# The Aggregate Effects of Credit Market Frictions: Evidence from Firm-level Default Assessments

Tim Besley, Isabelle Roland, and John Van Reenen

London School of Economics and Political Science

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# MOTIVATION: Causes of global productivity slowdown?


- Weak demand?
- Slowdown of technological change?
- **Credit frictions**?
  - Credit constraints: Are firms deprived of credit?
  - Allocation: Are the "right" firms getting credit?
- Why should you care?
  Well-functioning credit markets matter for growth!

# CASE STUDY: "UK labor productivity puzzle"

- **Q4 2015: 16% gap between post-1979 trend and actual labor productivity**

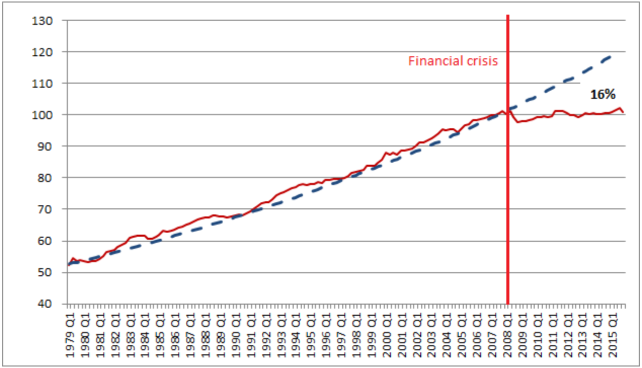



Figure: GDP/hour Q4 2007=100, trend=2.3% p.a.(Q1 1979-Q2 2008 average)
Note: Q2 2008=start of recession. Source: ONS

- **Slowdown stands out in UK historical <u>and</u> international comparisons**

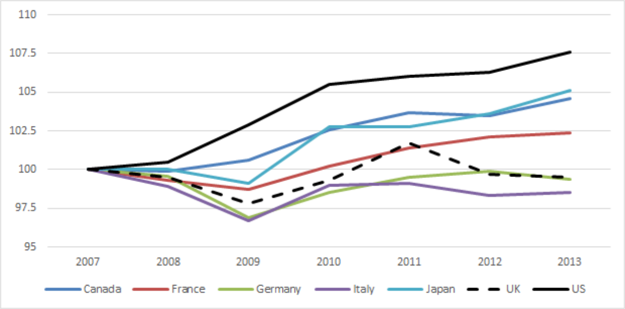



Figure: GDP/hour, 2007=100. Source: OECD and ONS

Historical comparison

# QUESTION: How much of this gap is related to credit constraints?

**Integrated theoretical-empirical framework**

- Literature on the aggregate consequences of firm-level distortions (e.g. Hsieh and Klenow, 2009)

$$\Pi_n = P_n Y_n - (1 + \tau_{Ln}) w L_n - (1 + \tau_{Kn}) R K_n$$

- Large number of frictions included in "tax wedges" $\tau_{Ln}$ and $\tau_{Kn}$
- **Disentangle credit frictions from "black box"** $\tau_{Kn}$
- Need theoretical framework to
  - Motivate a way of measuring credit frictions at the firm level
  - Measure how this translates into aggregate output losses
- Ensure theoretical concepts can be taken to panel data

# OUR ANSWERS: Credit frictions substantially depress output and labor productivity

- On average over 2004-2012 level of UK output was 7% to 9% lower due to credit market frictions (mainly among SMEs)
- Impact worsened during the crisis and lingered thereafter
- Frictions account for between a fourth and third of
  - the 11% productivity gap at the end of 2012
  - the productivity fall in 2008-2009
- Productivity gap mainly driven by deterioration of average default risk as opposed to misallocation of credit

- Theoretical framework
- Data and measurement
- Core results
- SMEs versus large firms
- Misallocation
- Conclusion

- STEP 1: Micro-found a (measurable) proxy for firm-level credit conditions
  - Model suggests focusing on *default risk*
  - Can be estimated empirically using a credit scoring algorithm
- STEP 2: Embed this in a model with heterogeneous firms
  - Firm-level implications
  - Aggregate implications: How does default risk translate into aggregate output losses?

**Simple model of equilibrium credit contracts with moral hazard**

**FIRMS**

- Risk neutral
- Heterogeneous productivities $\theta_n$ and collateral $A_n$
- Produce using labor $L_n$ and capital $K_n$: $Y_n = \theta_n \left(L_n^{1-\alpha} K_n^{\alpha}\right)^{\eta}$
- Borrow $B_n$ from banks and $K_n = A_n + B_n$
- Output is stochastic - Production takes place or fails (0)
- Manager exerts costly effort which determines the probability of success $\phi_n$
- Effort is not observed by lenders

**LENDERS**

- Risk neutral
- Compete and offer credit terms $\{B_n, R_n\}$ tailored to a firm's characteristics $\{\theta_n, A_n\}$
- Access funds at cost $\rho > 1$
- Limited liability: Firm does not pay back $R_n$ if output is 0 $\rightarrow$ Collateral $A_n$ seized

## LENDING CONTRACTS

1. Nature assigns each firm to a bank
2. Banks offer credit contracts $\{B_n, R_n\}$ given firm's outside option $U(\theta_n, A_n)$
3. Manager chooses effort to maximize expected profits
4. Default occurs with probability $(1 - \phi_n)$ in which case firm loses $A_n$
5. If there is no default, firm makes labor hiring decisions, produces, and repays $R_n$

## Optimal $\phi$ (stage 3)

- Choice of default probability maximizes firm's expected profits given any credit contract $\{R_n, B_n\}$ offered
- First order condition for optimal effort implies: $\phi_n^*$ increases in profit and collateral but decreases in interest payment

## Optimal contracts (stage 2)

- Credit contract maximizes bank's expected profits s.t. IC effort
- Focus on case where firm's outside option $U(A_n, \theta_n)$ binds
- This pins down $R_n^*$ and $\phi_n^*(A_n, \theta_n) = f(g(U(A_n, \theta_n) + A_n))$

- Repayment probability $\phi^*$ can fall because of:
  - Factors affecting function $f(\cdot)$, e.g. more challenging business conditions
  - Balance sheet deterioration, e.g. a fall in $A_n$
  - Higher switching costs as lenders are less keen for new business, i.e. lower $U(A_n, \theta_n)$

- Plugging this into the bank's profit function gives an expression which depends only on $B_n$
- Maximizing with respect to $B_n$ yields

$$\Pi_K\left(\theta_n, w, A_n + B_n^*\left(A_n, \theta_n\right)\right) = \frac{\rho}{\phi_n^*\left(A_n, \theta_n\right)}$$

- MPK = Lender's risk-adjusted cost of funds
- Lower default risk means more capital, all else equal
- Model yields a simple micro-foundation for "tax wedge" in Hsieh and Klenow (2009)

$$\tau\left(A_n, \theta_n\right) = \frac{1 - \phi_n^*\left(A_n, \theta_n\right)}{\phi_n^*\left(A_n, \theta_n\right)}$$

**Closing the model: Outside option**

- Suppose there is a switching cost, $\kappa$, from moving to an alternative bank
- Equilibrium outside option offered by lender is the best possible terms another bank can offer - $\kappa$
- Higher switching cost implies worse outside option
- Firms with worse outside options are more prone to default
- This lowers the amount of capital they are allocated

Outside option

**Firm-level decisions**

- Production: $Y_{nt} = \theta_{nt} \left( L_{nt}^{1-\alpha} K_{nt}^{\alpha} \right)^{\eta}$ with $\eta < 1$
- Fully flexible labor while loans are determined as above
- Factor demands maximize

$$\left\{ \theta_{nt} \left( L_{nt}^{1-\alpha} K_{nt}^{\alpha} \right)^{\eta} - w_t L_{nt} - \frac{\rho_t}{\phi_{nt}^*} K_{nt} \right\}$$

- FOCs for $L$ and $K$ imply

$$Y_{nt}^* = \theta_{nt}^{\frac{1}{1-\eta}} \psi\left(w_t, \rho_t\right) \left(\phi_{nt}^*\right)^{\frac{\eta\alpha}{1-\eta}}$$

- Similar equations can be derived for $K_{nt}$ and $L_{nt}$
- Factors which decrease PD increase output, employment, and the use of capital
- Firm level TFP also matters alongside macro effects

Monopolistic competition

**Aggregate implications**

- $\rho_t$ is determined in global capital markets
- Exogenously fixed aggregate labor supply $L$
- Aggregate expected output is:

$$Y_t = \hat{\theta}_t^{\frac{1}{1-\eta}} \psi\left(w_t, \rho_t\right) \sum_{n=1}^{N} \left(\frac{\theta_{nt}}{\hat{\theta}_t}\right)^{\frac{1}{1-\eta}} \phi_{nt}^{1+\frac{\eta\alpha}{1-\eta}}$$

- where $\hat{\theta}_t = \left(\sum_{n=1}^{N_t} (\theta_{nt})^{\frac{1}{1-\eta}}\right)^{1-\eta}$ is aggregate *TFP*, and
- $\omega\left(\theta_{nt}\right) = \left(\frac{\theta_{nt}}{\hat{\theta}_t}\right)^{\frac{1}{1-\eta}}$ are productivity weights s.t. $\sum_{n=1}^{N} \omega\left(\theta_{nt}\right) = 1$

**Aggregate implications**

- Key magnitude for the efficiency loss due to credit frictions

$$\Theta_t\left(\sigma_t, \rho_t\right) = \sum_{n=1}^{N_t} \omega\left(\theta_{nt}\right) \phi_{nt}^{1+\frac{\eta\alpha}{1-\eta}}$$

- Weighted average of probabilities of repayment where weights = relative TFP
- $0 \leq \Theta_t \leq 1$ scales output up and down
- No default $\rightarrow \Theta_t = 1$ and output is at first-best $Y_t^*$
- Output loss due to credit frictions is

$$\frac{Y_t^* - Y_t}{Y_t^*} = 1 - \Theta_t\left(\sigma_t, \rho_t\right)^{\frac{1-\eta}{1-\alpha\eta}}$$

- $\Theta_t$ estimated using TFP and PD estimates (or employment data)

Estimation with employment data

# DATA: Value added, employment, and TFP

- Annual Business Inquiry and Annual Business Survey
  - Establishment level administrative surveys (ONS)
  - Census of large businesses and stratified random sample of Small and Medium Sized Enterprises (SMEs) (under 250 employees)

- Measure productivity as real gross value added per employee

- Estimate capital stock (PIM) and TFP as Solow residual

- Focus on "market sector, excluding financial services, education, health, social work, agriculture, mining and quarrying, utilities, real estate, and non-profit organizations

- Use sampling weights to measure *aggregate* productivity developments

# DATA: Default probabilities

- Estimate default risk using credit scoring model (S&P's)
  - Inputs: BvD company accounts, industry, and macroeconomic factors
  - Output: risk score (aaa, bbb, etc.)
- Match risk score to *historical* default rates to capture historical information set of lenders

# DATA: Sample

| | ABI/ABS market sector | Sample market sector | | | |
|---|---|---|---|---|---|
| | All firms | All firms | % | SMEs | Large firms |
| 2004 | 38,670 | 26,155 | 68% | 21,819 | 4,336 |
| 2005 | 37,762 | 25,358 | 67% | 21,192 | 4,166 |
| 2006 | 31,804 | 21,989 | 69% | 18,149 | 3,840 |
| 2007 | 35,361 | 24,363 | 69% | 20,052 | 4,311 |
| 2008 | 38,333 | 23,614 | 62% | 18,729 | 4,885 |
| 2009 | 36,872 | 23,283 | 63% | 18,603 | 4,680 |
| 2010 | 36,919 | 23,010 | 62% | 18,626 | 4,384 |
| 2011 | 36,378 | 24,048 | 66% | 19,449 | 4,599 |
| 2012 | 36,513 | 24,720 | 68% | 20,058 | 4,662 |

Figure: Annual number of firms

- On average 24K firms per year

Annual productivity changes in our sample | Sample representativeness

# DATA: Default probabilities

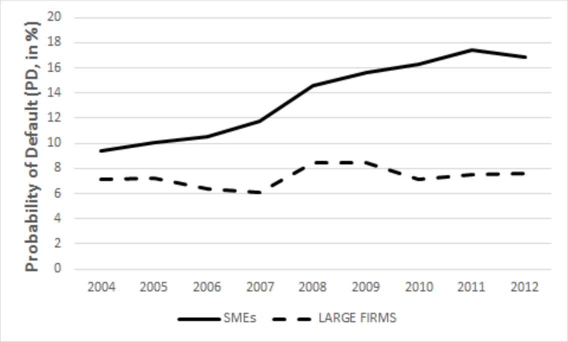



Figure: Aggregate probability of default at the 1-year horizon (in %)

- Probability of default (PD) systematically larger for SMEs
- Increase after 2007 is significant for both types of firms
- Aggregate developments largely driven by SMEs

# DATA: Default probabilities

- Model predicts following *correlations*: Factors which decrease PD increase output, employment, and investment

Figure: OLS with year and firm fixed effects

| | ln(Labor) | ln(GVA) | ln(Capex) |
|---|---|---|---|
| Lagged default risk | -0.102*** | -0.610*** | -0.912*** |
| N | 60,816 | 60,816 | 60,816 |
| R2 | 0.980 | 0.941 | 0.825 |
| | ln(Capital) | ln(Fixed assets) | ln(Capex/labor) |
| Lagged default risk | -0.083*** | -0.390*** | -0.814*** |
| N | 60,816 | 60,816 | 60,816 |
| R2 | 0.992 | 0.968 | 0.693 |

- Default risk is significant indicator of firm performance
- Non-trivial coefficients: e.g. 10pp increase in PD associated with a 9% fall in investment

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Estimated using Solow residual | | Estimated using employment data | |
| | Credit Friction | Percentage Output loss | Credit Friction | Percentage Output loss |
| 2004 | 0.819 | 6.5 | 0.823 | 6.3 |
| 2005 | 0.842 | 5.6 | 0.815 | 6.6 |
| 2006 | 0.805 | 7 | 0.82 | 6.4 |
| 2007 | 0.795 | 7.4 | 0.819 | 6.4 |
| 2008 | 0.764 | 8.6 | 0.773 | 8.2 |
| 2009 | 0.734 | 9.8 | 0.753 | 9 |
| 2010 | 0.729 | 10 | 0.754 | 9 |
| 2011 | 0.702 | 11.1 | 0.74 | 9.5 |
| 2012 | 0.704 | 11.1 | 0.732 | 9.9 |
| Average | 0.766 | 8.6 | 0.781 | 7.9 |

All results assume labor share = 2/3. Credit friction = ϴ. Percentage output loss= $1-\Theta_t^{\frac{1-\eta}{1-\alpha\eta}}$

- On average 7.9% to 8.6% output loss per annum btw 2004 and 2012
- Increasing losses from 2006 onwards
- Impact worsens during the crisis and lingers thereafter

Robustness: Empirical factor shares

# How much of the productivity gap can we explain?

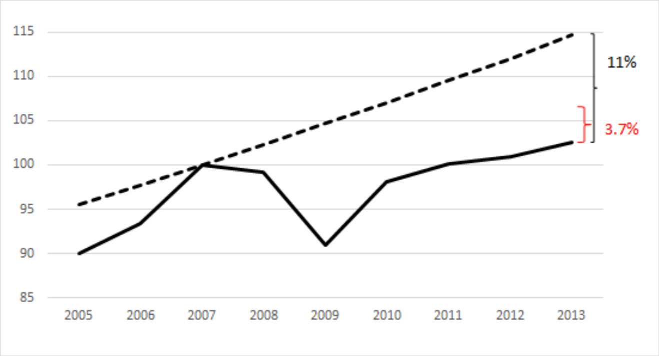



Figure: Real GVA per worker - actual versus trend, 2007=100. Source: ABI & ABS surveys, authors' calculations.

- LP would be 3.5-3.7% higher in 2012 had the level of credit frictions stayed at their level in 2007
- Approx. 33-34% of the productivity shortfall at the end of 2012

Application to productivity slowdown

# EXTENSION: SMEs versus large firms

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | SMEs | | Large firms | |
| | Credit Friction | Percentage Output loss | Credit Friction | Percentage Output loss |
| 2004 | 0.822 | 6.3 | 0.887 | 3.9 |
| 2005 | 0.84 | 5.6 | 0.89 | 3.8 |
| 2006 | 0.799 | 7.2 | 0.898 | 3.5 |
| 2007 | 0.802 | 7.1 | 0.892 | 3.7 |
| 2008 | 0.769 | 8.4 | 0.863 | 4.8 |
| 2009 | 0.733 | 9.8 | 0.861 | 4.9 |
| 2010 | 0.735 | 9.8 | 0.869 | 4.6 |
| 2011 | 0.707 | 10.9 | 0.866 | 4.7 |
| 2012 | 0.705 | 11 | 0.869 | 4.6 |
| Average | 0.768 | 8.5 | 0.877 | 4.3 |

All results estimated using Solow residuals and assuming labor share = 2/3.

- Default risk systematically higher among SMEs
  - Higher output losses among SMEs
  - Aggregate deterioration driven by SMEs

Demand effects

# EXTENSION: Misallocation versus average default risk

- Output loss could come from two sources:

  1. Average deterioration of default risk given the joint distribution of default risk and TFP
  2. Changes in the joint distribution of default risk and TFP given average default risk
     - Credit is *misallocated* if it flows to low-productivity firms

- Decompose $\Theta$ into MEAN (1) and COVARIANCE (2) components

- $\Theta$ can be written as

$$\Theta_t = \sum_{n=1}^{N_t} \left[ \omega_{nt} - \frac{1}{N_t} \right] (\phi_{nt})^{\mu} + \frac{1}{N_t} \sum_{n=1}^{N_t} (\phi_{nt})^{\mu}$$
$$= \text{COVARIANCE}(\omega_{nt}, \phi_{nt}^{\mu}) + \text{MEAN}(\phi_{nt}^{\mu})$$

- where $\mu = 1 + \frac{\eta\alpha}{1-\eta}$
- COVARIANCE=0 in the absence of default
- In a world with default, COVARIANCE can be positive or negative
- A higher COVARIANCE signals better allocational efficiency

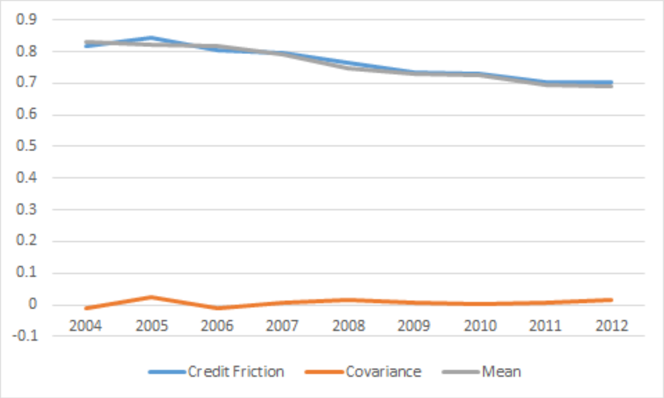
# EXTENSION: Misallocation versus average default risk

| | (1) Credit Friction | (2) Covariance | (3) Mean |
|---|---|---|---|
| 2004 | 0.819 | -0.012 | 0.83 |
| 2005 | 0.842 | 0.022 | 0.82 |
| 2006 | 0.805 | -0.011 | 0.817 |
| 2007 | 0.795 | 0.006 | 0.789 |
| 2008 | 0.764 | 0.015 | 0.748 |
| 2009 | 0.734 | 0.005 | 0.729 |
| 2010 | 0.729 | 0.004 | 0.725 |
| 2011 | 0.702 | 0.006 | 0.696 |
| 2012 | 0.704 | 0.014 | 0.69 |
| Average | 0.766 | 0.005 | 0.76 |

All results estimated using Solow residuals and assuming labor share = 2/3.

- COVARIANCE mostly positive and small
- Most of the action is in the MEAN

# EXTENSION: Misallocation versus average default risk




- COVARIANCE mostly positive and small
- Most of the action is in the MEAN

# CONCLUSIONS

- Do credit frictions play a role in productivity slowdown?
- Developed a theoretical-empirical framework to motivate a way of measuring the impact of credit frictions on the real economy
- UK Case Study with rich administrative firm-level panel data
    - Substantial output and productivity losses from generalized increase in default risk
    - Worsening since 2007 - mainly due to frictions on SME credit markets
    - Little evidence of worsening allocational efficiency

# CASE STUDY: "UK productivity puzzle"

- Slowdown stands out in historical perspective

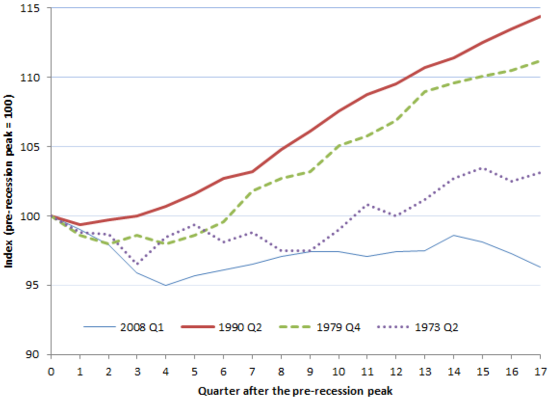



Figure: Output per worker, 2008-09 recession and previous 3 UK recessions. Pre-recession peak=100. Source: ONS.

International comparison

**Closing the model: Outside option**

- Suppose there is a switching cost, $\kappa$, from moving to an alternative bank
- Define the maximized profit of a lender facing an outside option $U$ as $\beta\left(A_n, \theta_n : U\right)$
- Define the outside option which generates zero profits for an alternative bank as $\tilde{U}\left(A_n, \theta_n\right)$ from $\beta\left(A_n, \theta_n : \tilde{U}\left(A_n, \theta_n\right)\right) = 0$
- This is the best possible terms that another bank would offer
- Equilibrium outside option is

$$U\left(\theta, A\right) = \tilde{U}\left(A, \theta\right) - \kappa$$

Outside option

- This is a "Lucas span of control model" where profits are a return to ownership of technological/managerial capital $\theta$
- The model could also be interpreted as a model with monopolistic competition where

$$\eta = 1 - \frac{1}{\varepsilon}$$

and $\varepsilon$ is the elasticity of demand, e.g.

- Cobb-Douglas production function

$$Y = \theta K^{1-\alpha} L^{\alpha}$$

- With iso-elastic demand curve

$$Q = P^{-\varepsilon}$$

Firm decisions

**Estimation of $\Theta$ with employment data**

- Less measurement error (no need for TFP estimation)
- Purely based on the model
- From FOC for $L$, employment solves $L_{nt} = \frac{\alpha\eta Y_{nt}}{w_t}$
- Can show that

$$\hat{\omega}_{nt} = \frac{\tilde{\gamma}_{nt}\hat{\Theta}_t}{\phi_{nt}^{1+\frac{\eta\alpha}{1-\eta}}}$$

- where $\tilde{\gamma}_{nt}$ is the employment share of firm $n$ at date $t$ in total employment
- Solve for $\hat{\Theta}_t$ using the fact that $\sum_{n=1}^{N} \hat{\omega}_{nt} = 1$

Output loss

# Growth of aggregate real GVA per worker

Table: Growth of aggregate real GVA per worker - based on ABI/ABS sample

| | **Growth of real GVA/worker (%)** |
|---|---|
| **2005** | 4.8 |
| **2006** | 3.7 |
| **2007** | 6.9 |
| **2008** | -0.6 |
| **2009** | -8.1 |
| **2010** | 7.7 |
| **2011** | 2 |
| **2012** | 0.9 |

Sample

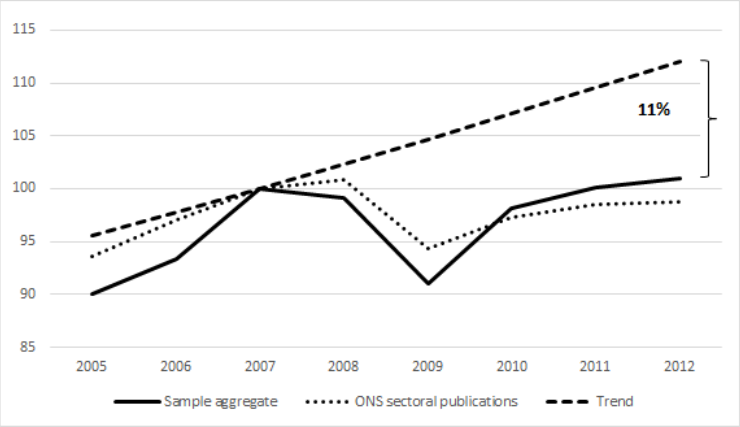



Figure: Representativeness of productivity developments in the sample

Sample

# Robust patterns across estimation methods

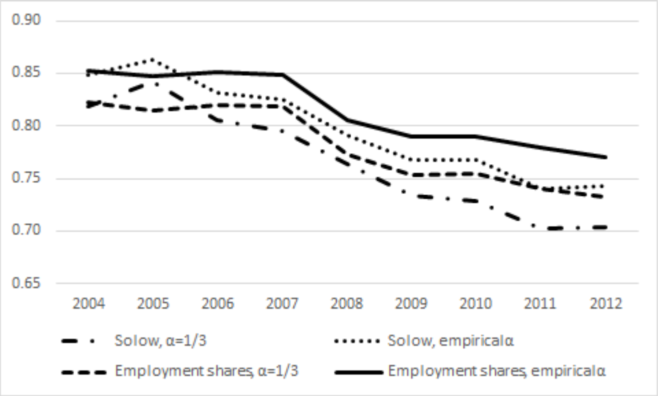



Figure: Estimates of Θ based on four estimation methods

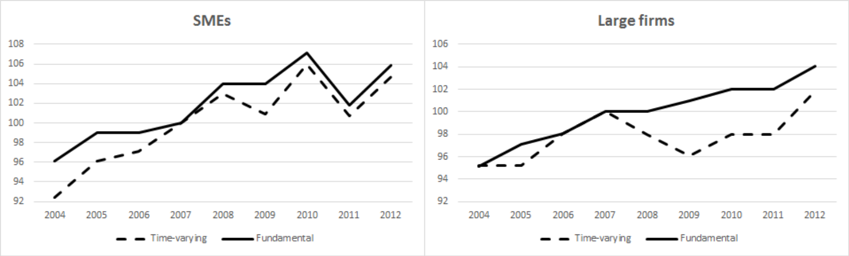
Core results

$$\Delta \log w_t = \frac{1-\eta}{1-\alpha\eta}\left[\ln \Theta_t - \ln \Theta_{t-1}\right]$$

- Comparison with actual real wage gives a sense of what fraction of the observed labor productivity change is due to credit frictions

| | Estimated using Solow residual, α=1/3 | |
|---|---|---|
| | Credit Friction | Contribution to productivity growth |
| 2004 | 0.819 | |
| 2005 | 0.842 | 0.9 |
| 2006 | 0.805 | -1.5 |
| 2007 | 0.795 | -0.4 |
| 2008 | 0.764 | -1.4 |
| 2009 | 0.734 | -1.3 |
| 2010 | 0.729 | -0.2 |
| 2011 | 0.702 | -1.2 |
| 2012 | 0.704 | 0.1 |
| Average | 0.766 | -0.6 |

# SMEs versus large firms: Role of demand effects?




- Credit frictions as measured by default risk matter mainly for SMEs
- Have large firms suffered larger demand shocks? (exports etc.)
- Difference between fundamental and time-varying TFP suggests so

Core results: SMEs versus large firms

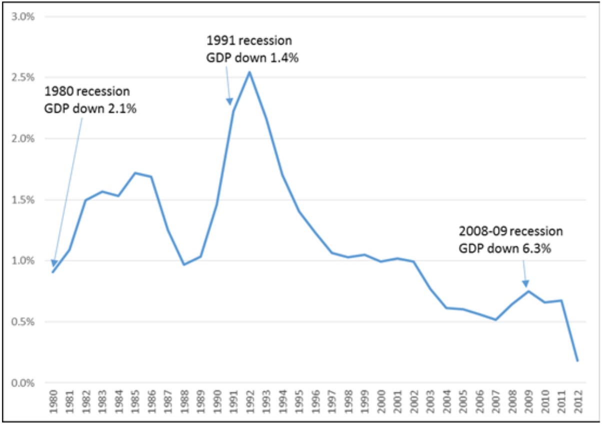
# Extension: Misallocation - between firm effects

Counterfactual: Each firm gets its industry average default probability

| | (1) | (2) | (3) |
|---|---|---|---|
| | Contribution to productivity growth (Counterfactual) | Contribution to productivity growth (Baseline) | Contribution of allocational efficiency to productivity growth |
| **2005** | -0.4 | 0.9 | 1.3 |
| **2006** | -0.1 | -1.5 | -1.4 |
| **2007** | -0.9 | -0.4 | 0.5 |
| **2008** | -2.1 | -1.4 | 0.7 |
| **2009** | -0.4 | -1.3 | -0.9 |
| **2010** | -0.6 | -0.2 | 0.4 |
| **2011** | -0.8 | -1.2 | -0.4 |
| **2012** | 0.4 | 0.1 | -0.3 |
| **Average** | -0.6 | -0.6 | -0.01 |

- On average between-firm effects depressed labor productivity by only 0.01% over 2005-12
    - Allocational deterioration in 2009: -0.9%
    - Continued deterioration after 2010 rebound: -0.7 % in 2011-2012
- Generalized increase in default risk matters more

# Surprisingly low liquidations given the size of output loss




- The rate of liquidations has been very low given the size of the output loss compared to previous recessions