Labor Share and Technology Dynamics

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(Preliminary and Incomplete)

Labor Share in the U.S. (1948Q1 to 2017Q1)

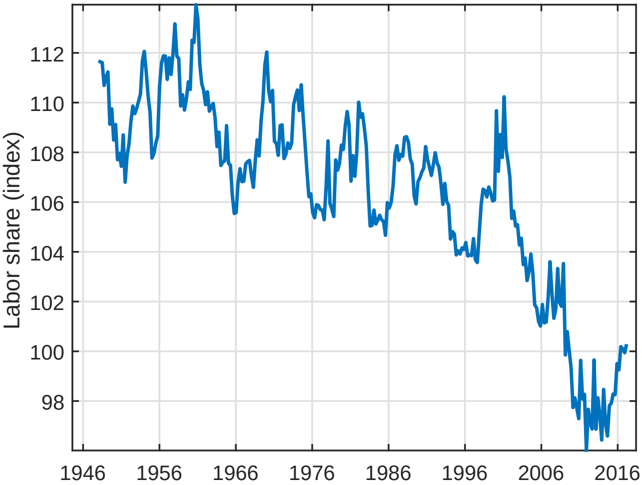


Figure: Worker's compensation over total value added, non-farm business (BLS)

Motivation:

- Factor shares of output are far from constant
- Long run dynamics? $\rightarrow$ Elsby, Hobijn and Sahin (2013), Karabarbounis and Neiman (2013), Koh, Santaeulalia-Llopis and Zheng (2016) among others.
- We want to understand cyclical properties of the shares (short/medium run dynamics)?
- We propose a real business cycle model where shares move endogenously

What we do:

- We develop a model with putty-clay technology (as Gilchrist and Williams 2000 and Gourio 2011) and non-competitive wage setting (in the search and matching tradition)
- We propose a novel way of thinking about the impact of disembodied technological change
- Test how the model performs quantitatively in replicating salient features of factor share dynamics

Labor Share: Results from a VAR(1)

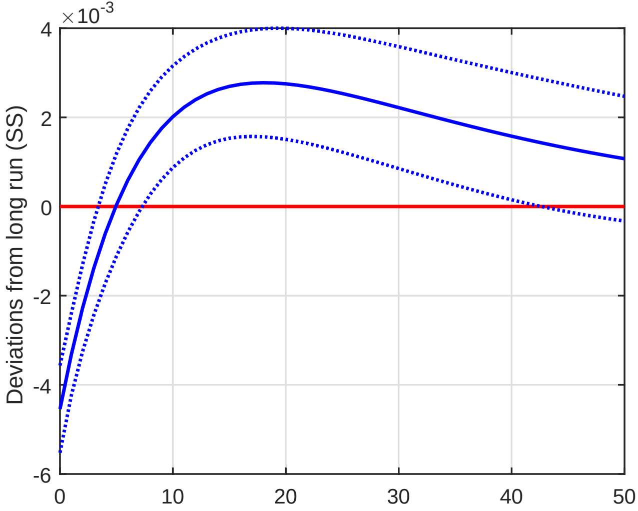


Figure: IRF, from bivariate VAR(1) between labor share index and GDP

A puzzling figure...

- Labor Share: $\frac{wn}{y} \rightarrow \frac{w}{y/n}$
- In standard theories, the fraction moves little

  $\Rightarrow$ low σ_u/σ_y in search and matching models

- *Overshooting* of the labor share is informative: why are wages consistently higher than average productivity (for about 20 quarters) after a positive technological shock?

THE MODEL

Putty-Clay Technology

- Only good in the economy is produced using individual units
- These units combine some **fixed** capital intensity (machine size) k and *one unit of labor* to produce, using a cobb-douglas production **menu**:

$$y(z, k) = 1^{1-\alpha} z k^{\alpha} = z k^{\alpha}$$

- z is an aggregate productivity shock
- Units take one period to become operational
- Once installed, machines cannot change size and break down exogenously at rate δ
- The menu of production is flexible ex-ante ('putty'), but fixed ex-post ('clay')

Aggregate "biased" shock

- There is a distinction between "new" and "old" productive units
- We introduce a novel biased technology shock:

$$z = \begin{cases} \widetilde{z} & \text{if new machine} \\ \lambda \widetilde{z} & \text{otherwise} \end{cases}$$

where $\ln \widetilde{z}_t = \rho \ln \widetilde{z}_{t-1} + \epsilon_t$ and $\epsilon \sim iid(0, \sigma_\epsilon^2)$

- $\lambda < 1$ is the "old-Ipad" effect

Investment and Labor

- Given fixed proportion (Leontief) production structure in the short run, labor and capital go hand in hand $\Rightarrow$ investment $=$ hiring (*putty-clay* effect, Gilchrist and Williams 2000)
- No search frictions in the labor market, but delay in employment adjustment
- Decisions for firms
  1. Intensive margin: size of new machines to install this period (k)
  2. Extensive margin: number of new machines to install (q)

Investment decision

- Profits of a firm with machine size k and aggregate state S:

$$\Pi(S,k) = zk^{\alpha} - w(S,k) + (1-\delta)E\left[R(S')\Pi(S',i)\right]$$

- the optimal size of new machines is defined by the following problem

$$\max_{i} \quad -i + E\left[R(S')\Pi(S',i)\right]$$

- q is determined by a zero profit condition

$$k^* + c_v = E\left[R(S')\Pi(S',k^*)\right]$$

where c_v is a vacancy/training cost

Households (HH)

- Formed by a measure-one of consumer-workers
- They supply labor inelastically
- HH like consumption and leisure of their members (b when not working)
- They pool income and share consumption
- HH state space: $\{S, a, x\}$:
  1. a are household savings
  2. $x(i)$ measure of "firms" smaller than i where HH members work

Recursive problem of the HH

$$
\begin{aligned}
W(S,a,x) &= \max_{c,a'} \ \log(c) + b\left[1 - \int x(i)di\right] + \beta E W(S',a',x') \\
s.t. & \\
c + a' &= (1+r)a + \int w(S,i)x(i)di + \pi(S) \\
x'(j) &= (1-\delta)x(j) + q_j(S) \ \ \forall j \\
S' &= G(S)
\end{aligned}
$$

- Where π are the profits of a mutual fund owned by HH; $w(S,k)$ and $q_j(S)$ are given

Wages

- Nash Bargaining protocol between the firm and the worker

- Define as $\overline{W}(S,k)$ the value (in terms of consumption) a household puts on having a marginal worker attached to machine k

$$\overline{W}(S,k) = w(S,k) - bc + (1-\delta)E\left[R(S')\overline{W}(S',k)\right]$$

- Firm and worker bargain over the match surplus

$$M(S,k) = \Pi(S,k) + \overline{W}(S,k)$$

with households having bargaining power μ

Wages: characterization

- Analytical wage formula:

$$w(S,k) = \mu z k^{\alpha} + (1-\mu) cb$$

- Current profits of a machine-worker pair are given by

$$\pi(S,k) = z k^{\alpha} - w(z,k) = (1-\mu)\left(z k^{\alpha} - cb\right)$$

- Analytical solution for $w(S,k)$ and $\pi(S,k)$ useful to solve the model

Aggregation and Dynamics (following Gourio 2011)

- State S still is infinite at this point
- Let $X(i)$ be the measure of productive machines in the economy smaller than i
- Two key assumptions:
  1. All machines are worked till exogenous breakdown
  2. No complementarities in production across machines.

- Some important aggregates:
  1. Installed capacity: $\overline{Y} = \int i^{\alpha} X(i) di$
  2. Employment: $N = \int X(i) di$
- Given assumption 1, we can write

$$X'(i) = (1-\delta)X(i) + q_i$$

  where q_i is the measure of units installed this period that are smaller than i
- Given the second assumption:

$$\begin{aligned} \overline{Y}' &= (1-\delta)\overline{Y} + qk^{\alpha} \\ N' &= (1-\delta)N + q \end{aligned}$$

- Then, $S = \{z, \overline{Y}, N\}$ (a reduced state space)

Cobb-Douglas world:

- Given this technology, capital and labor are perfect complements in the short run
- However, in the long run (steady state), we are back to Cobb-Douglas:

$$
\begin{aligned}
N^{ss} &= \frac{q^{ss}}{\delta} \\
Y^{ss} &= \frac{q^{ss}}{\delta}(k^{ss})^{\alpha} \\
\Rightarrow Y^{ss} &= N^{ss}(k^{ss})^{\alpha} \\
\Rightarrow Y^{ss} &= (N^{ss})^{1-\alpha}(N^{ss}k^{ss})^{\alpha}
\end{aligned}
$$

Relation with Search Framework:

- Total employment is equal to number of installed machines (they are like a vacancy in the search framework)
- Lag of one period in installing productive units creates a lagged response of employment, much like the lag due to search frictions
- Euler equation for the number of machines to install this period (q) is analogous to recursive surplus equation of labor search and matching models
- However, a key difference is that the firm can treat the last/marginal worker differently from everyone else
- In what follows, we compare our baseline with the general equilibrium version of Mortensen-Pissarides (Merz 1995, Andolfatto 1996, Cheron and Langot 2004)

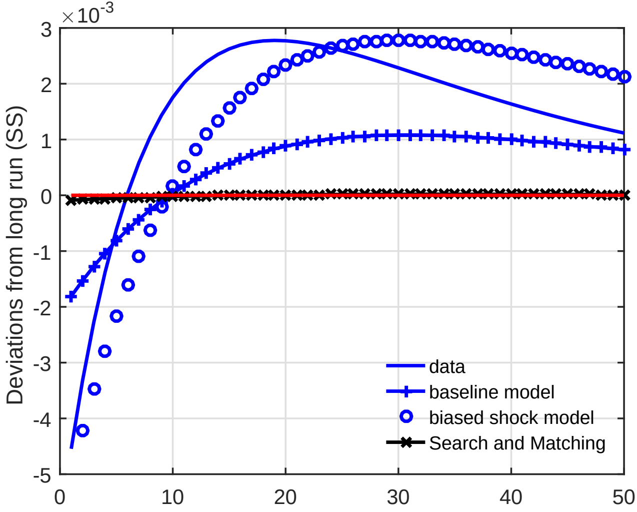
Calibration

- Model period corresponds to one month ($\beta = 0.9967$)
- We pick $\{\alpha, \delta, b, \mu, c_v, \rho, \sigma_\epsilon\}$ jointly to match:
  1. Average labor share (0.65)
  2. Consumption output ratio (0.75)
  3. Average unemployment rate (0.058)
  4. Value of leisure (in consumption units) in terms of average wages (0.7)
  5. Aggregate recruitment expenditures per hire, over GDP (0.005)
  6. Solow residual estimates
- In the baseline, $\lambda = 1$ (no biased shock)
- Otherwise, λ is calibrated to match the peak of IRF of labor share

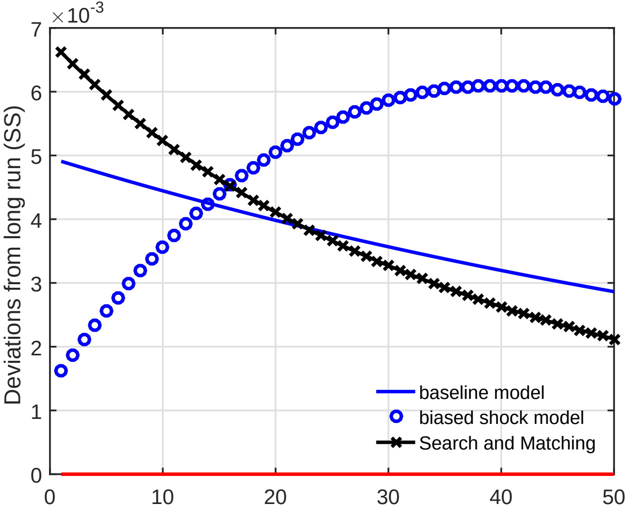
Results: Parameterization

Parameter	Description	Baseline	Biased
α	curvature of prod. menu	0.5389	0.5389
δ	plant destruction rate	0.0084	0.0085
b	value of leisure	0.6455	0.6457
μ	bargaining weight workers	0.3592	0.3600
c_v	vacancy cost	0.3103	0.3060
ρ	persistence of aggregate shock	0.9717	0.9675
σ_ϵ	st. dev. of aggregate shock	0.0048	0.4323
λ	shock bias	1.0000	0.0026

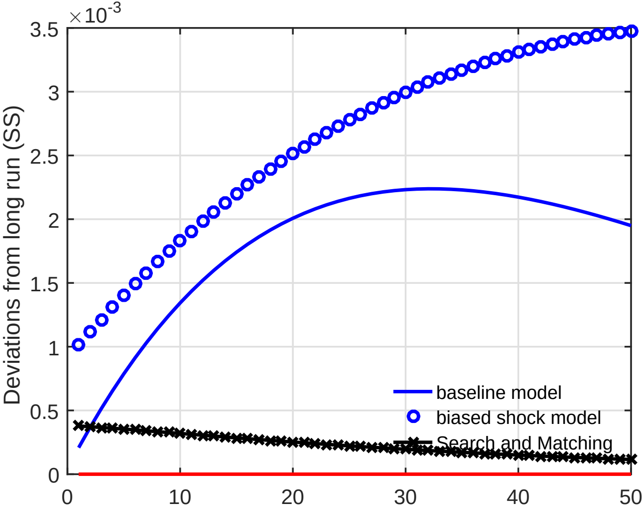
Response to productivity shock: Labor Share



Response to productivity shock: wages



Response to productivity shock: employment



Cyclical volatility: relative variances with respect to output

	US	Baseline	Biased shock	S&M
Employment	0.237	0.044	0.270	0.007
Unemployment	41.976	16.296	169.847	1.772
Labor Share	0.252	0.081	0.449	0.000
Wages	0.383	0.494	0.104	0.834
Consumption	0.326	0.214	0.720	0.098
Investment	11.685	7.794	25.512	10.571

US data from 1948:QI-2017:Q1

All variables in logs and H-P filtered

Autocorrelation/propagation

	US	Baseline	Biased shock	S&M
Output	0.848	0.799	0.844	0.799
Employment	0.902	0.960	0.957	0.833
Unemployment	0.893	0.960	0.946	0.833
Labor Share	0.629	0.790	0.787	0.709
Wages	0.788	0.791	0.910	0.789
Consumption	0.811	0.862	0.855	0.860
Investment	0.807	0.783	0.778	0.795

US data from 1948:QI-2017:Q1

All variables in logs and H-P filtered

Summary: baseline model

- Our baseline model is able to replicate the *overshooting* of the labor share
- It also produces more volatility of employment than the Search and Matching model
- But it does not get close to the data
- Culprit? cost of employment creation is vacancy cost PLUS investment (big sacrifice in consumption)
- There are ways to increase this volatility: we could introduce idiosyncratic plant productivity, and extensive margin adjustments as in Gilchrist and Williams (2000)

Summary: biased shock model

- The Biased shock model can produce sizeable volatility of employment and unemployment
- It fits well the autocorrelation of output
- However, the bias is exaggerated: $\lambda = 0.0026$ implies that TFP shocks are more than 380 times bigger for a new Ipad than for a *ONE month* old one

Conclusion

- Cyclical movements of factor shares are a strong disciplining device for models: we should not overlook what they imply
- We introduced a new type of technology that can improve implied propagation mechanisms and simulated cyclicality of hours in our model
- Our model improves (marginally) on standard models in a classic macro problem: low simulated volatility of hours
- Future agenda:
  1. improve quantitative performance of the model
  2. Think about the long run?