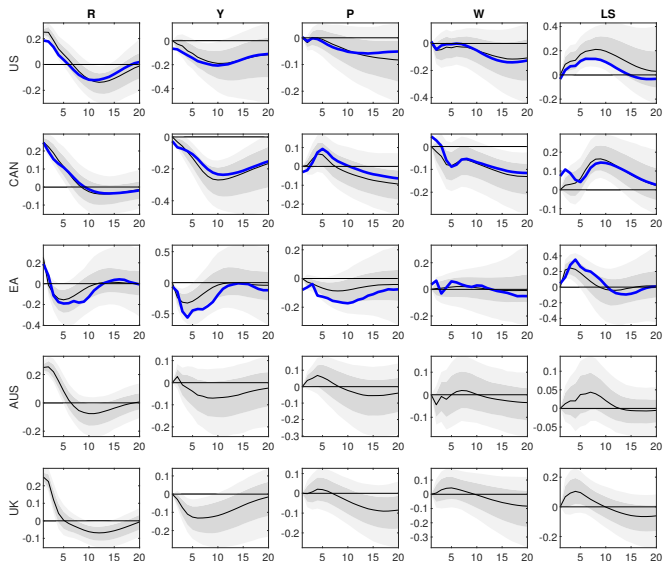
- ▶ We consider, as a baseline specification, a **7 variables VAR**.
- ▶ The variables in the information set are: Real GDP, GDP deflator, CPI, index for price of commodities, Real Wages, Labor Share and short term interest rates. [▶ Details](#)
- ▶ Instruments:
 - ▶ US: 3 instruments **jointly** as in Mertens and Ravn (2012): (i) Romer and Romer (2004) **narrative**; (ii) Gertler and Karadi (2015) and (iii) Miranda-Agrippino (2016) **high frequency**.
 - ▶ EA: Andrade and Ferroni (2016) **high frequency**.
 - ▶ Canada: Champagne and Sekkel (2018) **high frequency**.
 - ▶ UK: Cloyne and Hurtgen (2016) **high frequency**.

Country	Sample	
US	1984:Q1	2007:Q4
EA	1999:Q4	2011:Q3
AUS	1985:Q1	2009:Q4
CAN	1985:Q1	2011:Q1
UK	1986:Q1	2008:Q1



Cholesky and Proxy SVAR

25 bps increase in the short term interest. Light (dark) gray 90% (68%) bands.



VAR Robustness: Information Set and Sample

- ▶ **Measurement:** Using different labor share proxies constructed for the US, Australia and Canada. [▶ Details](#)
- ▶ **Structural Break:** Only for the US we check the original sample as [CEE05] 1965:Q1-1995Q3 and 1965:Q1-2007:Q4. [▶ Details](#)
- ▶ 10 variable SVAR adding TFP and Corporate Bond Spread. [▶ Larger VAR](#)
- ▶ **Sign restrictions**, as in [Uhlig, 2005] . [▶ Details](#)
- ▶ **Sectoral composition** [▶ Details](#)

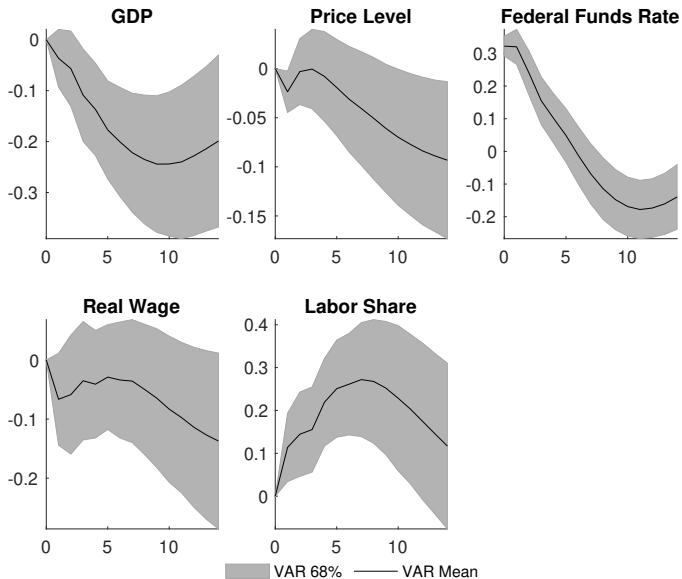
Labor Share in DSGE models

- ▶ In the paper we show analytically that **in a canonical NK model with price and wage rigidities it is not possible to obtain a positive response of the labor share to a MP contraction on impact in line with our empirical evidence.**
- ▶ This is because of the tight negative relationship between the labor share and the inverse of the mark-up.
- ▶ Several mechanisms have been presented that can **break down** the labor share and the inverse of the mark-up.
- ▶ Focus here on the '**sticky prices/wages**' version of the model in [Christiano et al., 2016] which includes:
 - ▶ The Cost channel of Monetary Policy: [Ravenna and Walsh, 2006], [Christiano et al., 2010].
 - ▶ Fix costs: [Nekarda and Ramey, 2019].
- ▶ Plus they show that generates dynamics very similar to a model variant with **Labor market search frictions.**

Methodology

- ▶ Given the size of this model we do this using a **three step approach**:
 1. **Prior Sensitivity Analysis (PSA)**: we assess the likelihood of the model to generate the sign of LS IRFs consistent with the data, conditional on the model and on a very loose prior specification. [▶ details](#)
 2. **Monte Carlo Filtering (MCF)**: to identify the parameters that are able to generate those patterns. [▶ details](#)
 3. **Bayesian IRF Matching** ([Christiano et al., 2010]): estimate the model (including the parameters identified in step 2) by minimizing the distance between the VAR and DSGE IRFs to a MP shock for a selected number of variables. [▶ details](#)

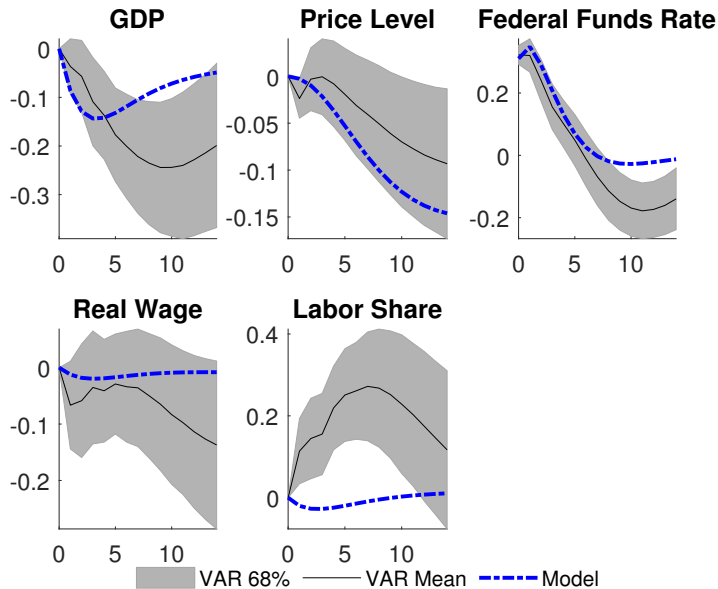
IRF Matching



IRF Matching

▶ posterior modes

▶ More



Conclusions

- ▶ Our results emphasise the **needs to develop models that are able to replicate the cyclical behaviour of the labor share** and its components.
- ▶ Models that can do a reasonable job at reproducing the dynamic responses of real variables cannot simultaneously match the dynamics of the labor share.
- ▶ Our results then imply that **either models are unable to separate the dynamics of the labor share from marginal costs, or that marginal costs do not respond in the way models predict.**

Appendix

Cross Country Labor Share

▶ return

▶ Data construction and sources

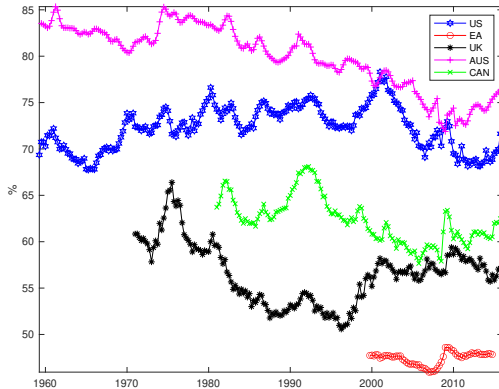


Figure: Cross Country Labor Share

▶ Descriptive Statistics

Data Construction and Sources: Labor Share

▶ return

- ▶ Measuring the share of labor in total income is complicated by problems associated with how to impute certain categories of income to labor and capital owners.
- ▶ The existence of self-employment income, the treatment of the government sector, the role of indirect taxes and subsidies, household income accruing from owner occupied housing, and the treatment of capital depreciation, are common problems highlighted in the literature.
- ▶ These have been discussed at length in [Gollin, 2002]), [Gomme and Rupert, 2004] and more recently in [Muck et al., 2015].
- ▶ We use 7 different proxies of Labor share for the US.

Data Construction and Sources: US Labor Share - 7 measures

▶ return

- LS1 An index of the Labor Share in the Non-Farm Business Sector taken from BLS.
- LS2 Labor share in the domestic corporate non-financial business sector as discussed by GR07. (*No issues with proprietors income and rental income, two ambiguous components of factor income.*)
- LS3 Deals with imputing ambiguous income (AI) and corresponds to the second alternative measure of the labor share proposed in GR07. The measure excludes the household and government sectors.
- LS4 Same as the above LS3 but not corrected for inventory valuation adjustment and an adjustment for capital consumption.
- LS5 Deals with AI as in [Ríos-Rull and Santaaulàlia-Llopis, 2010] in the calculation of the capital share.
- LS6 Taken from [Fernald, 2014]. In computing the capital share assumes non-corporate sector has the same factor shares as the corporate non-financial sector.
- LS7 An index of the Labor Share in the Non-Financial Corporation Sector taken from BLS.

▶ Details

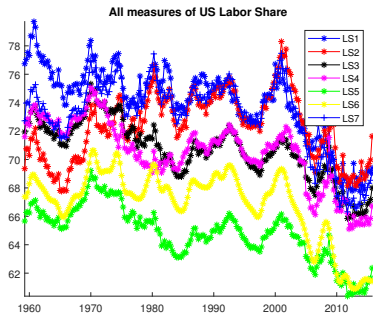
Data Construction and Sources: Labor Share

▶ [return](#)

- ▶ We constructed measures of the labor share on a quarterly basis for some other countries for which data were available for a sufficiently long period of time.
- ▶ Those countries are Australia (1959:Q3-2016:Q1), Canada (1980:Q2-2016:Q1), the Euro Area (1980:Q1-2014:Q4) and the UK (1955:Q1-2016:Q1).
- ▶ For some of these countries, however, data availability limits the extent to which we can obtain corrected labor share measures and, in many cases, we work with rough estimates of labor shares.
- ▶ We use one each for the Euro Area and the UK, 2 for Canada and 5 for Australia. [▶ Details](#)
- ▶ [▶ Data on Wages and Labor Productivity](#)

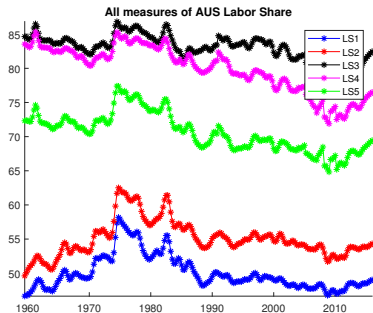
US Proxies

▶ return



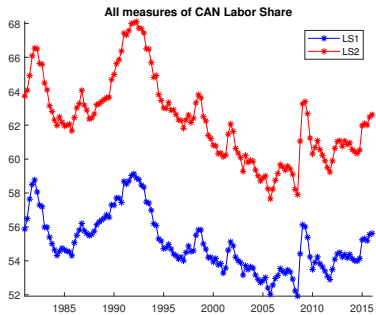
AUS Proxies

▶ return



CAN Proxies

▶ return



Data Construction and Sources: Wages and Labor Productivity

▶ return

- ▶ For real wages, we used nominal compensation of employees deflated by the CPI over hours worked from the BLS and [Ohanian and Raffo, 2012].
- ▶ Labor productivity is calculated as real GDP over hours worked from the same databases.

Data Construction and Sources

▶ return

- 1 **Labor share 1**: Labor share in the non-farm business sector. This is taken directly from BLS. The series considers only the non-farm business sector. It calculates the labor share as compensation of employees of the non-farm business sector plus imputed self-employment income over gross value added of the non-farm business sector. Self-employment imputed income is calculated as follows: an implicit wage is calculated as compensation over hours worked and then the imputed labor income is the implicit wage times the number of hours worked by the self-employed.

Data Construction and Sources

▶ return

2 **Labor share 2:** Labor share in the domestic corporate non-financial business sector. This follows [Gomme and Rupert, 2004] first alternative measure of the labor share. The use of data for the non-financial corporate sector only has the advantage of not having to apportion proprietors income and rental income, two ambiguous components of factor income. It also considers the wedge introduced between the labor share and one minus the capital share by indirect taxes (net of subsidies), and only makes use of unambiguous components of capital income. This approach also takes into account the definition of aggregate output in constructing the labor share. In all the above measures we used GDP, however sectoral studies often use gross value added (GVA) (see [Bentolila and Saint-Paul, 2003], [Young, 2010] and [Young, 2013]). [Valentinyi and Herrendorf, 2008] and [Muck et al., 2015] show that factor shares in value added differ systematically from factor income shares in GDP. By considering gross value added net interest and miscellaneous payments (NI_t^{gva} , NIPA Table 1.14), gross value added corporate profits (CP_t^{gva} , NIPA Table 1.14), net value added (NVA_t , NIPA Table 1.14) and gross value added taxes on production and imports less subsidies (Tax_t^{gva} , NIPA Table 1.14) the labor share is thus calculated as:

$$\text{Labor Share 2: } LS_t = 1 - \frac{CP_t^{gva} + NI_t^{gva} - Tax_t^{gva}}{NVA_t}.$$

Data Construction and Sources

▶ return

- 3 **Labor share 3:** This approach deals with imputing ambiguous income for the macroeconomy and corresponds to the second alternative measure of the labor share proposed in [Gomme and Rupert, 2004]. The measure excludes the household and government sectors. They define unambiguous labor income (Y^{UL}) as compensation of employees, and unambiguous capital income (Y^{UK}) as corporate profits, rental income, net interest income, and depreciation (same series as above from NIPA Tables 1.1.12 and 1.7.5). The remaining (ambiguous) components are then proprietors' income plus indirect taxes net of subsidies (NIPA Table 1.1.12). These are apportioned to capital and labor in the same proportion as the unambiguous components. The resulting labor share measure is:

$$\text{Labor Share 3: } LS_t = \frac{CE_t}{CE_t + RI_t + CP_t + NI_t + \delta_t} = \frac{Y^{UL}}{Y^{UK} + Y^{UL}}.$$

Data Construction and Sources

▶ return

- 4 **Labor share 4:** This is the same as the above *Labor Share 3* but not corrected for inventory valuation adjustment and an adjustment for capital consumption. Using rental income of persons (without CCAAdj) (RI_t^a , NIPA Table 1.1.12) and corporate profits before tax (without IVA and CCAAdj) (CP_t^a , NIPA Table 1.1.12):

$$\text{Labor Share 4: } LS_t = \frac{CE_t}{CE_t + RI_t^a + CP_t^a + NI_t + \delta_t} = \frac{Y^{UL}}{Y^{UK} + Y^{UL}}.$$

Data Construction and Sources

▶ return

- 5 **Labor share 5:** Follows [Ríos-Rull and Santaaulàlia-Llopis, 2010] and is similar to *PI-2-GDP*. The labor share of income is defined as one minus capital income divided by output. As above, to deal with mixed income, they assume that the proportion of ambiguous capital income to ambiguous income is the same as the proportion of unambiguous capital income to unambiguous income. But the calculation somewhat differ in the computation of Unambiguous income and in the use of Gross National Product (GNP_t , NIPA Table 1.7.5) instead of GDP.

$$CS_t^U = \frac{UCI_t + \delta_t}{UI_t} = \frac{RI_t + NI_t + GE_t + CP_t + \delta_t}{RI_t + NI_t + GE_t + CP_t + \delta_t + CE_t}$$

$$ACI_t = CS_t^U AI_t$$

$$\text{Labor Share 5: } LS_t = 1 - CS_t = 1 - \frac{UCI_t + \delta_t + ACI_t}{GNP_t}$$

Data Construction and Sources

▶ return

- Labor share 6:** Is taken from [Fernald, 2014] and it's utilization adjusted quarterly series. In computing the capital share he assumes that the non-corporate sector has the same factor shares as the corporate non-financial sector. But it's not exactly the same implementation as in *Labor Share 2*. One difference, for example, is in the treatment of some taxes on production and imports that represents payments for capital, namely property taxes and motor vehicle taxes.
- Labor share 7:** Labor share in the non-financial corporation sector. This is taken directly from BLS (FRED series id PRS88003173 provided as an index number). The series considers only the non-financial corporations sector.

Data Construction and Sources: Australia

1959:Q3-2016:Q1 Source: Australian Bureau of Statistics

▶ return

1. Total wages and salaries (including social security contributions) over GDP (AUS_LS1).
2. Total wages and salaries (including social security contributions) over total factor income (AUS_LS2).
3. One minus gross operating surplus of private non-financial corporations as a percentage of total factor income (AUS_LS3).
4. One minus gross operating surplus of private non-financial corporations plus all financial corporations as a percentage of total factor income (AUS_LS4).
5. $(\text{total income} - \text{surplus of all corporations} - \text{gross operating surplus of government} - \text{mixed income imputed to capital}) / \text{total income}$ (AUS_LS5).

Data Construction and Sources: Canada 1980:Q2-2016:Q1 Source: Statistics Canada

▶ return

1. Compensation of employees over total factor income (GDP corrected by taxes and subsidies) (CAN_LS1).
2. We imputed mixed income in the same proportion as unambiguous labor and capital income, and added it to the previous measure of labor income (CAN_LS2) .

Data Construction and Sources: UK, and EA

▶ [return](#)

UK Compensation of employees over gross value added at factor costs (UK_LS). (1955:Q1-2013:Q3 from the Office for National Statistics).

EA Compensation of employees over GDP at factor costs (EA_LS). (1999:Q1-2013:Q4 period from the Area Wide Model database).

Descriptive Statistics

▶ return

Country	Sample	Output	Policy Rate
US	1955Q1-2015Q3	[-0.29, 0.04]	[0.28, 0.60]
EA	1999Q1-2014Q4	[-0.91, -0.37]	[-0.76, -0.28]
UK	1971Q1-2016Q1	[-0.41, 0.11]	[-0.52, 0.08]
AUS	1959Q3-2013Q4	[-0.23, 0.12]	[0.49, 0.70]
CAN	1981Q2-2013Q4	[-0.56, -0.07]	[0.45, 0.72]

Table: GMM 95 % Confidence Intervals and sample coverage.

VAR Data details: US

▶ [return](#)

- ▶ CPI: CPI of all good for all urban consumers for US.
- ▶ Real GDP all Economy.
- ▶ GDP Deflator.
- ▶ Price of commodity index: CBR SPOT commodity index.
- ▶ M2 from IMF.
- ▶ Federal Funds Rates
- ▶ Real wages: we used nominal compensation of employees deflated by the CPI over hours worked from the BLS.
- ▶ Labor productivity is calculated as real GDP over hours worked from the same databases.

VAR Data details: EA

▶ return

- ▶ Price of commodity index: CBR SPOT commodity index.
- ▶ We consider the OECD and New AWM database.
- ▶ HICP excluding energy
- ▶ Short-term interest rate
- ▶ real GDP
- ▶ the GDP deflator
- ▶ M2 from IMF.
- ▶ For Real wages: compensation of employees from OECD QNA deflated by CPI and total hours from AWM.
- ▶ For Labor productivity we use Real GDP over total hours.
- ▶ All variables are in logs but short term interest rate.

VAR Data details: AUS, CAN and UK

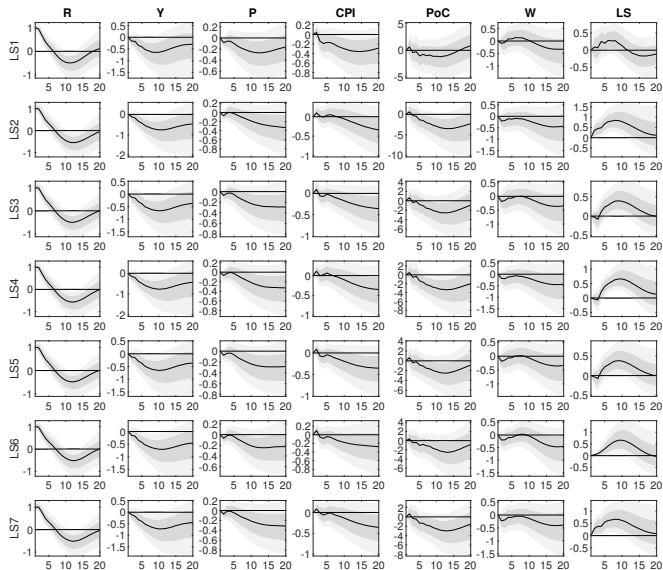
▶ return

- ▶ For core CPI we used OECD consumer prices of all goods.
- ▶ Price of commodity index: CBR SPOT commodity index.
- ▶ For real consumption expenditure we used real private final consumption expenditure from the OECD.
- ▶ For real investment we used real gross fixed capital formation from the OECD.
- ▶ Short term interest rates
- ▶ M2 from datastream
- ▶ For Real wages: compensation of employees from OECD QNA deflated by CPI and total hours from [Ohanian and Raffo, 2012].
- ▶ For Labor productivity we use Real GDP over total hours.

VAR Robustness - Cholesky US different proxies

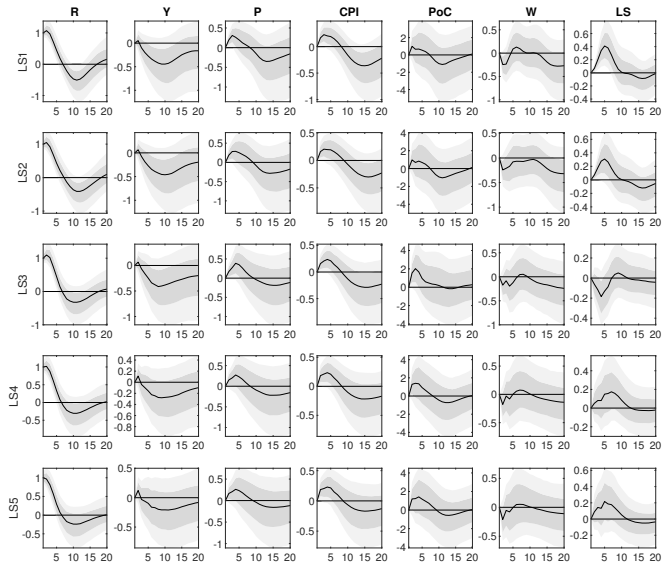
normalized 1% increase in the short term interest rate. 1984Q1-2007Q4

[▶ return](#)



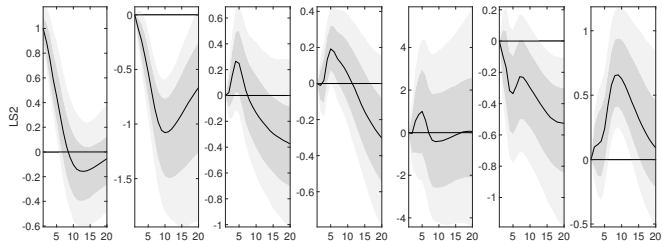
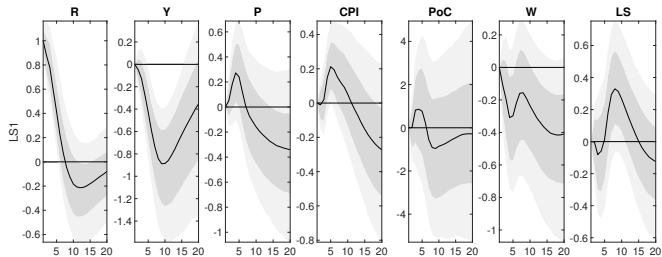
VAR Robustness - Cholesky AUS different proxies

normalized 1% increase in the short term interest rate. [▶ return](#)



VAR Robustness - Cholesky CAN different proxies

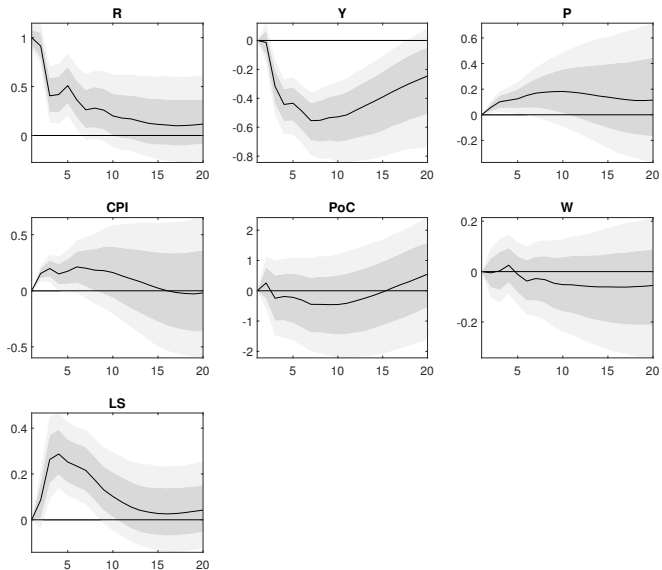
normalized 1% increase in the short term interest rate. [▶ return](#)



VAR Robustness - Cholesky US Sample 1965Q3-1995Q3

normalized 1% increase in the short term interest rate.

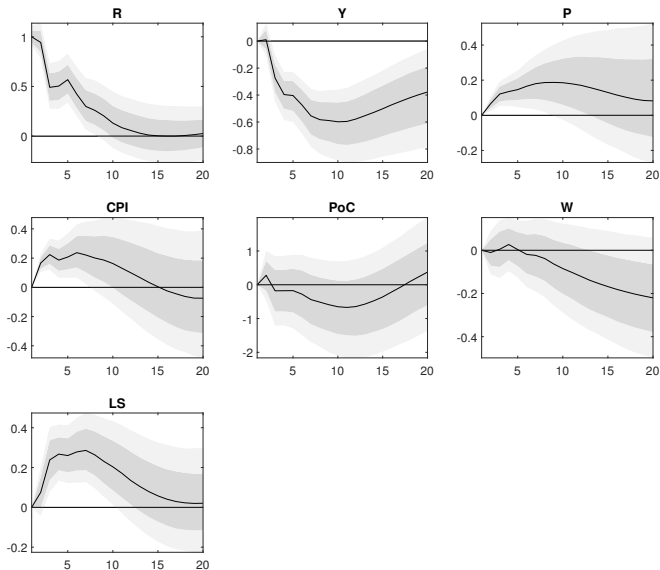
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VAR Robustness - Cholesky US Sample 1965Q3-2007Q4

normalized 1% increase in the short term interest rate.

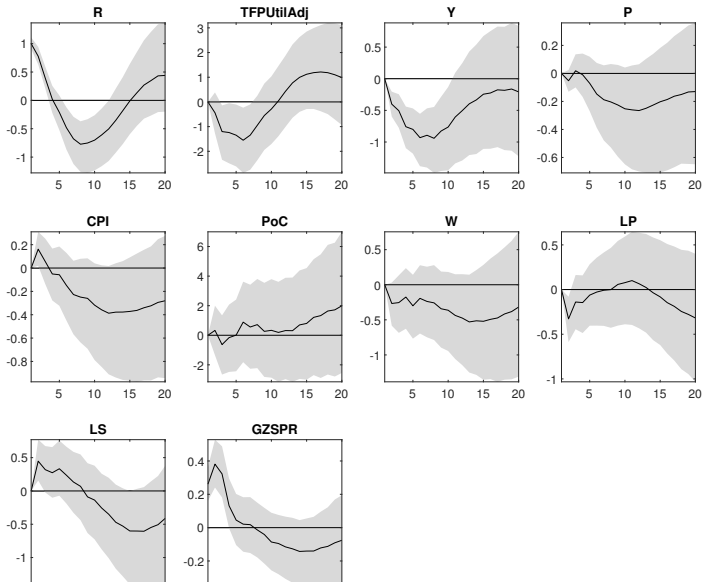
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VAR Robustness - Cholesky US - 10 variable VAR

normalized 1% increase in the short term interest rate. Adding Labor Productivity
Fernald (2012) measure of Utilization Adjusted TFP and the Gilchrist and Zakrajsek
(2012) corporate bond spread.

[▶ return](#)



VAR Robustness: Sign Restrictions

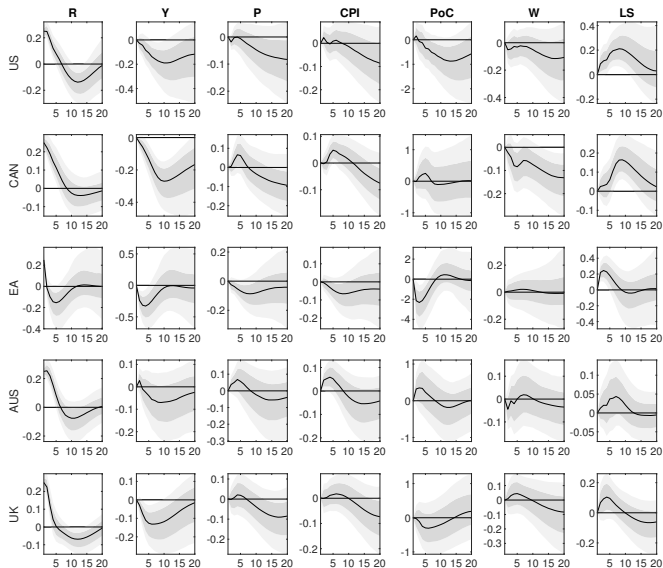
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- ▶ **Sign restrictions**, see [Uhlig, 2005]. We postulate that a monetary policy shock
 - ▶ increases the short term nominal interest rate at $t = 0, 1, 2$
 - ▶ decreases prices, i.e. the GDP deflator and CPI at $t = 0, 1, 2$
 - ▶ induces a contraction in M2 at $t = 0, 1, 2$

VAR Results: Robustness - Sign Restrictions

normalized 1% increase in the short term interest rate.

[▶ return](#)



Sectoral Evidence

▶ return

- ▶ Is this evidence robust also across sectors?
- ▶ Is the increase in the labor share due to changes in the composition of output from sectors with low to sectors with high labor shares rather than a change of the labor share within sectors?
- ▶ We exploit the cross-section and time-series variation of labor shares at the disaggregated sector level.
- ▶ Using NBER-CES and Klems data we show that the increase in the LS happens also within sectors.

Sectoral Evidence: Panel model

▶ return

- ▶ We can estimate the impact of the shock on sectoral labor shares by running the following panel model:

$$S_{i,t}^h = \alpha_i + \alpha_t + \rho S_{i,t-1}^h + \theta MP_t + \epsilon_{i,t}, \quad (1)$$

- ▶ where α_i and α_t are sector and time-specific fixed effects, and $\epsilon_{i,t}$ is an error term.
- ▶ θ then captures the contemporaneous effect of the MP shock on the labor share controlling for past values of the labor share as well as sector and time fixed effects.
- ▶ To capture the effect of the MP shock on the labor share after the shock, we estimate:

$$S_{i,t+h}^h = \alpha_i + \alpha_{t+h} + \rho S_{i,t+h-1}^h + \theta_h MP_t + \epsilon_{i,t+h}. \quad (2)$$

with $h = 1, 2, 3, 4$.

- ▶ Coefficient θ_h then captures the effect of the MP shock at time t on the labor share $t + h$ periods ahead.

Sectoral Evidence: Data

- ▶ Two databases:
 - ▶ NBER-CES productivity database: highly disaggregated split of the US manufacturing sector (464 sectors - 1985-2007).
 - ▶ Klems database: less disaggregated split by sectors but covers not only manufacturing but all sectors in the economy including services (30 sectors - 1987-2007).
- ▶ The labor share at the sector level is defined as compensation of employees over value added.
- ▶ The measure of MP_t is obtained by aggregating quarterly shocks from the Cholesky SVAR using aggregate data.
- ▶ Standard errors are estimated following Driscoll and Kraay (1998). [▶ Data](#)

Sectoral Evidence: NBER - Cholesky VAR MP

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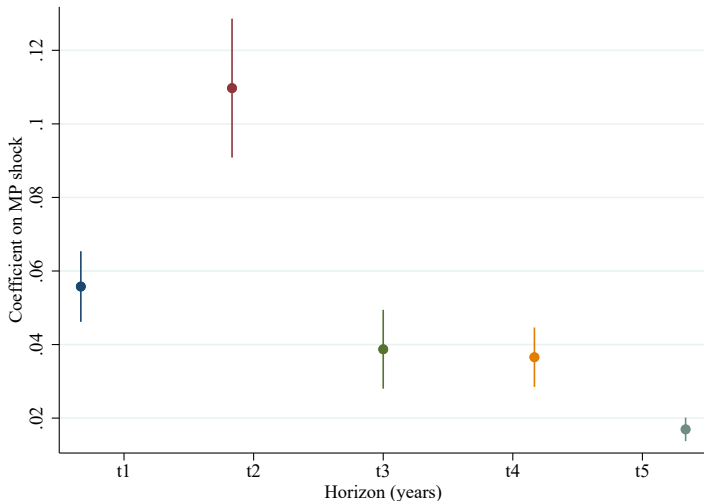


Figure: Coefficient on monetary policy shock variable (Cholesky VAR) using the NBER manufacturing database (464 manufacturing sectors). Period is 1985-2007. The plot shows the coefficient on the year of impact (t_1) and four years after.

Sectoral Evidence: Klems - Cholesky VAR MP

▶ return

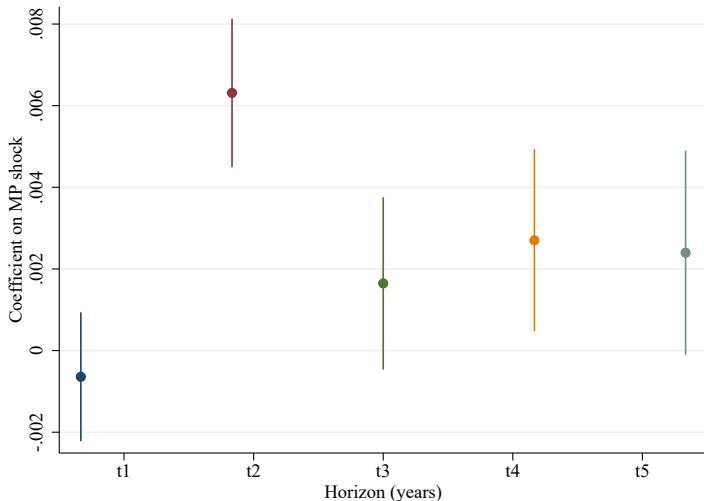


Figure: Coefficient on monetary policy shock variable (Cholesky VAR) using the Klems database (30 sectors). Period is 1987-2007. The plot shows the coefficient on the year of impact (t_1) and four years after.

- 1 How likely is the structural model to generate the sign pattern of the conditional moments (IRF) we observe in the data?
 - ▶ As explained by [Canova, 1995], [Lancaster, 2004] and [Geweke, 2005], prior predictive analysis is a powerful tool to shed light on complicated objects that depend on both the joint prior distribution of parameters and the model specification.
 - ▶ By generating a random sample from the prior distributions, one can compute the reduced form solution and the model-implied statistics of interest, e.g. impulse responses.
 - ▶ Many replicas of the latter generates an empirical distribution of the model- and prior-implied statistics of interest. ([Leeper et al., 2015] and [Fève and Sahuc, 2014])

Description	Distribution
Inverse of Frish Elasticity of Labor Supply	$U[1, 10]$
Investment adjustment costs	$U[1, 20]$
Habits in Consumption	$U[0, 1]$
Capacity utilization costs	$U[0, 1]$
Price stickiness	$U[0, 1]$
Wage stickiness	$U[0, 1]$
Price markup	$U[1.1, 2]$
Wage markup	$U[1.1, 2]$
Interest rate smoothing	$U[0, 1]$
Taylor rule response to inflation	$U[1.01, 5]$
Taylor rule response to output	$U[0, 1]$
Price Indexation	$U[0, 1]$
Wage Indexation	$U[0, 1]$
Working capital fraction	$U[0, 1]$
Technology diffusion	$U[0, 1]$
AR(1) MP shock	$U[0, 1]$

Prior Sensitivity Analysis [▶ return](#)

We check the % of the parameter space that generates a (+) IRF of labor share and a (-) IRF of wages from quarters 2 to 5 and 5 to 8.

Restrictions					
2:5 quarters			5:8 quarters		
ls (+)	w (-)	ls (+); w (-)	ls (+)	w (-)	ls (+); w (-)
11.2%	-	-	42.2%	-	-

Prior Sensitivity Analysis [▶ return](#)

We check the % of the parameter space that generates a (+) IRF of labor share and a (-) IRF of wages from quarters 2 to 5 and 5 to 8.

Restrictions					
2:5 quarters			5:8 quarters		
ls (+)	w (-)	ls (+); w (-)	ls (+)	w (-)	ls (+); w (-)
11.2%	60.5%	-	42.2%	39.4%	-

Prior Sensitivity Analysis [▶ return](#)

We check the % of the parameter space that generates a (+) IRF of labor share and a (-) IRF of wages from quarters 2 to 5 and 5 to 8.

Restrictions					
2:5 quarters			5:8 quarters		
ls (+)	w (-)	ls (+); w (-)	ls (+)	w (-)	ls (+); w (-)
11.2%	60.5%	2.5%	42.2%	39.4%	3.3%

- 2 Which are the parameters that mostly drive these patterns in each model?
- ▶ This question is more subtle because it requires an inverse mapping. Montecarlo filtering (MCF) techniques offer a statistical framework to tackle this question.
 - ▶ MCF are computational tools that allow researchers to recover, in a nonlinear model, the critical inputs that generate a particular model output.
 - ▶ In MCF all parameters move simultaneously.
 - ▶ Smirnoff test offers implicitly a statistical ranking of parameters from the most to the least influential ones.

MCF: Parameters driving prior restrictions in the model.

[▶ return](#)

	2:5 quarters	
Parameter	D-Stat	P-value
Wage stickines	0.502	0.000
Price markup	0.389	0.000
Interest rate smoothing	0.216	0.000
Working capital fraction	0.213	0.000
Wage indexation	0.210	0.000
Investment adjustment costs	0.193	0.000
Habits in consumption	0.170	0.000
Taylor rule response to output	0.106	0.000
AR(1) MP shock	0.100	0.000

	5:8 quarters	
Wage stickiness	0.434	0.000
Price markup	0.283	0.000
Investment adjustment costs	0.265	0.000
Working capital fraction	0.216	0.000
Interest rate smoothing	0.164	0.000
Wage indexation	0.153	0.000
Price indexation	0.152	0.001
AR(1) MP shock	0.150	0.000
Price stickiness	0.131	0.000
aylor rule response to output	0.083	0.000

Table: Smirnov statistics in driving prior restrictions

- ▶ We partition each model parameters into two groups. The first is composed of **calibrated** ones and follows the same calibration as in [Christiano et al., 2016].
- ▶ The second group of parameters, for each model, is estimated by minimizing a measure of the distance between the models and empirical impulse response functions.
- ▶ Follow [Christiano et al., 2005], [Christiano et al., 2010] and [Christiano et al., 2016] we use a Limited information Bayesian approach. [▶ details](#)

Bayesian IRF Matching

- ▶ Let γ be the vector of parameter to estimate and $\Psi(\gamma)$ denote the mapping from γ to the model IRFs.
- ▶ Let $\hat{\Psi}$ denote the corresponding empirical IRFs from the SVAR.
- ▶ $\hat{\Psi} \stackrel{a}{\sim} N(\Psi(\gamma^0), V(\gamma^0, \zeta^0, T))$.
- ▶ $\hat{\Psi}$ are treated as 'data' and we choose γ to make $\Psi(\gamma)$ as close as possible to $\hat{\Psi}$.
- ▶ Approximate likelihood function

$$f(\hat{\Psi}|\gamma) = \left(\frac{1}{2\pi}\right)^{\frac{N}{2}} V^{-\frac{1}{2}} \exp\left[-\frac{1}{2} (\hat{\Psi} - \Psi(\gamma))' V^{-1} (\hat{\Psi} - \Psi(\gamma))\right]. \quad (3)$$

- ▶ V is a diagonal matrix with the sample variances of the $\hat{\Psi}$'s along the diagonal.
- ▶ So, given this choice of V , γ is effectively chosen so that $\Psi(\gamma)$ lies as much as possible inside the $\hat{\Psi}$'s confidence intervals.

Priors and Posterior Mode - IRF Matching

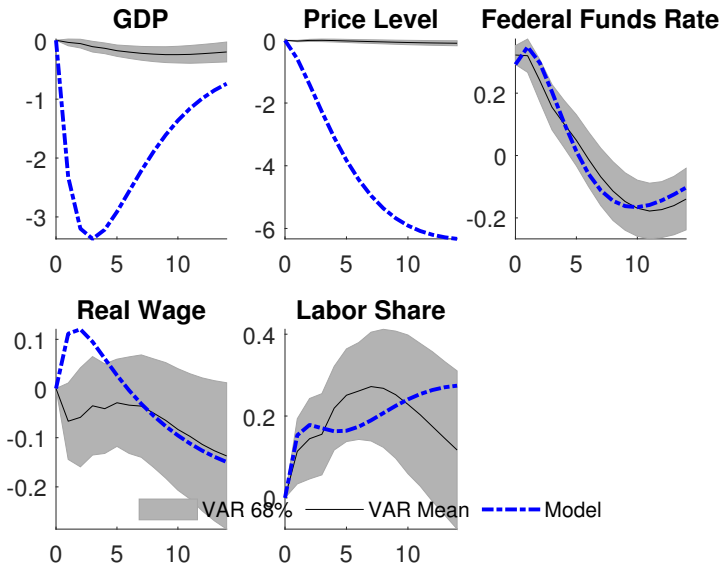
▶ return



Description	Priors	Posteriors
Inverse of Frish Elasticity of Labor Supply	$\Gamma(1, 0.25)$	1.01 (0.55,1.49)
Investment adjustment costs	$\Gamma(8, 2)$	7.29 (3.73,11.10)
Habits in Consumption	$B(0.5, 0.15)$	0.58 (0.32,0.82)
Capacity utilization costs	$\Gamma(0.5, 0.3)$	0.49 (0.04,1.07)
Price stickiness	$B(0.66, 0.1)$	0.67 (0.52, 0.80)
Wage stickiness	$B(0.66, 0.1)$	0.68 (0.56,0.79)
Price markup	$\Gamma(1.2, 0.05)$	1.22 (1.13,1.32)
Interest rate smoothing	$B(0.7, 0.15)$	0.61 (0.37,0.82)
Taylor rule response to inflation	$\Gamma(1.7, 0.15)$	1.72 (1.44,2.00)
Taylor rule response to output	$\Gamma(0.1, 0.05)$	0.07 (0.01,0.14)
Price Indexation	$B(0.5, 0.15)$	0.53 (0.24,0.81)
Wage Indexation	$B(0.5, 0.15)$	0.58 (0.30,0.85)
Working capital fraction	$B(0.8, 0.1)$	0.78 (0.58,0.97)
MP shock stdev	$\Gamma(0.27, 0.05)$	0.30 (0.25,0.35)
AR(1) MP shock	$\Gamma(0.5, 0.15)$	0.50 (0.22,0.80)

Posterior mean of the parameters. 95% HDP interval in parenthesis. tiny Distributions: Γ Gamma, B Beta, N Normal.

IRF Matching - Matching only Federal Funds Rates and the Labor share

[▶ return](#)



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