Heterogeneous Firms, Wages, and the Effects of Financial Crises

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Introduction

The US and the UK experienced the financial crisis differently.
From 2007-11:

Labour market:

- US: Large decrease in hours ($\simeq 10\%$)
- UK: Modest decrease in hours ($\simeq 5\%$)

Productivity:

- US: Mild decrease in TFP ($\simeq 0\%$)
- UK: Large decrease in TFP ($\simeq 5\%$)

Question: Why did the financial crisis manifest differently in these two countries?

Labour hoarding cannot provide an explanation

Inconsistent with worker flows data

Labour hoarding is a natural explanation:

- If firms hoard more labour in the UK, employment would naturally fare better
- And TFP would be worse in UK if workers are idle

However, this explanation is inconsistent with data on worker flows:

- Larger employment decline in US due to larger decline in job creation, not greater rise in job destruction

Importance of job creation suggests another explanation:

- Workers reallocated to new jobs in UK; unemployment in US
- Simultaneously, more evidence of **misallocation** of resources in UK during crisis

Could wages provide an explanation?

Keeping workers employed could come at the cost of misallocation

Larger real wage fall in the UK during the crisis:

- 0-2% fall in US, at least 6% fall in UK
- Due to combination of UK running higher inflation and institutional factors details

My contribution is to build a theoretical model which, *conditional on the behaviour of wages*, can explain the greater decline in TFP in the UK, and hours in the US

- Model of heterogeneous firms subject to financial frictions and wage rigidity. (Khan and Thomas, 2013, Buera and Moll, 2015)
- Wage declines protect employment, but induce misallocation of resources across firms which reduces TFP
- Results quantitatively relevant:
  - Greater wage fall in UK can explain 1/2 of greater US hours decline, and 1/3 of UK's greater TFP decline

Related literature

Theoretical models of crises:

Models of financial crises with heterogeneous firms:

- Khan & Thomas (2013), Buera & Moll (2015), Arellano, Bai & Kehoe (2012), Petrosky-Nadeau (2013), Buera, Fattal-Jaef & Shin (2014)
- I show that wage adjustment is quantitatively important for the transmission of crises in this class of models

Allocative role of interest rates:

- Reis (2013), Gopinath et al. (2015)
- I show wages have similar allocative role

Empirical studies of crises:

International comparisons:

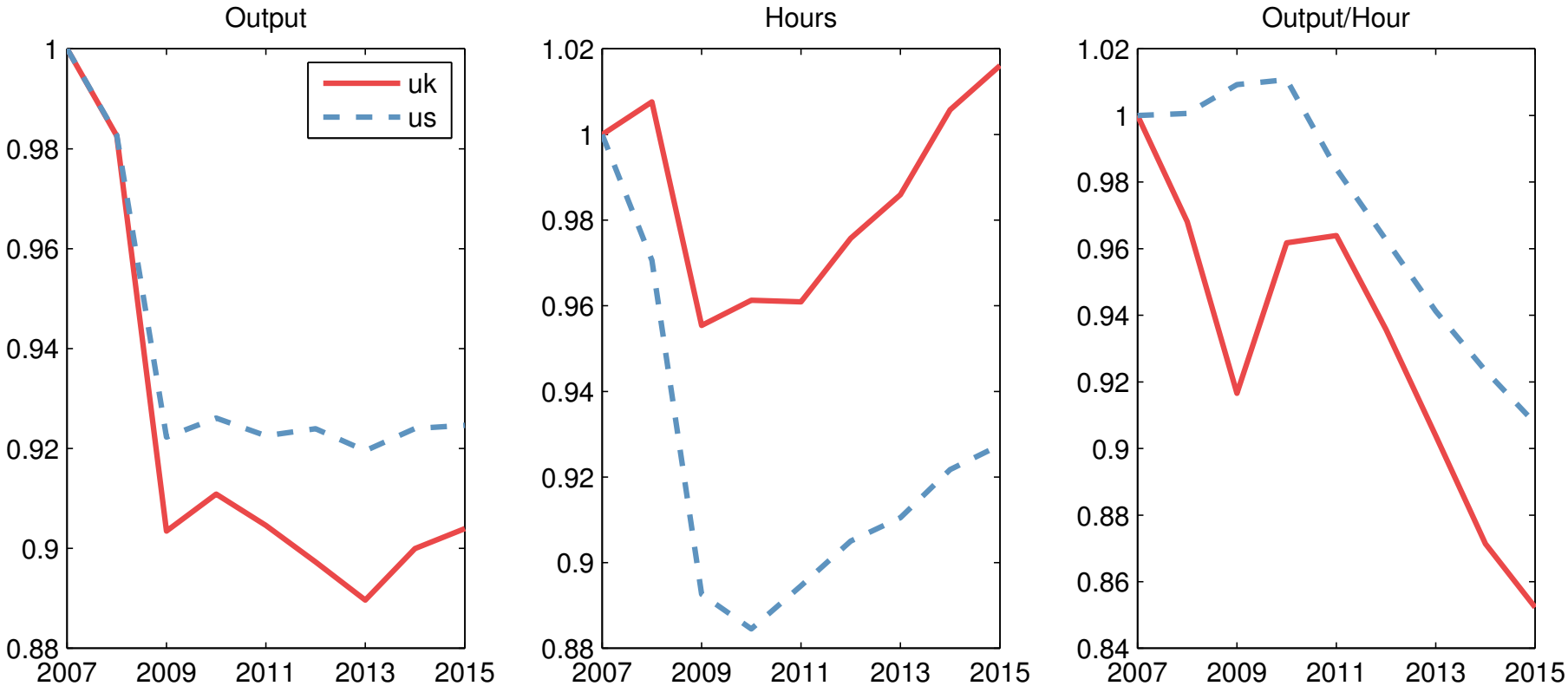
- Ohanian (2010), Calvo et al. (2014), Daly et al. (2014), Barth et al. (2016), Brinca et al. (2016)
- I add comparison of worker flows for US and UK

Outline

Section 1: Stylised Facts

Output, hours, and TFP (excluding finance)

Fact 1: hours fell more in US, TFP more in UK

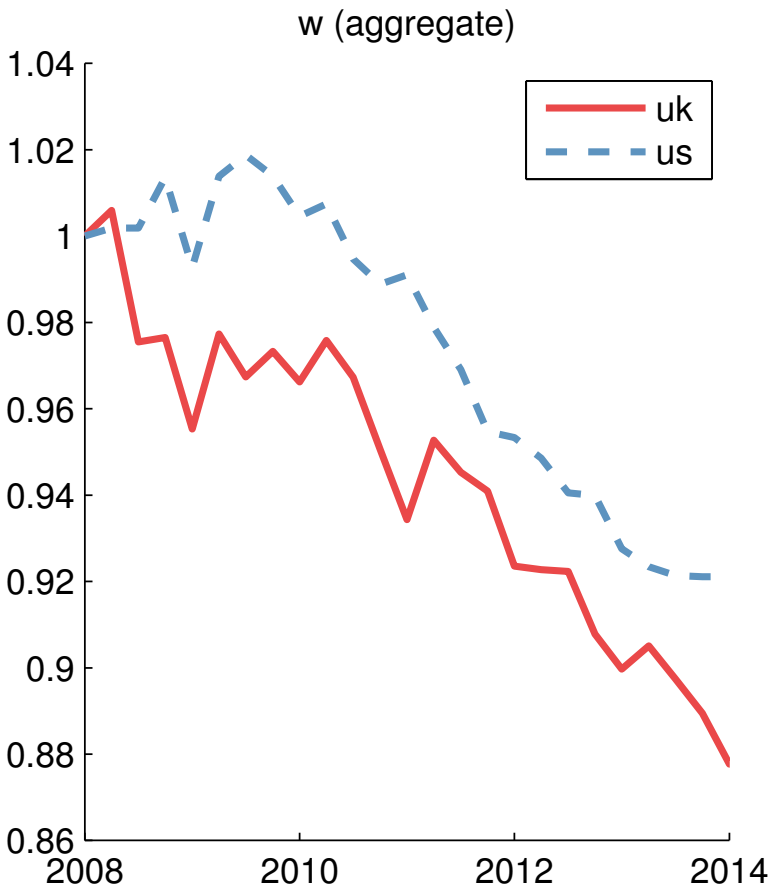


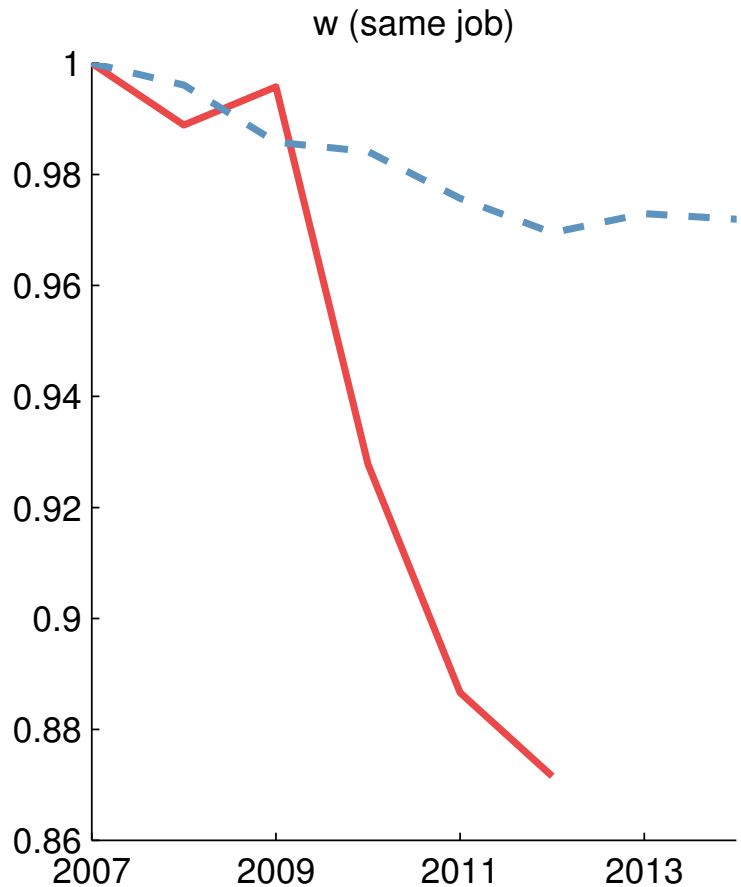
Best **TFP** numbers for 2007-11. UK: -5.25% US: -0.96%.

Further refinements: refining TFP | alternative labour indicators

Fact 2: Real wages fell more in the UK

Even controlling for composition effects

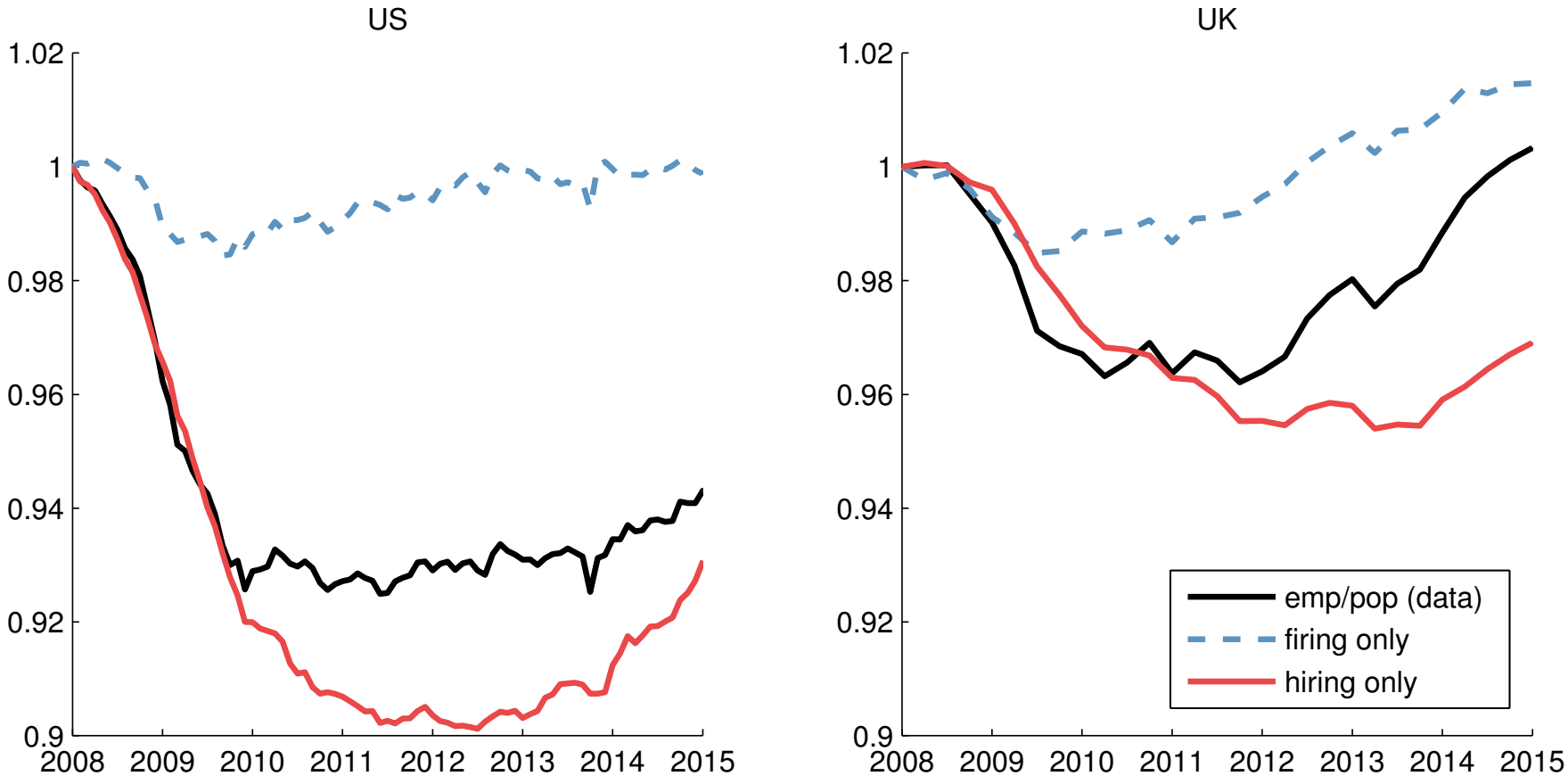




Note: Within job wage data from Daly and Hobijn (2016) and Blundell, Crawford and Jin (2014)

Fact 3: Worker flows data

Greater fall in employment in US due to less job creation



- Against labour hoarding explanation for lower emp. fall in UK
- Indicative of more labour reallocation in UK
  - **Fact 4:** Evidence of larger increase in misallocation in UK

Section 2: Analytical results

Model

Stripped back version of quantitative model. One period.

Household: (representative)

- Equilibrium wage is assumed to satisfy: $w = w_0^{\gamma} w_{mc}^{1-\gamma}$
- where $w_{mc} = \frac{v'(L)}{u'(C)}$

Final goods producer: (representative)

- Production function: $Y = \left(\int_0^1 y_i^{\rho} di \right)^{\frac{1}{\rho}}$
- FOC: $y_i = p_i^{-\sigma} Y$, where $\sigma = 1/(1-\rho)$

Intermediate goods producers

Continuum, measure one

- Differentiated output, monopolistic competition
- Known idiosyncratic productivity, z_i, and net worth n_i, distribution $f(n, z)$ over firms
- CRS Production function: $y_i = z_i k_i^{\alpha} l_i^{1-\alpha}$
- Purchase l and k in spot markets, maximise profit
- Capital purchase limited by net worth: $k_i \leq \lambda n_i$.
  - $k_i = \min \left\{ (\alpha\rho)^{\frac{1}{1-\rho}} \left(\frac{1-\alpha}{\alpha}\right)^{\frac{\nu}{1-\rho}} Y z_i^{\frac{\rho}{1-\rho}} w^{\frac{-\nu}{1-\rho}}, \lambda n_i \right\}$

Aggregation:

- Define production function: $Y = Z K^{\alpha} L^{1-\alpha}$
- Can show TFP given by: $Z = \mathrm{E}_{n,z} \left[z^{\frac{\rho}{1-\nu}} \tilde{k}^{\frac{\alpha\rho}{1-\nu}} \right]^{\frac{1-\nu}{\rho}}$, where $\tilde{k}_i \equiv k_i / K$

Preliminaries: Effect of financial frictions on TFP

1. Constrained always have higher $TFPR_i$:

- $TFPR_i \equiv \frac{p_i y_i}{k_i^{\alpha} l_i^{1-\alpha}} \propto z_i^{\frac{\alpha\rho}{1-\nu}} k_i^{\frac{-\alpha(1-\rho)}{1-\nu}}$
- Unconstrained: $k_i \propto z_i^{\frac{\rho}{1-\rho}} \Rightarrow TFPR_i$ equalised
- Constrained: k_i too low $\Rightarrow TFPR_i > TFPR_{unc}$

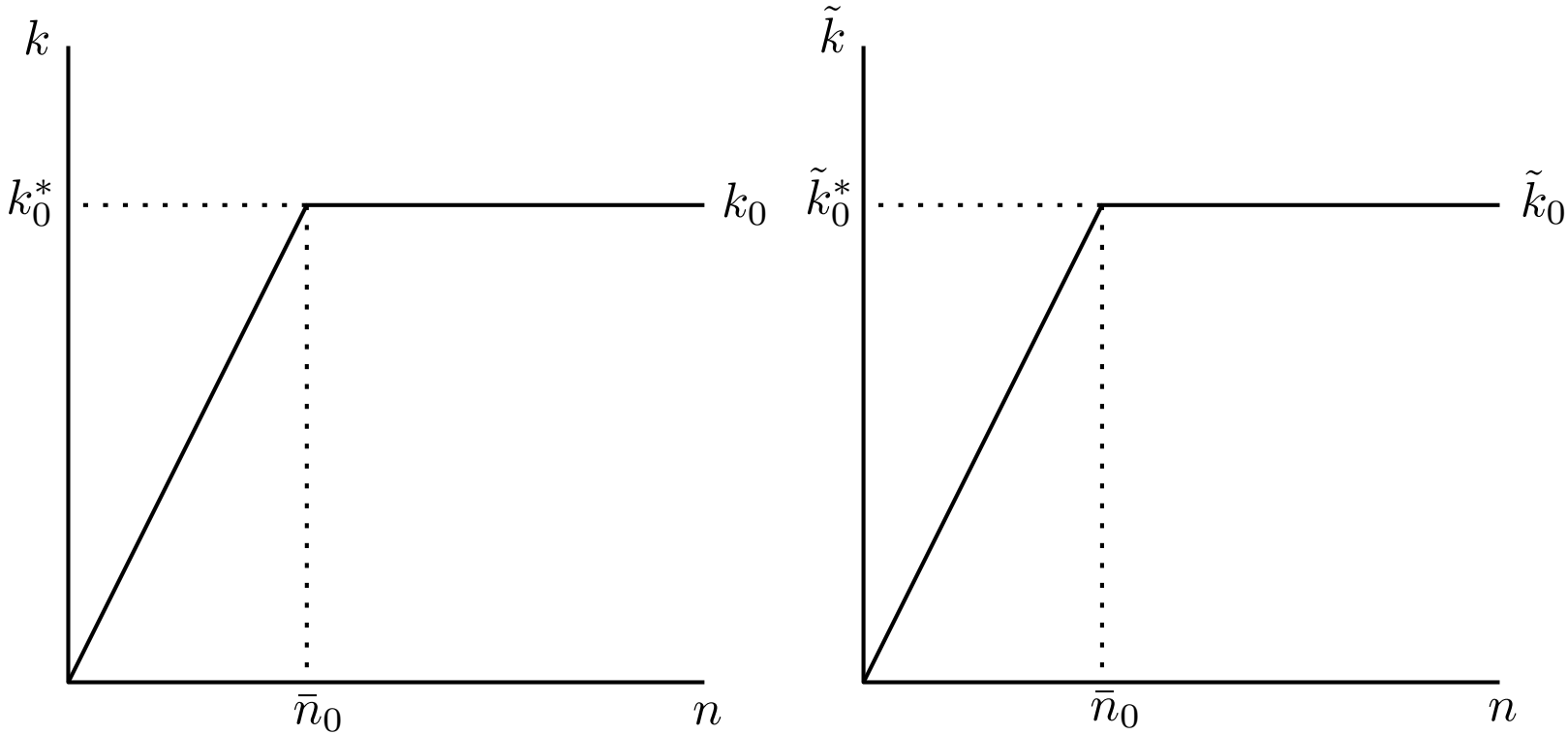
2. Firms affect aggregate TFP via their $TFPR_i$:

- Aggregate TFP: $Z = \mathrm{E}_{n,z}\left[z^{\frac{\rho}{1-\nu}} \tilde{k}^{\frac{\alpha\rho}{1-\nu}}\right]^{\frac{1-\nu}{\rho}}$
- Effect of increasing resources to firm i: $\Rightarrow \frac{\partial Z}{\partial \tilde{k}_i} \propto TFPR_i^{\frac{1}{\alpha}}$

$\Rightarrow$ Any shock which moves resources to unconstrained firms will reduce TFP.

Proposition 1: Financial crisis with fixed wage

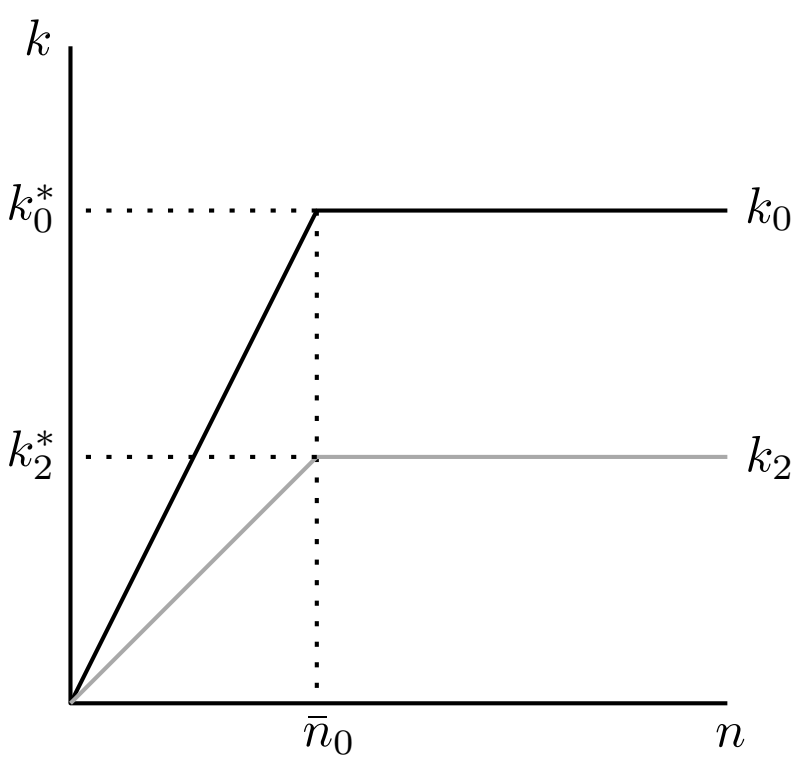
No fall in TFP following financial crisis

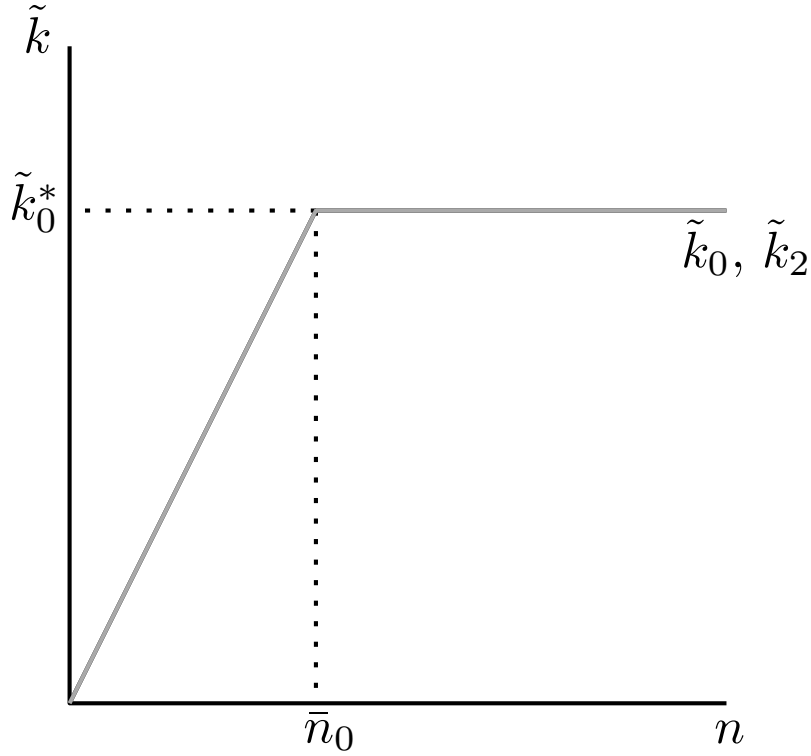


$$k_i = \min\left\{(\alpha\rho)^{\frac{1}{1-\rho}}\left(\frac{1-\alpha}{\alpha}\right)^{\frac{\nu}{1-\rho}} Y z_i^{\frac{\rho}{1-\rho}} w^{\frac{-\nu}{1-\rho}}, \lambda n_i\right\}, \quad \tilde{k} \equiv \frac{k}{K}$$

Proposition 1: Financial crisis with fixed wage

No fall in TFP following financial crisis because no change in $\tilde{k}_i$ distribution





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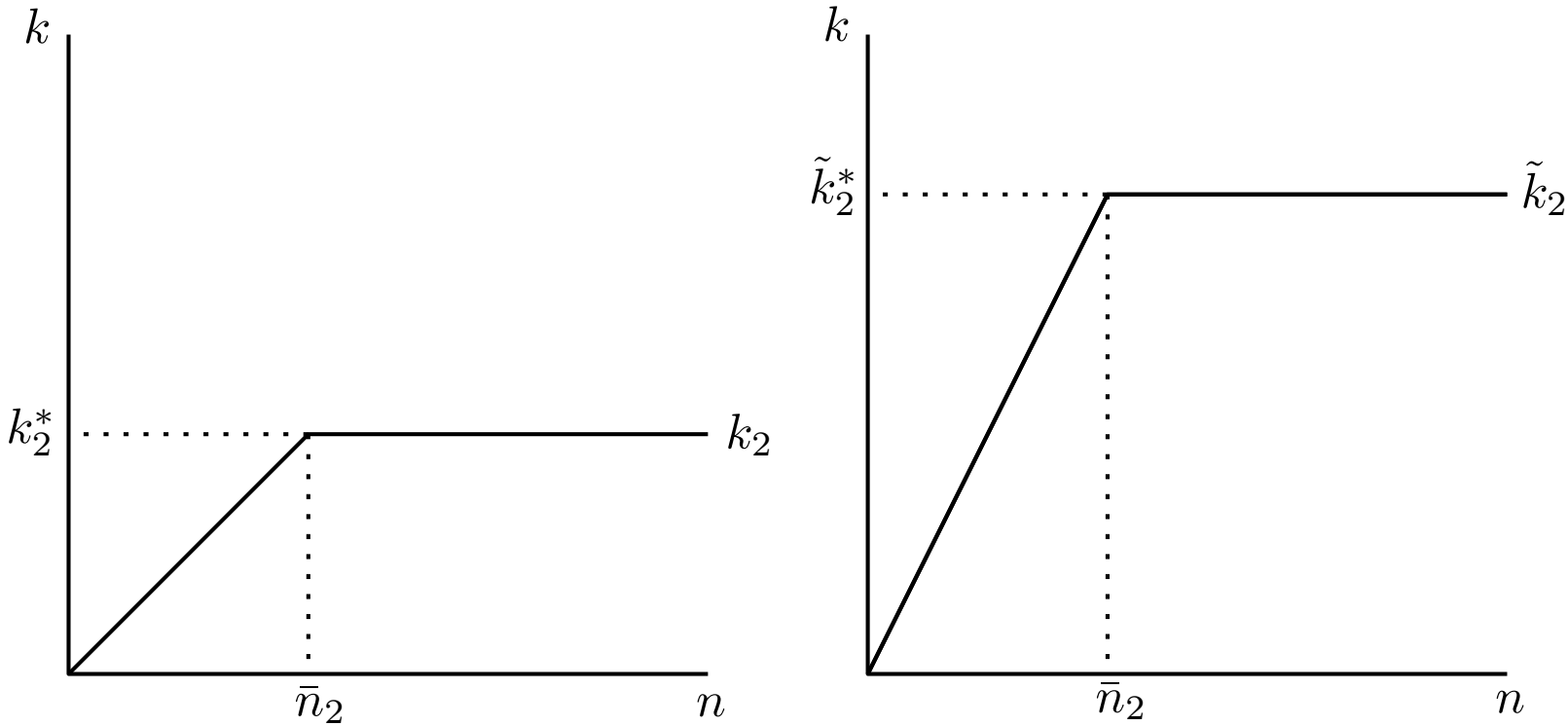
Proposition 2: Financial crisis with wage fall

Wage decline causes misallocation which reduces TFP



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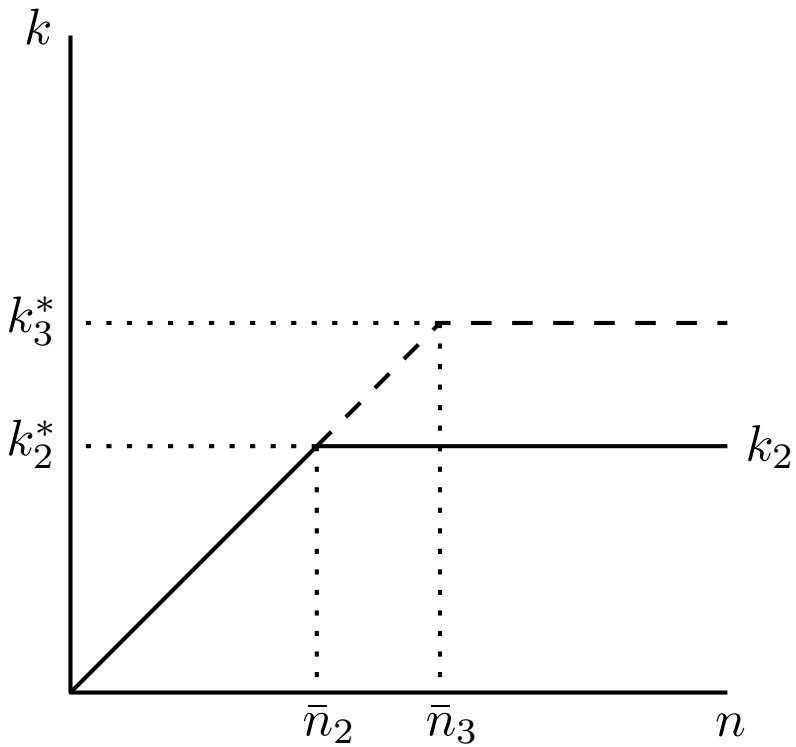

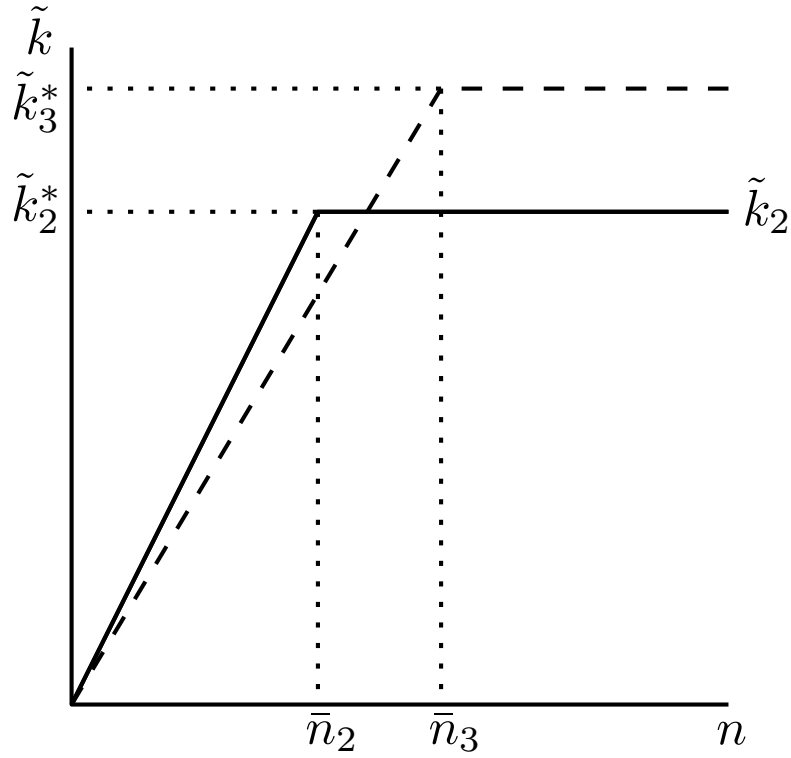

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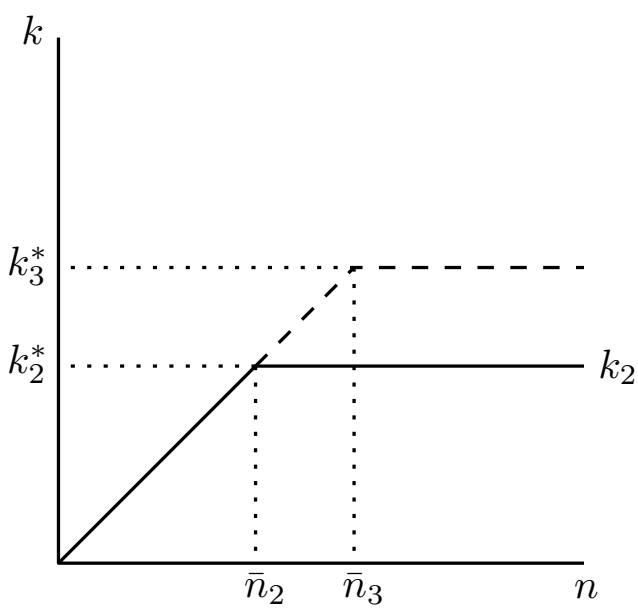
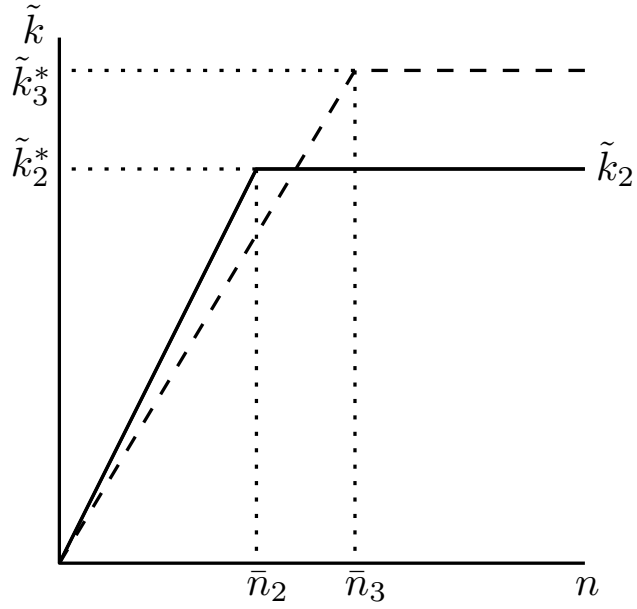
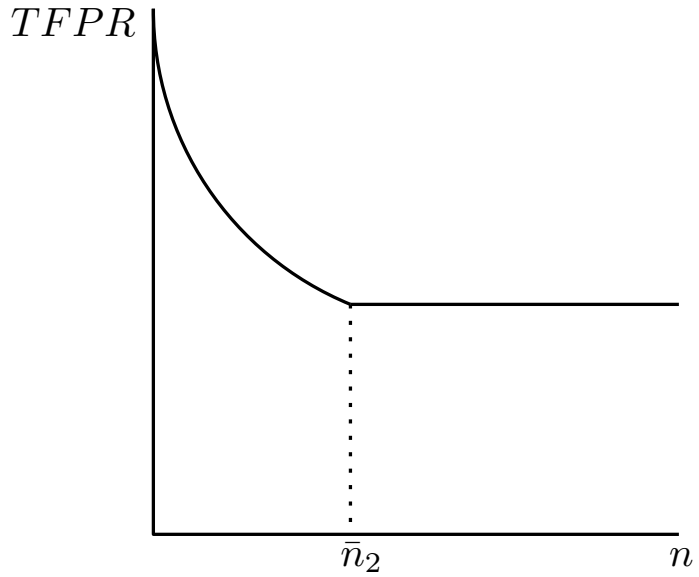






Summary

Tradeoff TFP and hours:

- Showed wage decline $\rightarrow$ fall in TFP
- Wage decline also $\rightarrow$ smaller fall in hours
- Degree of wage adjustment $\Rightarrow$ tradeoff TFP/hours

Result:

- Wages fell more in UK during crisis: model can explain why TFP fell more in UK and hours more in US

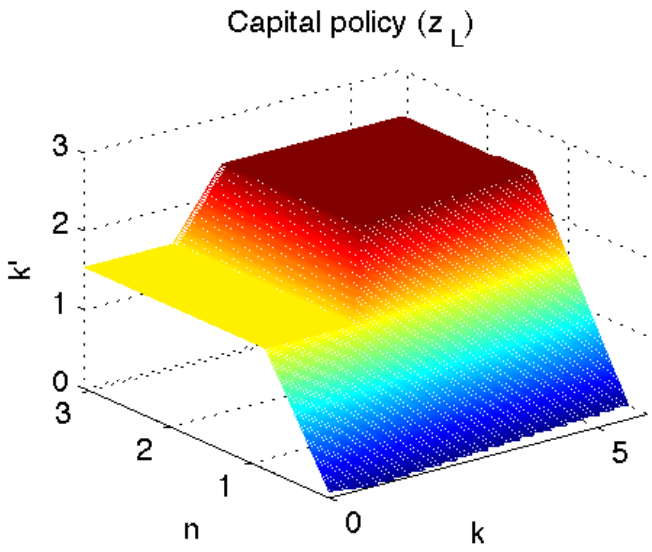
Extensions: entry/exit enhance effects, robust to more general borrowing constraints, CKM wedges

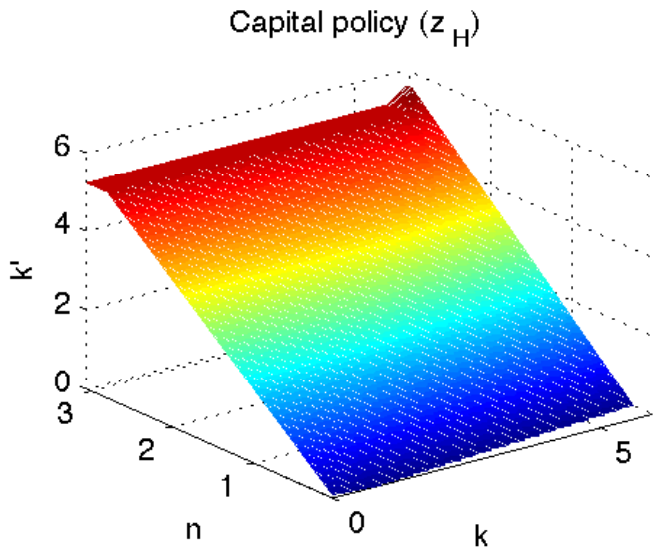
Section 3: Dynamic model

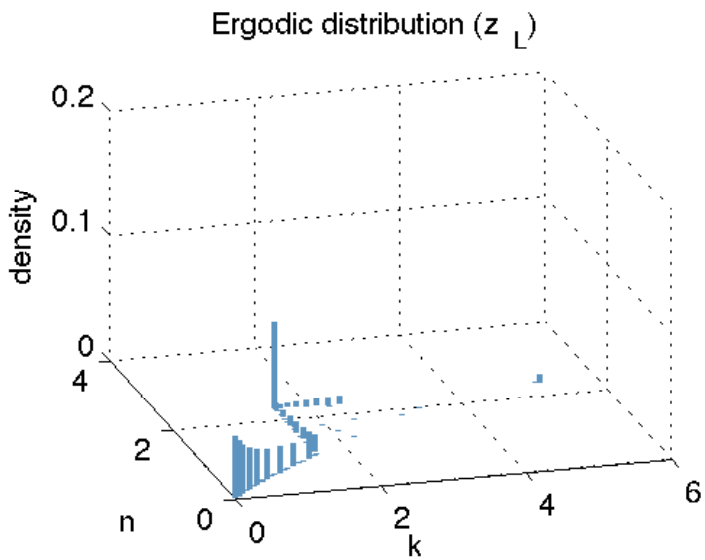
Dynamic model

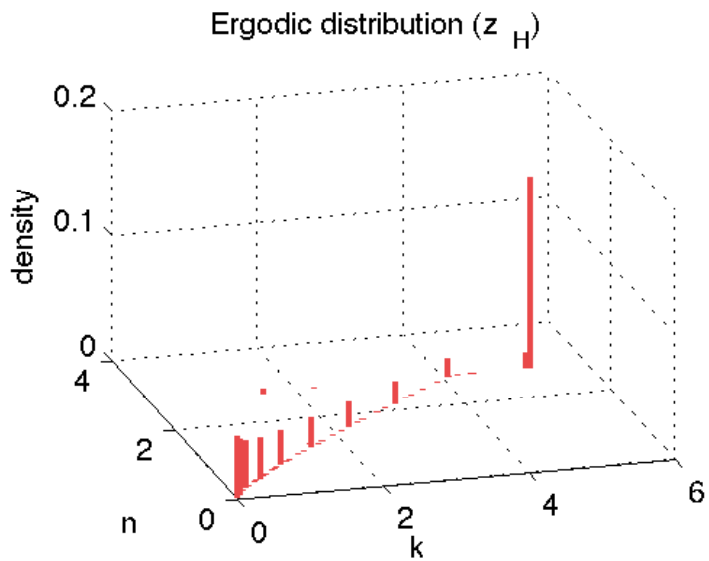
- Maintain structure of static model. Discrete time.
- **Household:** same + risk neutral, $r_t = 1/\beta$
- **Final goods:** identical
- **Intermediate goods:** details
  - Model evolution of net worth
  - Born, and exit with exogenous probability $\rightarrow$ firm life cycle
  - Capital adjustment costs: $q^d < q^i = 1$
  - Collateral constraint: $d_t \leq \lambda_t q^d k_t$
  - Stochastic productivity, policy fns: $k_t = k_t(n_t, k_{t-1}, z_t)$
- Solved nonlinearly via value function iteration, calibrated to aggregate and firm level moments calibration
- No aggregate uncertainty. Simulate via new non-stochastic simulation procedure which simulates the entire population of firms on endogenous grids

Steady state distribution and policy functions





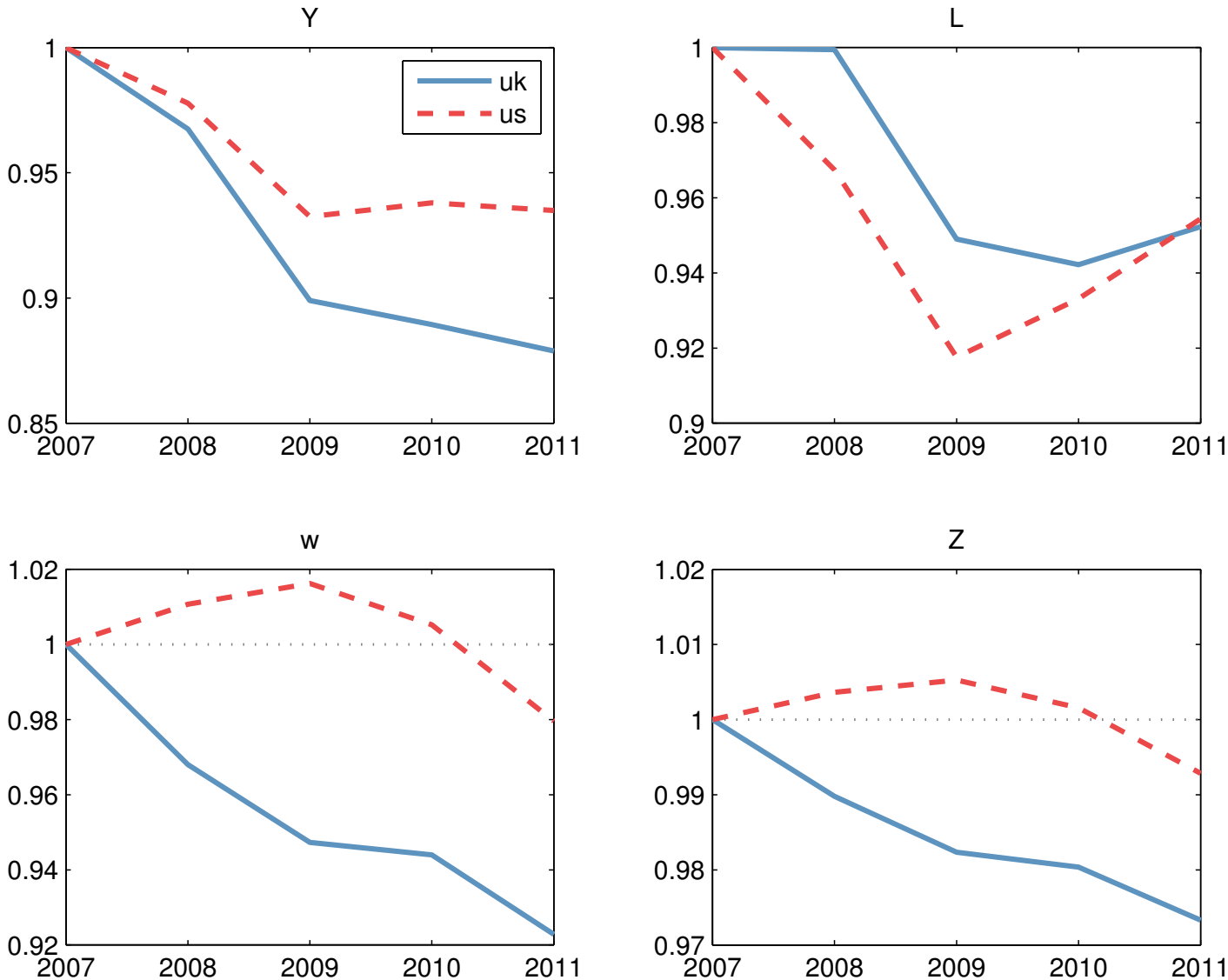




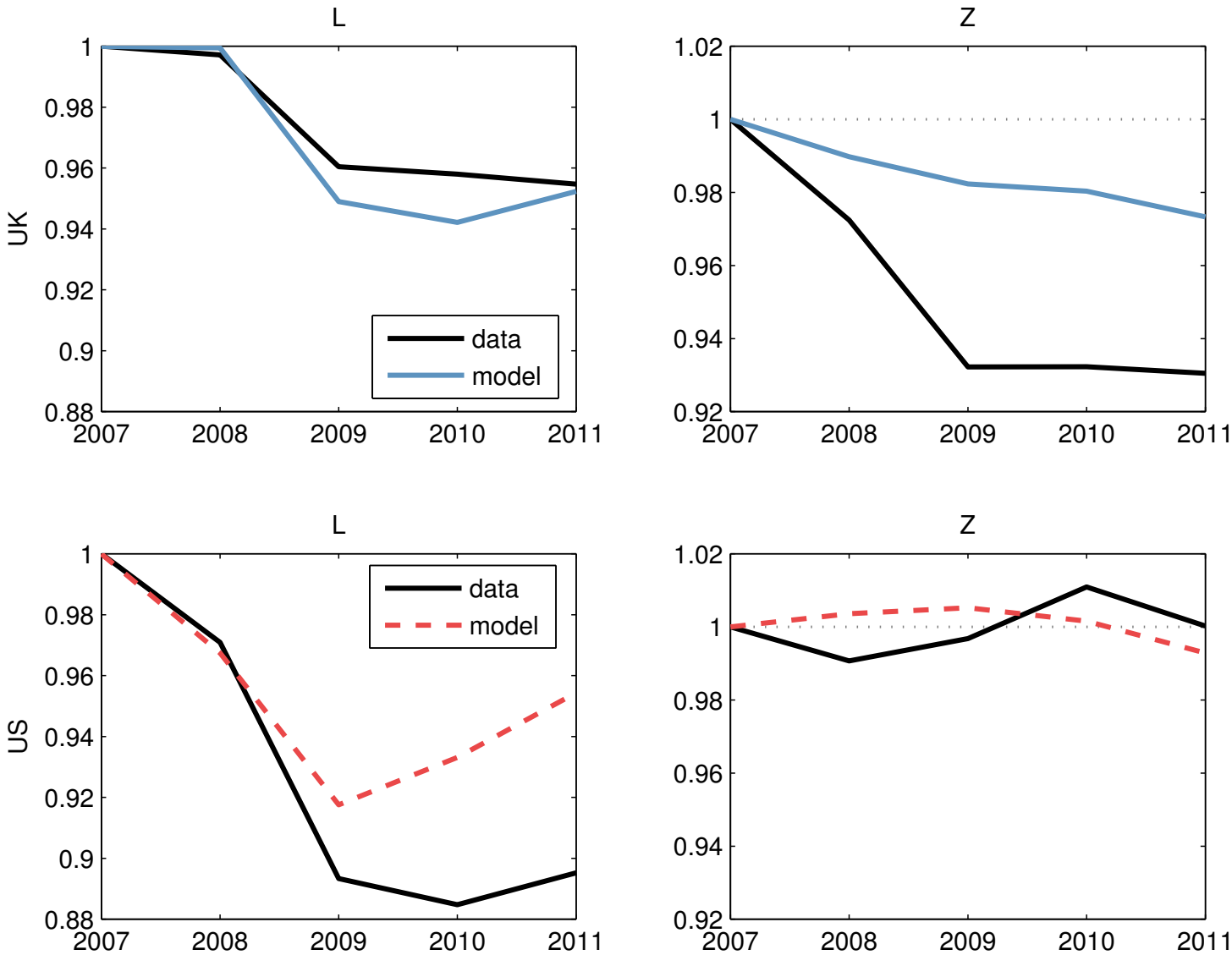
Decomposition exercise 1

- Idea: conditional on matching Y and w paths, how well does the model match L and Z paths?
- Construct perfect foresight exercise starting from steady state
- Feed in $\{w_t\}$ data from each country (partial equilibrium) and pick $\{\lambda_t\}$ to match $\{Y_t\}$
- Match annual data from 2007-11. Use unadjusted data.

UK vs US: model



UK vs US: model and data



Conclusion

The recent crisis manifested more in hours/employment in the US; TFP in the UK.

Labour hoarding isn't the answer. Instead, evidence of greater increase in misallocation in the UK.

Real wages fell more in the UK. I argue this provides an explanation.

Contributions:

1. Highlight the role of wage adjustment in transmitting financial crises in heterogeneous firm models
2. Apply this insight to understand US/UK during the recent crisis. Model can rationalise 1/3 of TFP and 1/2 of hours differences (*conditional on wages*)

Future work:

1. Implications for policy
2. Heterogeneous wages

Decomposition exercise 2

- Next exercise: allow for both financial (λ) and common TFP (Z_c) shock. Identify via model.
- Pick $\Delta\lambda$ and ΔZ_c to match ΔY and ΔZ. Again partial equilibrium given Δw.
- Data: Y, L excluding finance. Z utilisation adjusted, excluding finance, increased scrapping. w composition adjusted.
- Adjusted Z data for UK only available at 2007 and 2011, so do comparative statics comparison of steady states.

Decomposition exercise 2: results

Data: 2007-2011

	Y	w	Z	L
UK	-9.54%	-11.3%	-5.25%	-3.91%
US	-7.74%	-2.43%	-0.96%	-10.5%
Diff	-1.80pp	-8.87pp	-4.29pp	6.59pp

Model: 2007-2011

	Z	Z (exog)	Z (endog)	L
UK	-5.25%	-2.97%	-2.28%	2.02%
US	-0.96%	-0.31%	-0.65%	-5.44%
Diff	-4.29pp	-2.66pp	-1.63pp	7.46pp

- Model generates 43.4% of UK TFP fall endogenously, and 51.8% of US hours decline
- And 38.0% of TFP gap endogenously. Over-states hours gap by 13.2%

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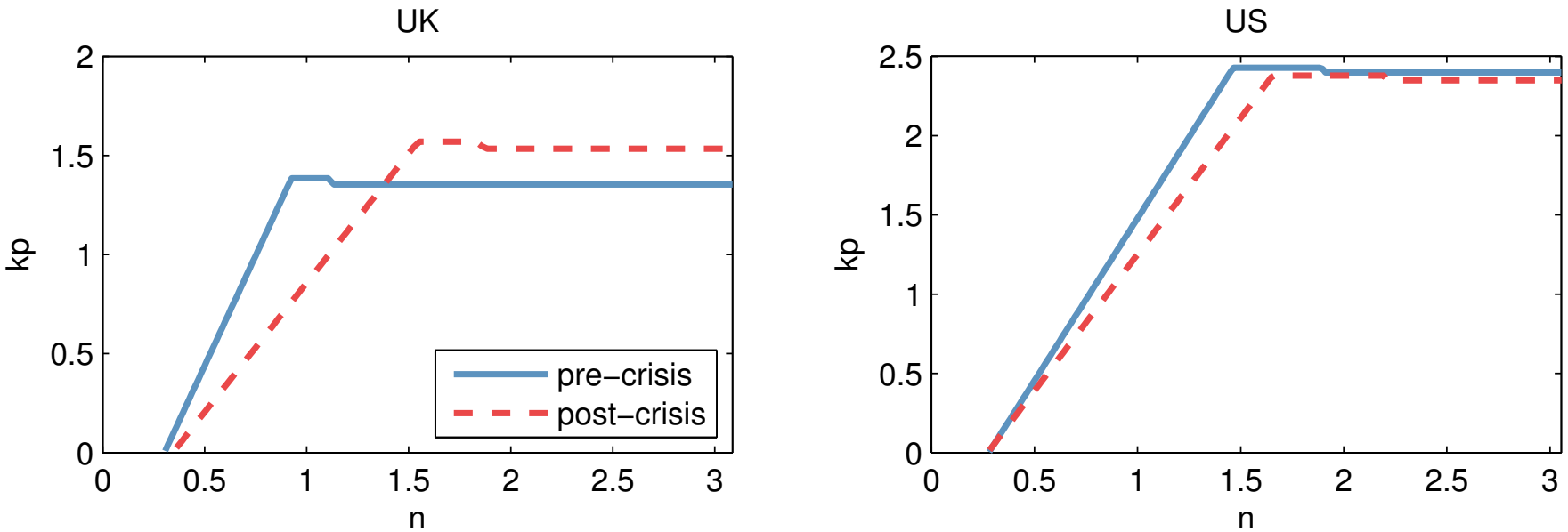
Section 4: Micro implications

Behaviour by firm size: model



- Plot capital policy function $k' = k(n, k, z)$ for given k and z *pre- and post-crisis*
- Model prediction:
  - Unconstrained expand more in UK due to large wage fall
  - Constrained-unconstrained investment gap should widen more in UK than US. **Data proxy: small-large investment gap.**

Firm size: UK data (Crawford, Jin, and Simpson, 2013)

- ARD data *(almost census of large, random sample of small)*
- Regression: details

$$\log(Inv_{i,t}) = \alpha_i + \beta Post08_t + \gamma Year_t + \delta Post06_t + u_{i,t}$$

- Sample 1997-09, yearly data. $Post08 = 1$ for 2008 and 2009.

Investment by firm size (employees):

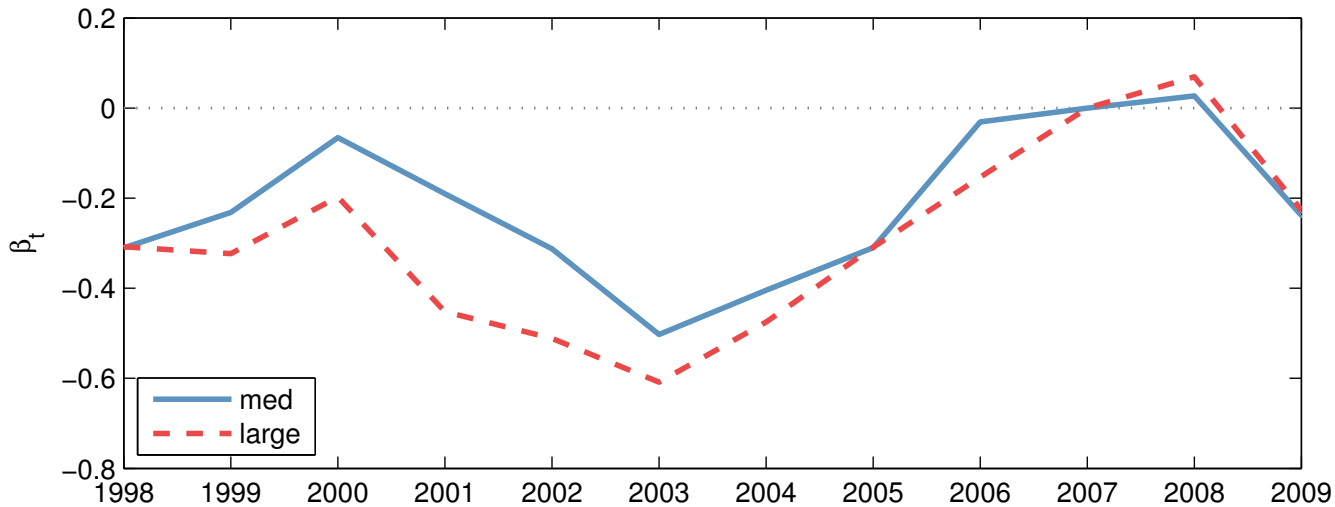
Size:	All	<50	50-249	>250
Post08	-0.099***	-0.107***	-0.157***	-0.042*

- Results:
  - Medium firms 4x larger fall in investment than large
  - Increase in S-L and M-L gaps. Larger than US?

Firm size: US data (Compustat)

- Attempt to stay as close as possible to UK methodology
- Compustat sample: 30k publicly traded companies
- Regression: trend/dummy

$$\log(Inv_{i,t}) = \alpha_i + \beta_t + u_{i,t}$$

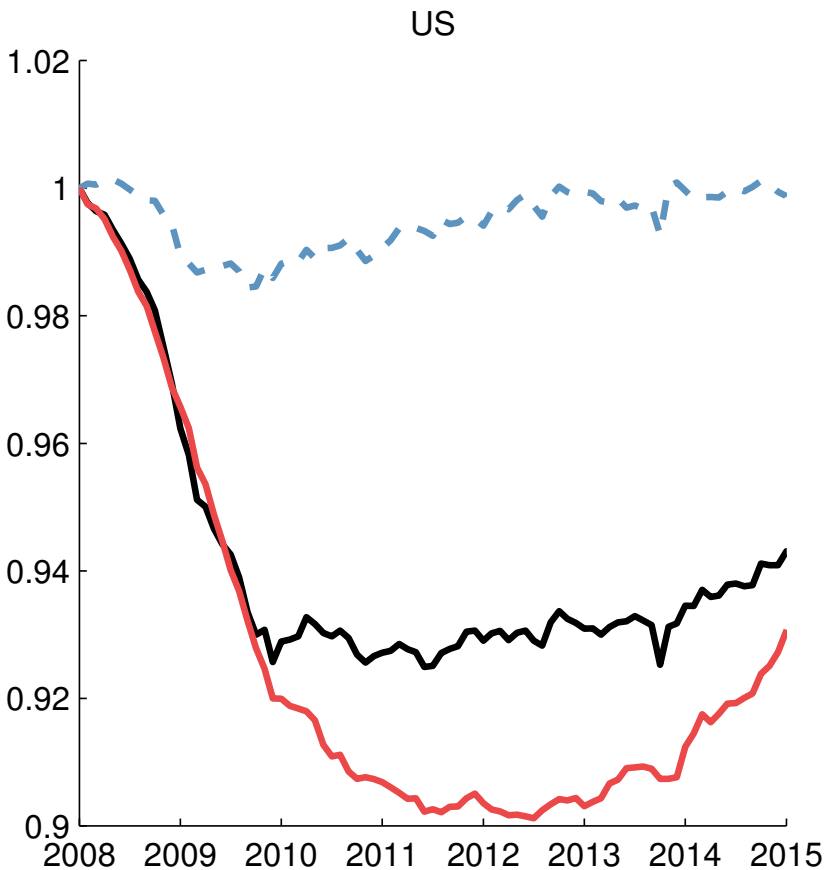


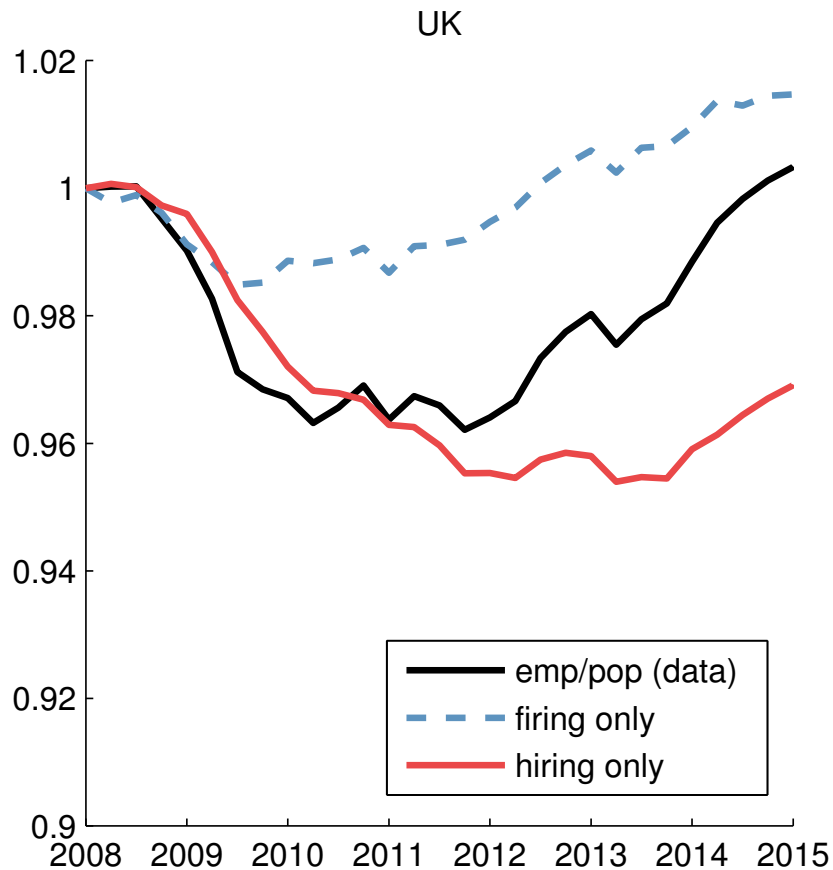
- Results:
  - Medium/large investment drops comparable
  - M-L gap widens more in UK, consistent with model

Labour flows

- Use employment flows data to decompose change in employment driven by flows out of employment and flows into employment
  - Simulate counterfactual emp/pop ratio holding other flows at pre-crisis level
  - "sep rates" series: allow only $e \to e$, $e \to u$ and $e \to n$ to vary
  - "other rates" series: allow all other rates to vary
- Can use to distinguish between theories

Labour flows: data





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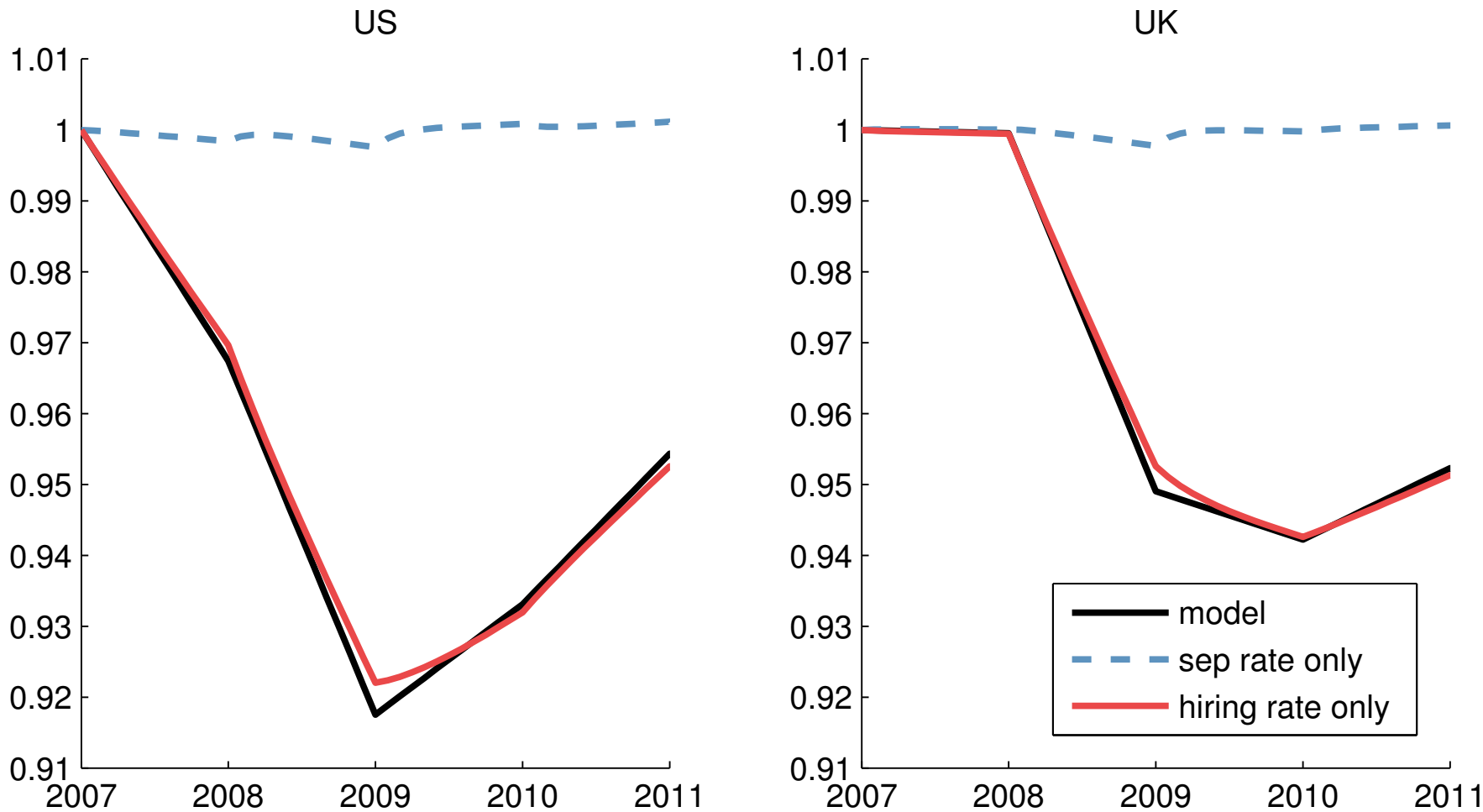
Labour flows

- Data shows difference in hiring is what drives employment differences
- Downplays labour hoarding as alternative explanation:
  - Alternative explanation of differential Z and L experience: more labour hoarding in UK
  - Less firing in UK props up L, but hoarding pushes down TFP.
  - But: data implication is that difference in employment driven by differences in firing
- My model is consistent with dominant role of hiring
  - Calculate hiring and firing firm-by-firm. Add exogenous quits to bring average flows in line with the data
  - Calculate flows along transition and repeat counterfactual exercise as in data

Labour flows: model



Intermediate goods firms: dynamic problem

Adjustment costs: **partial irreversibility**

- Purchase capital at price 1
- Sell at price $q^d < 1$
- Leads to (S, s) policy functions

One period non-defaultable debt subject to **collateral constraint:**

$$d_t \leq \lambda_t q^d k_t$$

Net worth: $n_t \equiv \pi_t + (1-\delta) q_t^i k_{t-1} - r_{t-1} d_{t-1}$

Balance sheet: $q_t k_t + e_t = \tilde{n}_t + d_t$

- Invest: $q_t = 1$ and $\tilde{n}_t = n_t$
- Disinvest: $q_t = q^d$ and $\tilde{n}_t = n_t - (q^i - q^d)(1-\delta) k_{t-1}$

Intermediate goods firms: dynamic problem 2

Value if invest:

$$V_t^i(n_t, k_{t-1}, z_t) = \max_{e_t \geq 0, (1-\delta)k_{t-1} \leq k_t \leq \frac{n_t}{q_t^i - \lambda_t q_{t+1}^d}} \left\{ e_t + \right.$$

$$\left. \mathrm{E}_t \left[\beta \frac{u'(c_{t+1})}{u'(c_t)} \left((1-\sigma)(n_{t+1} - (1-q^d)(1-\delta)k_t) + \sigma V_{t+1}(n_{t+1}, k_t, z_{t+1}) \right) \right] \right\}$$

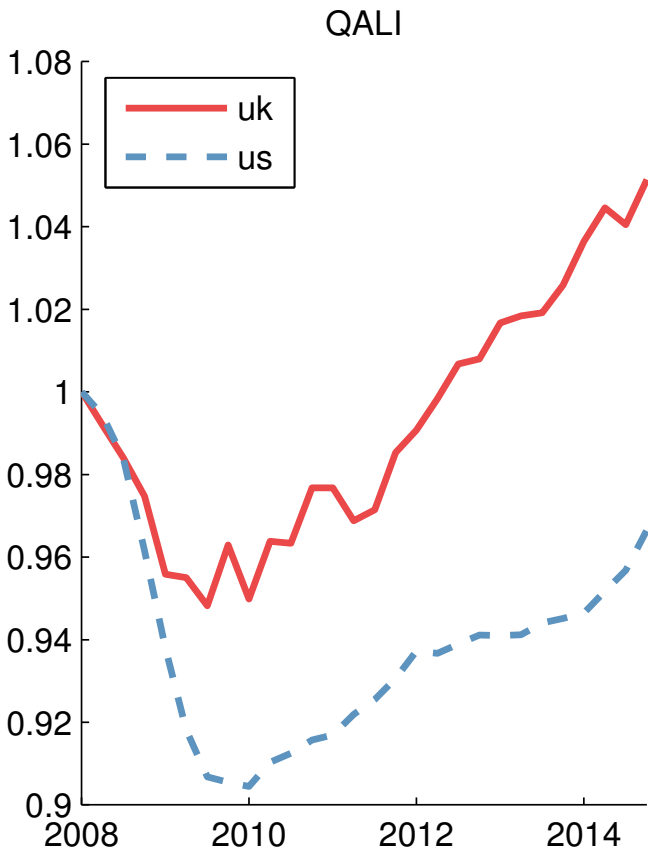
Value if disinvest:

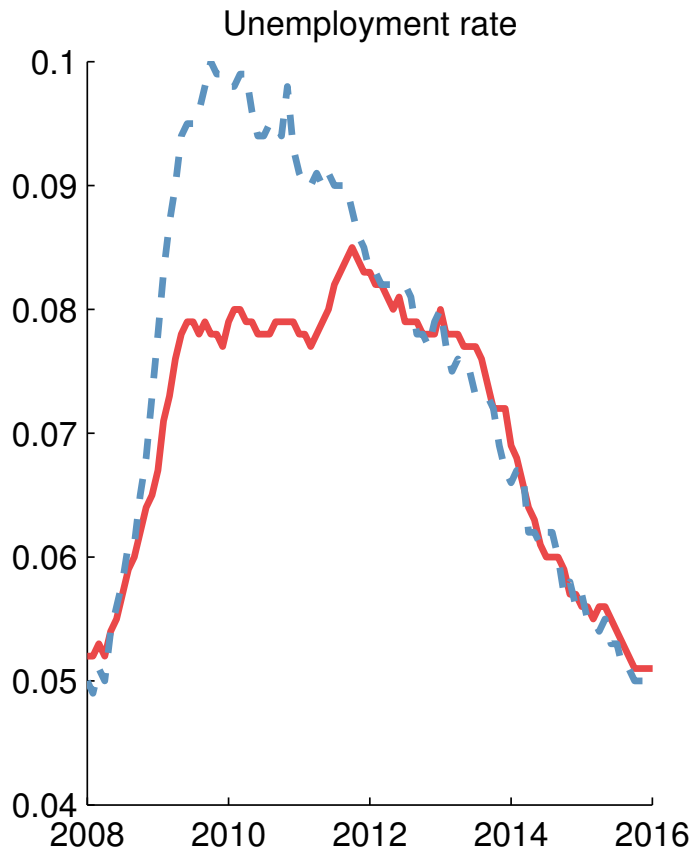
$$V_t^d(n_t, k_{t-1}, z_t) = \max_{e_t \geq 0, k_t \leq \min\{ \frac{n_t - (q_t^i - q_t^d)(1-\delta)k_{t-1}}{q_t^d - \lambda_t q_{t+1}^d}, (1-\delta)k_{t-1} \}} \left\{ e_t + \right.$$

$$\left. \mathrm{E}_t \left[\beta \frac{u'(c_{t+1})}{u'(c_t)} \left((1-\sigma)(n_{t+1} - (1-q^d)(1-\delta)k_t) + \sigma V_{t+1}(n_{t+1}, k_t, z_{t+1}) \right) \right] \right\}$$

return

QALI and unemployment





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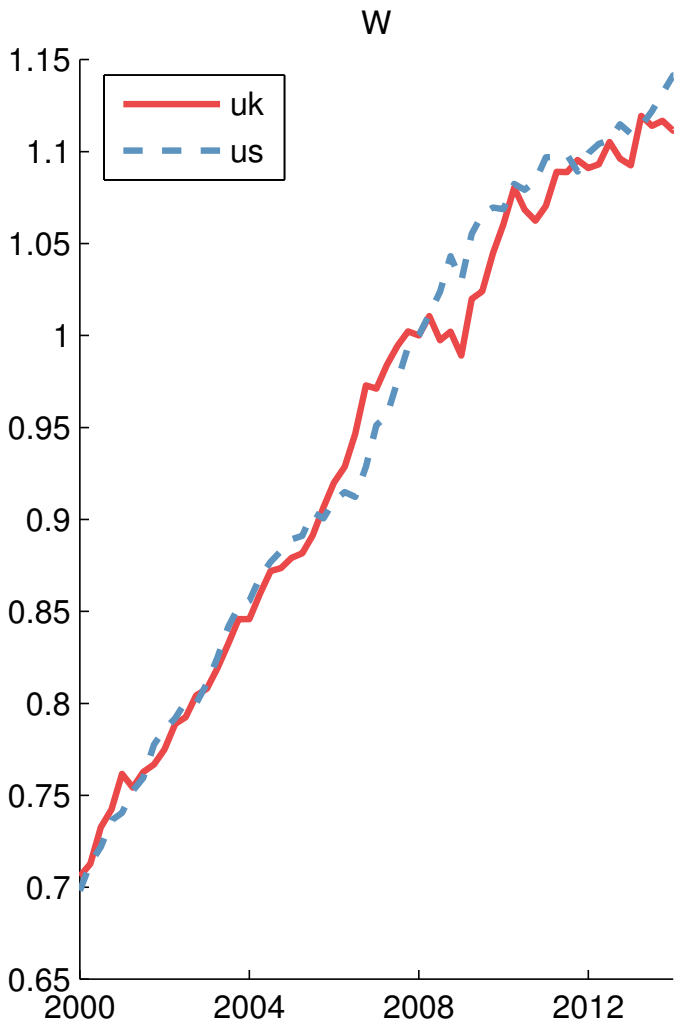
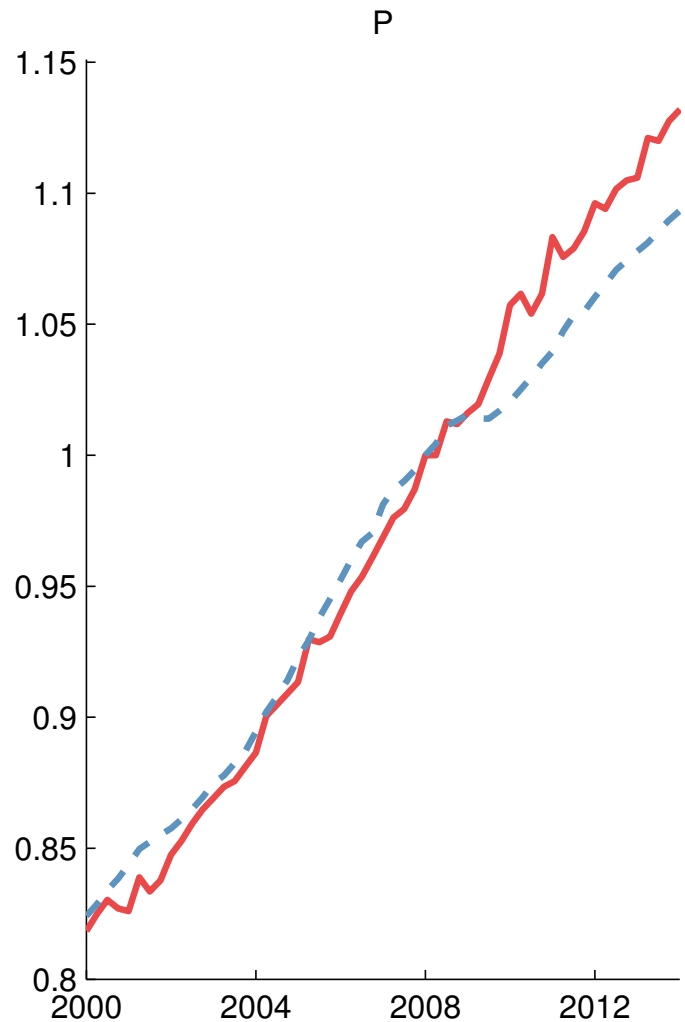
Nominal wages, or inflation?





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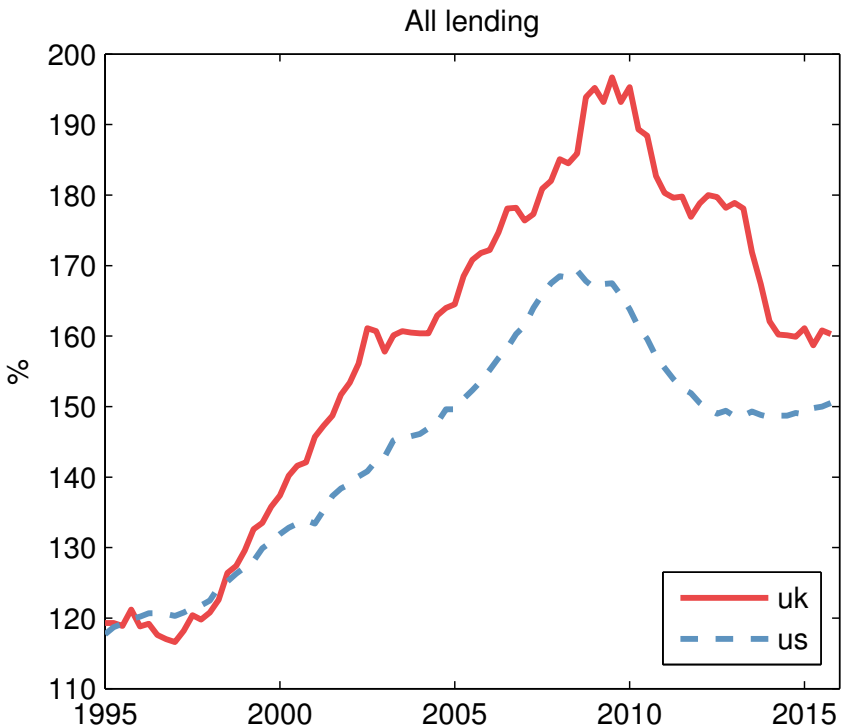
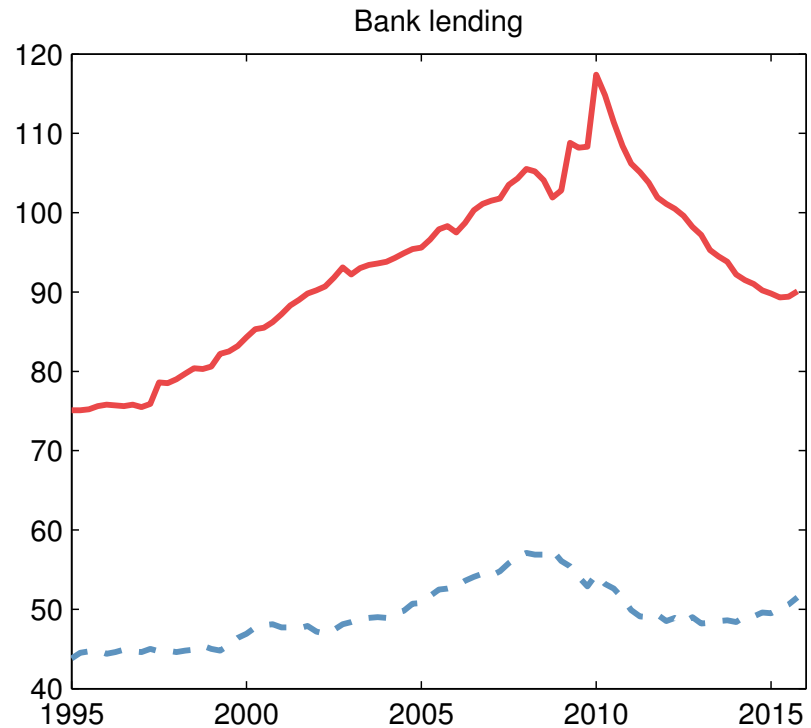
Lending to Non-financial firms





- Similar decline in total debt issuance in both US and UK
- But UK decline particularly concentrated in bank lending

Refining TFP measures

TFP difference is robust to several corrections:

- Basu, Fernald, and Kimball (2006) utilisation correction
- Excluding financial sector
- Potential increased capital scrapping ($\uparrow \delta$ by 25%)

Δ TFP: 2007-2011

	TFP	+ Util adj	+ Excl finance	+ $\uparrow$ depr
UK	-12.2%	-10.1%	-7.08%	-5.25%
US	-3.84%	-3.24%	-2.77%	-0.96%

Note: UK data are from Goodridge, Haskell, and Wallis (2015). US TFP and utilisation adjusted data are from Basu, Fernald, and Kimball (2006).

return

Business cycle accounting

Using data on capital, labour, output and consumption, measure the "wedge" in each of the four RBC equations:

$$y_t = e^{\tau_t^e} k_{t-1}^{\alpha} \left((1+g_z)^t l_t\right)^{1-\alpha} \tag{1}$$

$$\frac{v'(l_t)}{u'(c_t)} = (1-\tau_t^l)(1-\alpha)\frac{y_t}{l_t} \tag{2}$$

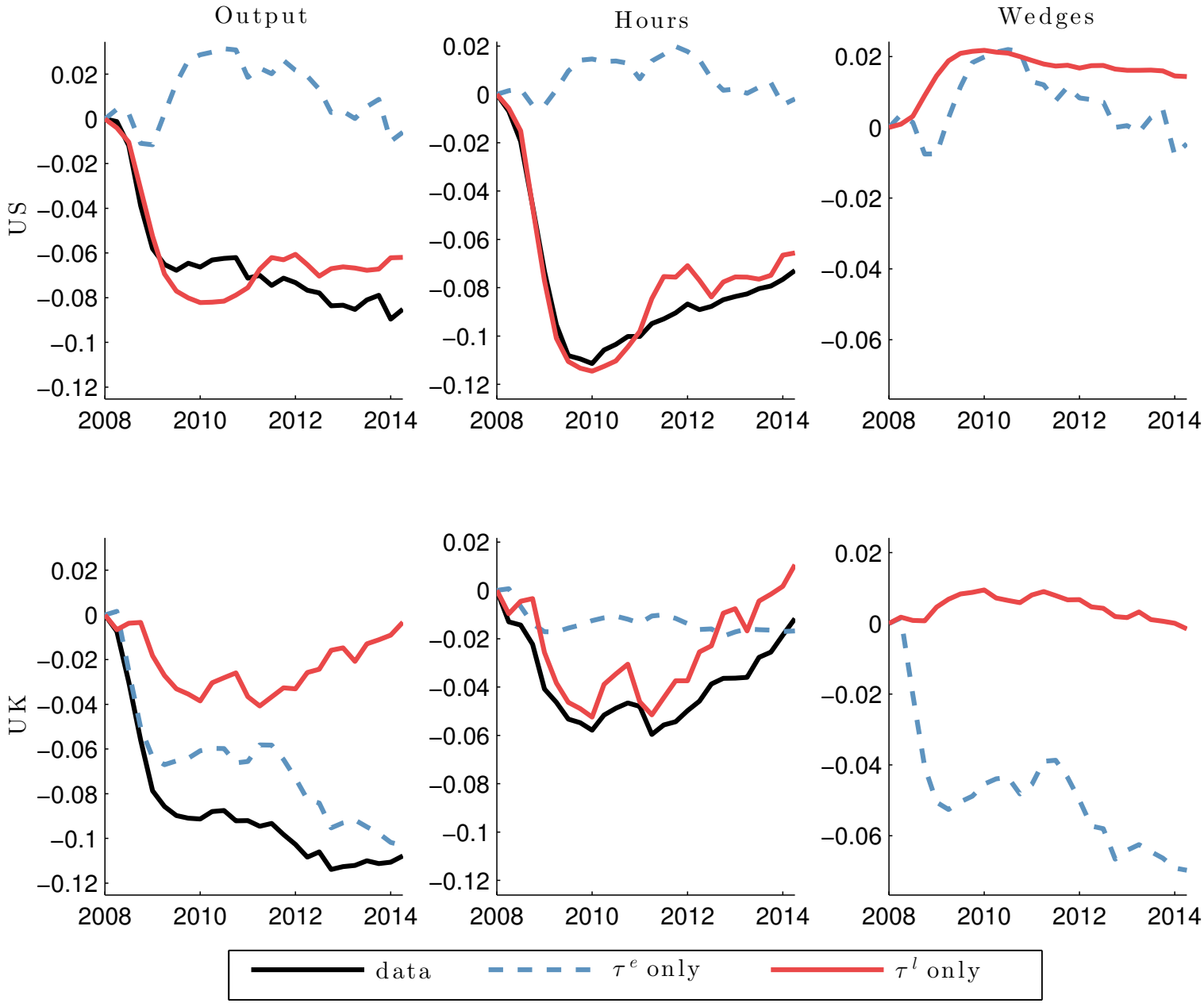
$$u'(c_t) = \beta E_t \left[u'(c_{t+1}) \left((1-\tau_t^x)\alpha \frac{y_{t+1}}{k_t} + 1 - \delta \right) \right] \tag{3}$$

$$c_t + (1+g_{N,t})k_t - (1-\delta)k_{t-1} + \tau_t^g y_t = y_t \tag{4}$$

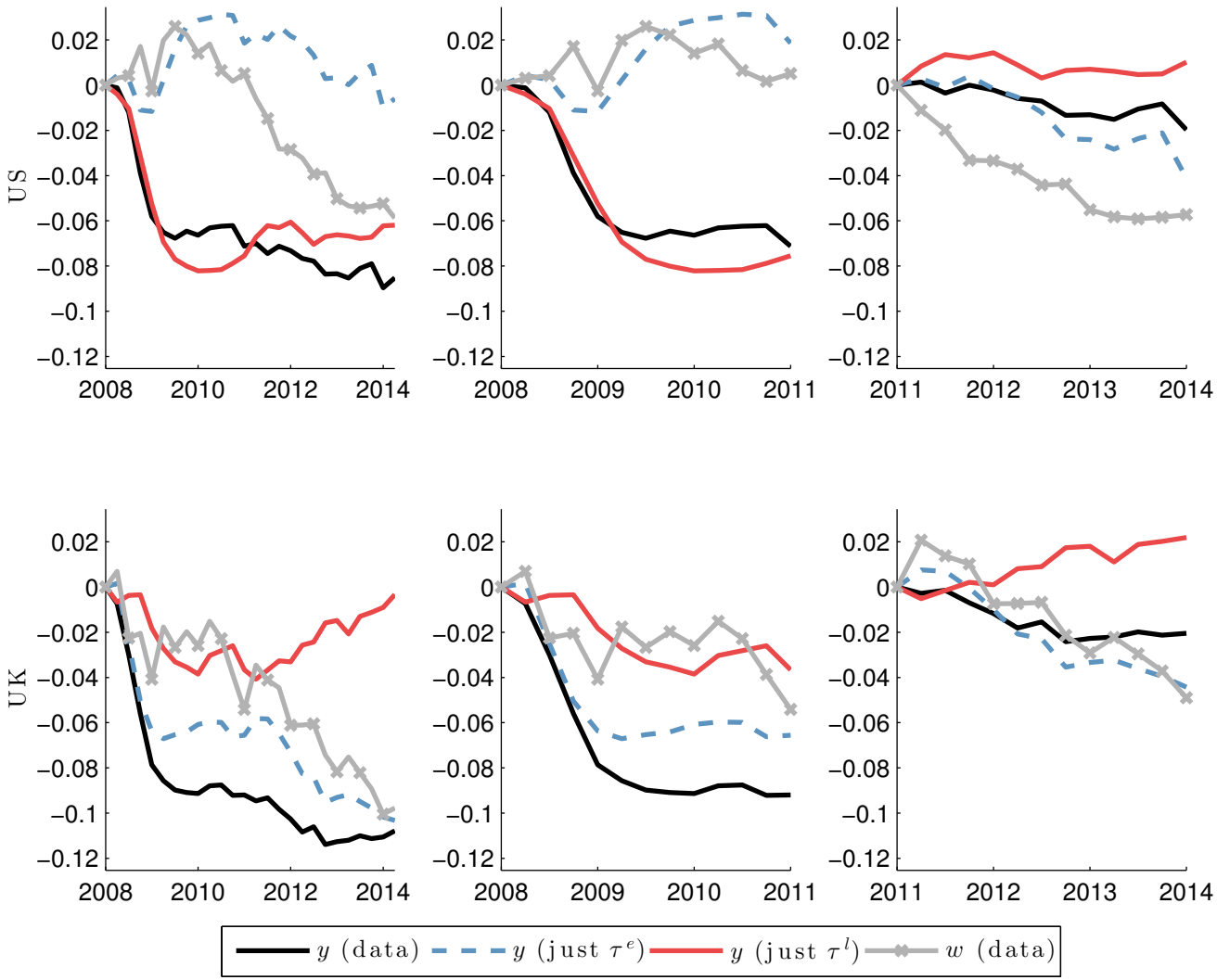
Interpretation: Capital income tax, labour income tax, TFP, government spending

Counterfactual exercise: simulate economy with only one wedge active

Business cycle accounting



Business cycle accounting



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Explaining Productivity in the UK

- Goodridge, Haskell, and Wallis (2015)
  - 33% simply due to finance / oil
  - 14% due to factor utilisation
  - Industry level reallocation of labour towards more productive
- Riley, Rosazza-Bondibene, and Young (2015)
  - Correlation between employment growth and productivity worsens during crisis
  - Worse for more bank-dependent industries
  - But, productivity fall mostly within firm
- Barnett, Chiu, Franklin, and Sebastiá-Barriel (2014)
  - 1/3 of labour productivity fall can be attributed to less labour reallocation and entry/exit
  - Within-firm component initially related to labour hoarding

Many potential explanations, some evidence for role of misallocation

International evidence

Data from OECD on TFP, hours, real wage and price level.

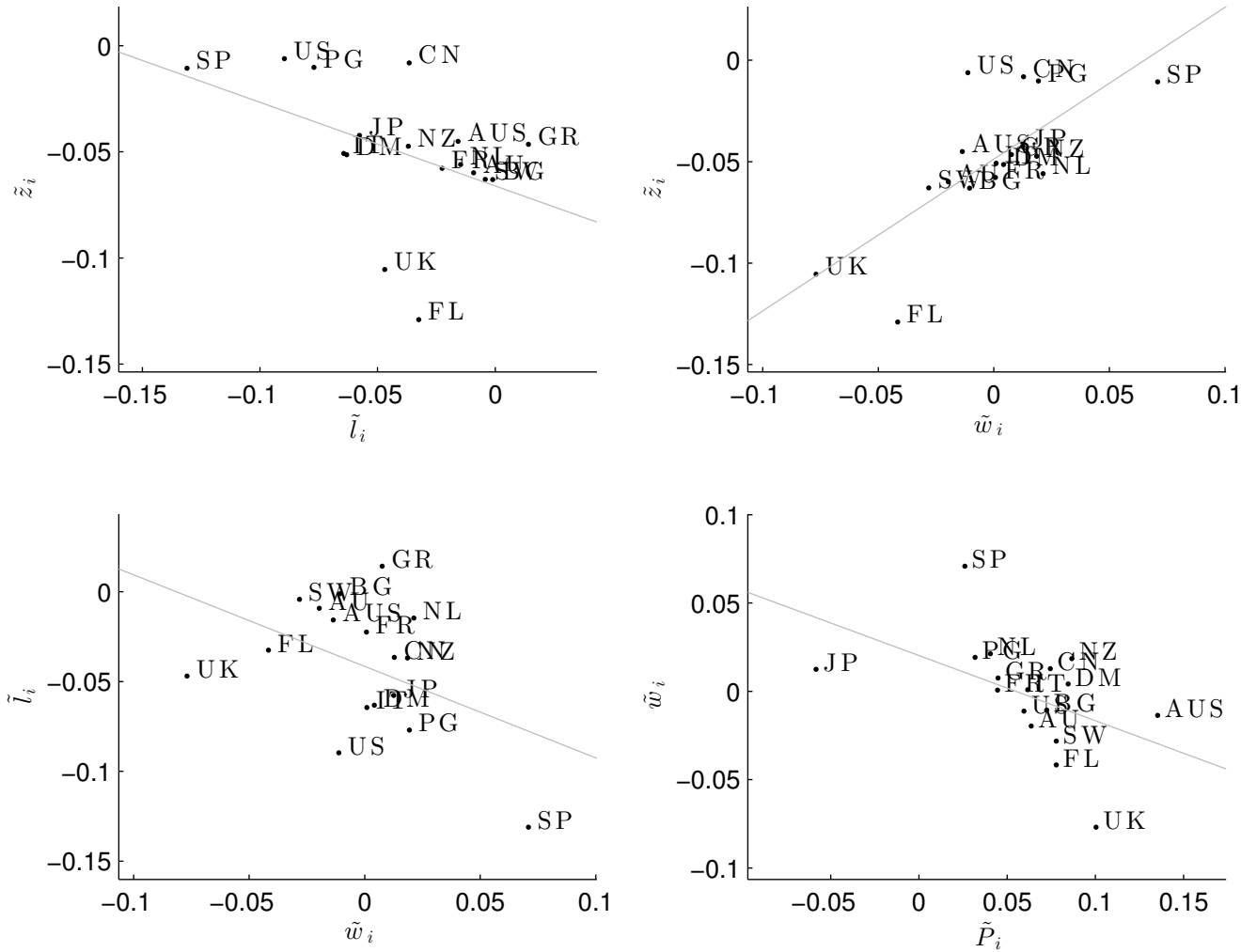
Simple correlations:

- $\tilde{x}_i = \log(x_{i,2011}/x_{i,2007})$
- Correlations between TFP, hours etc using cross country variation

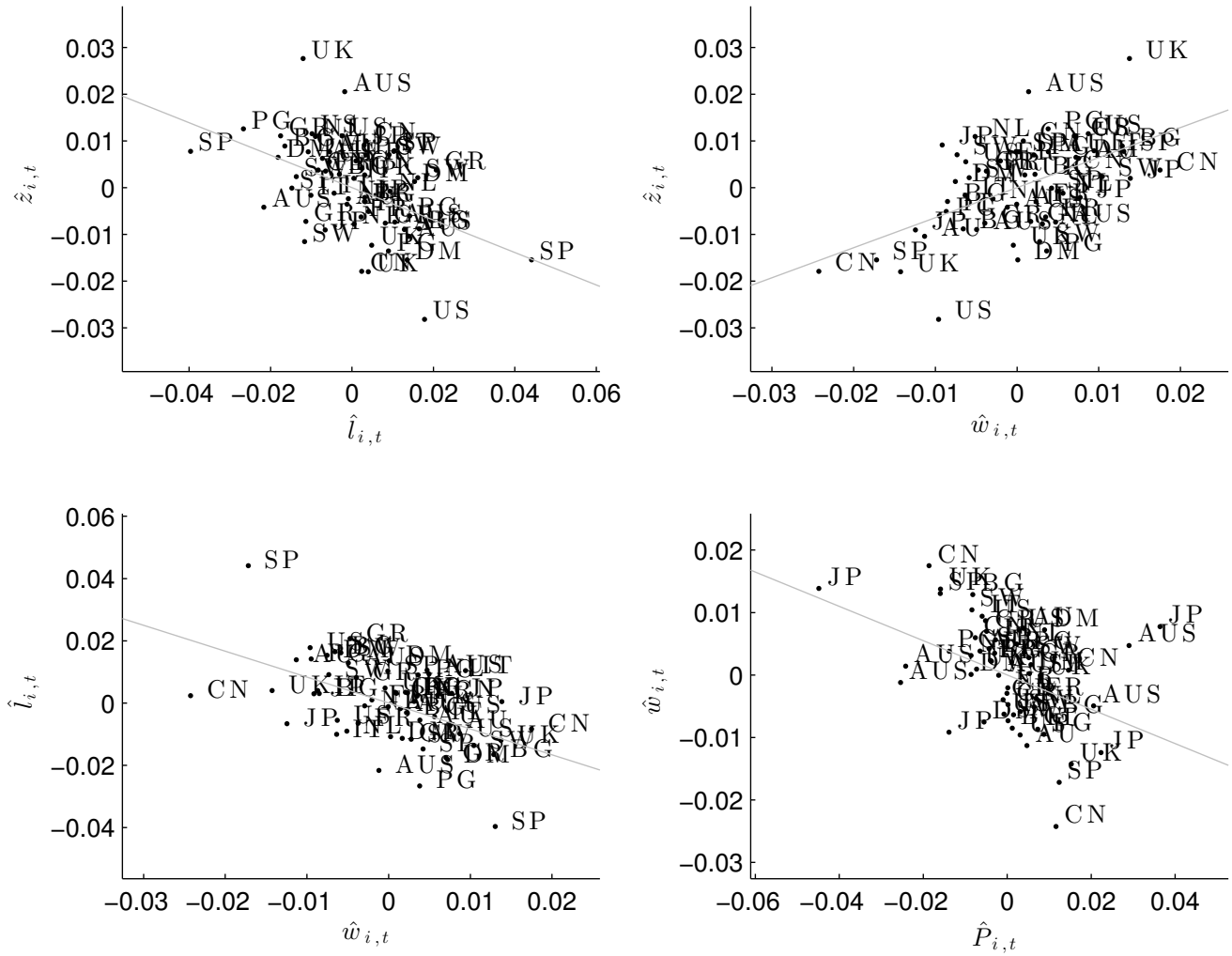
Partial correlations:

- $\tilde{x}_{i,t} = \log(x_{i,t}/x_{i,2007})$ for $t = \{2008, 2009, 2010, 2011\}$
- Partial correlations after controlling for country and time fixed effects $\rightarrow$ using within country variation
- Also control for "credit intermediation ratio" $\rightarrow$ plots conditional on size of financial disruption

International evidence: cross section



International evidence: (sort of) panel



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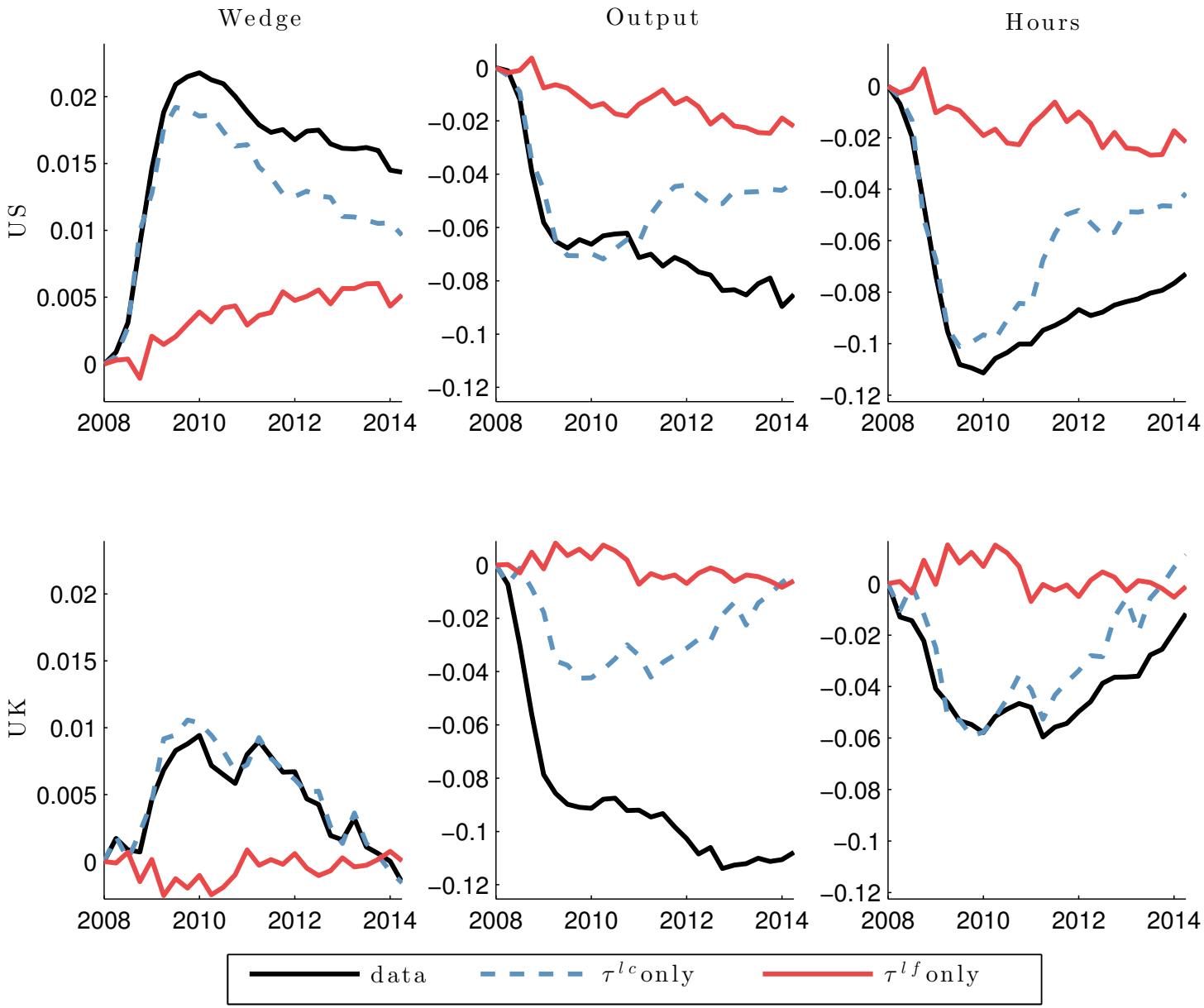
Little distortion of firm-side wedge in either country



Intermediate goods producers 2

Labour optimality:

$$l_i = \left(\frac{\nu Y^{1-\rho}}{w}\right)^{\frac{1}{1-\nu}} z_i^{\frac{\rho}{1-\nu}} k_i^{\frac{\alpha\rho}{1-\nu}}$$

Constrained:

$$k_i = \lambda n_i$$

$$y_i = \left(\frac{\nu Y^{1-\rho}}{w_i}\right)^{\frac{1-\alpha}{1-\nu}} z_i^{\frac{1}{1-\nu}} k_i^{\frac{\alpha}{1-\nu}}$$

Unconstrained:

$$k_i = (\alpha\rho)^{\frac{1}{1-\rho}} \left(\frac{1-\alpha}{\alpha}\right)^{\frac{\nu}{1-\rho}} Y z_i^{\frac{\rho}{1-\rho}} w^{\frac{-\nu}{1-\rho}}$$

$$y_i = \alpha^{\frac{\alpha}{1-\rho}} (1-\alpha)^{\frac{1-\alpha}{1-\rho}} \rho^{\frac{1}{1-\rho}} Y z_i^{\frac{1}{1-\rho}} w^{-\frac{1-\alpha}{1-\rho}}$$

Note: unconstrained move one-for-one with aggregate output

Can low wages cause low productivity?

"But some in the profession are also beginning to ask whether the **link between low productivity and low wages may run in both directions.** Low pay allows firms to employ workers profitably in marginal jobs and to continue to use workers even though robots or software could replace them. **Investments in automated checkout machines, for example, are less attractive when there are lots of cheap humans around.**

Some economists, such as Joao Paulo Pessoa and John Van Reenen of the London School of Economics, reckon low British wages, which tumbled during the Great Recession, help account for weak productivity growth during the subsequent recovery, since **firms felt less pressure to economise.**"

– The Economist, 2016

Underlying US/UK differences

1. Why was wage adjustment slower in US?
   - DNWR + higher inflation in the UK $\Rightarrow$ 50%
   - Changes to labour market institutions
   - Demographics / labour supply

2. Isn't it just higher firing costs in UK?
   - Higher US unemployment mostly driven by lower hiring
   - US labour turnover is higher than UK on average ($\sim 3\times$), but TFP differences have persisted for over six years...

3. Was there more misallocation in UK?
   - Firing rates doubled in both, but employment falls more in US $\Rightarrow$ more labour reallocated in UK.
   - But, reallocated $\Rightarrow$ misallocated?
   - Evidence of more misallocation in UK from firm-level data

UK appendix

$$\log(Inv_{i,t}) = \alpha_i + \beta Post08_t + \gamma Year_t + \delta Post06_t + u_{i,t}$$

Investment by firm size (employees):

Size:	All	<50	50-249	>250
Post08	-0.099***	-0.107***	-0.157***	-0.042*
Post06	0.131***	0.115***	0.139***	0.135***
Year	-0.046***	-0.044***	-0.048***	-0.045***
No. obs	208,169	77,145	79,752	51,272
No. RUs	75,772	40,253	24,349	11,170

return

US appendix

Investment by firm size (employees):

Size:	All	<50	50-249	>250
Post08	0.110***	0.233**	0.111	0.098***
Post06	0.382***	0.709***	0.318***	0.361***
Year	-0.006	-0.051***	0.003	-0.003
No. obs	38,285	3,525	7,320	27,440
No. RUs	8,425	998	1,932	5,495

Investment by firm size (employees):

Size:	All	<50	50-249	>250
Post08	0.193***	0.346***	0.172**	0.181***
Year	0.026***	0.012	0.031***	-0.027***
No. obs	38,285	3,525	7,320	27,440
No. RUs	8,425	998	1,932	5,495

return

Substitutability discussion 1

- Revenue function for DRS ρ and K/L sub s

$$y = (ak^s + (1-a)l^s)^{\frac{1}{s}} \Rightarrow r = py = (ak^s + (1-a)l^s)^{\frac{\rho}{s}} Y^{1-\rho}$$

- $s = 1$ is perfect subs, $s = 0$ is CD, $s \to -\infty$ is perfect comps. E of sub: $\epsilon = 1/(1-s)$
- Effect of reducing capital on marginal revenue product of labour:

$$\frac{\partial^2 r}{\partial l \partial k} = a(1-a)\rho(\rho - s)l^{s-1}k^{s-1}\left(ak^s + (1-a)l^s\right)^{\frac{\rho}{s}-2} Y^{1-\rho}$$

- Two cases:
  1. $\rho - s < 0$: Reducing k encourages you to increase l
  2. $\rho - s > 0$: Reducing k encourages you to decrease l

Substitutability discussion 2

- For baseline $\rho = 0.82$ you need $s > 0.82$ ($\epsilon = 1/(1-s) > 5.56$) in order for reduced k to lead to increased l. Very far from CD ($s = 0$, $\epsilon = 1$) and even further from data which says k/l are complements (Greg paper $\epsilon = 0.6$, $s = -0.67$)
- Conc: for standard parameter values, reduced investment should lead to fall in employment, not rise *for a given wage*
- Thus only way to generate increased labour at small/constrained firms is for wage to fall there

Calibration (US)

	Interpretation	Value	Source
	Aggregates:		
β	Discount factor	0.95	–
α	$y = zk^{\alpha}l^{1-\alpha}$	0.33	–
δ	Depreciation rate	0.065	$I_{ss}/K_{ss} = 0.065$
$\mathrm{E}[z]$	Mean firm prod	1.70	Normalise $Y_{ss} = 1$
w_{ss}	Mean wage	1.64	$L_{ss} = 1/3$
	Firm level:		
ρ	Good substitution	0.82	Cooper and Haltiwanger (2006)
σ_z	$\mathrm{std}(z_{i,t})$	0.06	$\mathrm{std}(ik_{i,t}) = 0.34$ *(large firms)*
ρ_z	autocorr. $z_{i,t}$	0.65	Khan and Thomas (2013)
q^d	Capital resale price	0.95	Khan and Thomas (2013)
λ_{ss}	Collateral rate	0.49	$D_{ss}/A_{ss} = 0.37$
σ	Survival rate	0.9	Exit rate 10%
n_e	New firm equity	0.04	$L_e/L = 0.1$

Calibration (UK) return

	Interpretation	Value	Source
	Aggregates:		
β	Discount factor	0.95	–
α	$y = zk^{\alpha}l^{1-\alpha}$	0.33	–
δ	Depreciation rate	0.065	$I_{ss}/K_{ss} = 0.065$
$\mathrm{E}[z]$	Mean firm prod	1.63	Normalise $Y_{ss} = 1$
w_{ss}	Mean wage	1.64	$L_{ss} = 1/3$
	Firm level:		
ρ	Good substitution	0.82	Cooper and Haltiwanger (2006)
σ_z	$\mathrm{std}(z_{i,t})$	0.09	$\mathrm{std}(ik_{i,t}) = 0.54$ *(all firms)*
ρ_z	autocorr. $z_{i,t}$	0.65	Khan and Thomas (2013)
q^d	Capital resale price	0.95	Khan and Thomas (2013)
λ_{ss}	Collateral rate	0.53	$D_{ss}/Y_{ss} = 1.15 \times (D_{ss}/Y_{ss})_{US}$
σ	Survival rate	0.89	Exit rate 11%
n_e	New firm equity	0.085	$L_e/L = 0.15$