Reallocation Effects of Monetary Policy

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Introduction

- There exist sizable and persistent heterogeneity among firms. (e.g. survey by Syverson, 2011)
    - productivity dispersion
    - innovating firms and no-R&D firms
    - heavy-tailed firm size distribution
- Misallocation and reallocation (e.g. Hsieh and Klenow, 2009)
    - Zombie firms and secular stagnation in Japan. (Cabarello, Hoshi and Kashyap, 2008)
- Reallocation and growth (Lentz and Mortensen, 2008)
    - From decomposition of aggregate growth, the selection effect accounts for about 50% of aggregate productivity growth in Denmark.
- Many of previous papers in this strand only consider the real aspect of the economy.

This Study: How about the Nominal Aspect?

- The role of monetary policy in firm reallocation
  - between good and bad firms
  - between small and large firms
  - What kind of monetary policy (e.g. inflation target) improves economic growth and welfare?
- The optimal inflation rate.

To this aim, we combine

- Endogenous growth with firm dynamics (Klette and Kortum, 2004; Lentz and Mortensen, 2005, 2008)
- Nominal rigidity à la menu cost.

Main Results

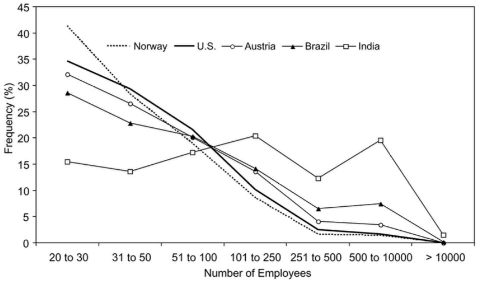
- In Japan, large firms tend to grow faster than small firms under inflation.
- In the model, inflation reallocates resources from inferior to superior firms. If this reallocation effect is sufficiently strong, positive nominal growth improves both real growth and welfare.
- The optimal nominal growth rate can be strictly positive if the reallocation effect is strong.
- Nominal rigidity can improve welfare.

Related Literature

- The optimal inflation rate in New Keynesian models: Goodfriend and King (1997), Khan et al. (2003), Burstein and Hellwig (2008), Schmitt-Grohe and Uribe (2010), Coibion et al (2012), Adam and Weber (2017)
- Endogenous growth with firm dynamics: Klette and Kortum (2004), Lentz and Mortensen (2005, 2008), Murao and Nirei (2011), Acemoglu et al. (2017)
- Nominal factor and real growth: Billbie et al (2014), Chu and Cozzi (2014), Oikawa and Ueda (2015), Chu et al (2017), Arawatari et al (2018)

Cross-country relation b/w inflation and firm distribution

- No direct study about relation b/w inflation and firm distribution.
- But in less developed countries (i.e., higher inflation), big firms account for a larger share. (Bartelsman et al, 2004; Alfaro et al, 2009; Poschke, 2017)



(from Alfaro et al, 2009)

Inflation and Firm Size Distribution in Japan

- Relationship between inflation and firm size distribution using Japanese firm-level data.

- Firm size dispersion in sales and employment,
    - Top-Middle ratio: 90 percentile/50 percentile
    - Top-Bottom ratio: 90 percentile/10 percentile
- Inflation: PPI input (average of the previous two years) by 14 industries in the manufacturing sector.
- Control: D.I. (financing) from *Tankan*, industry-level real sales, industry and year FEs.
- IV: inflation in international commodity price.

Inflation and Reallocation: Sales

	Top/Middle ratio			Top/Bottom ratio		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	2SLS	OLS	OLS	2SLS
$\bar{\pi}^{\text{input}}$	**100.6*****	**102.7*****	**194.6*****	**282.7*****	**289.0*****	**620.5*****
	(20.16)	(20.58)	(27.73)	(63.48)	(64.53)	(87.52)
D.I. gap (T/M or T/B)		-0.0454	0.135		-0.134	0.365
		(0.18)	(0.18)		(0.49)	(0.53)
D.I.		-0.358	-0.547**		-1.220*	-1.876**
		(0.22)	(0.23)		(0.70)	(0.73)
Industry RS		2.168	3.437		-6.377	-5.679
		(5.69)	(6.08)		(17.85)	(19.26)
Constant	4.591	-20.99	-33.84	17.9800	104.8	106.2000
	(5.40)	(72.16)	(77.19)	(17.00)	(226.40)	(244.40)
Year/Industry FE	yes/yes	yes/yes	yes/yes	yes/yes	yes/yes	yes/yes
Obs.	322	316	302	322	316	302
$\bar{R}^2$	0.509	0.507	0.483	0.679	0.679	0.653
Underidentification			164.1			165.4
Weak identification			22.97			23.37

Inflation and Reallocation: Employment

	Top/Middle ratio			Top/Bottom ratio		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	2SLS	OLS	OLS	2SLS
$\bar{\pi}^{\text{input}}$	**3.484*****	**3.343*****	**5.903*****	**11.24*****	**11.80*****	**16.73*****
	(1.027)	(0.992)	(1.309)	(2.734)	(2.674)	(3.497)
D.I. gap (T/M or T/B)		-0.0215***	-0.0116		0.0242	0.0436**
		(0.008)	(0.009)		(0.020)	(0.021)
D.I.		-0.0245**	-0.0279***		-0.0529*	-0.0588**
		(0.011)	(0.011)		(0.029)	(0.029)
Industry RS		1.097***	1.290***		2.735***	3.172***
		(0.273)	(0.284)		(0.737)	(0.764)
Constant	4.510***	-9.090***	-10.95***	11.21***	-23.19**	-28.16***
	(0.275)	(3.455)	(3.608)	(0.732)	(9.337)	(9.661)
Year/Industry FE	yes/yes	yes/yes	yes/yes	yes/yes	yes/yes	yes/yes
Obs.	322	316	302	322	316	302
$\bar{R}^2$	0.7	0.729	0.723	0.776	0.791	0.786
Underidentification			163.7			165.1
Weak identification			22.84			23.27

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Firm Size and Growth under Inflation

- Divide firm size distribution into 10 deciles (size groups: 1,2,...,10) and take the average growth rates of real sales and employment within size groups.

- Check the cross effect: inflation $\times$ size group index

	Sales growth			Employment growth		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	2SLS	OLS	OLS	2SLS
$\bar{\pi}^{\text{input}}$	-0.592***	-0.628***	-0.623***	-0.0464**	-0.0611***	-0.0408
	(0.0792)	(0.0797)	(0.1500)	(0.0191)	(0.0187)	(0.0354)
Size group	-0.00687***	-0.00838***	-0.00837***	-0.00245***	-0.00301***	-0.00296***
	(0.0007)	(0.0008)	(0.0009)	(0.0002)	(0.0002)	(0.0002)
$\bar{\pi}^{\text{input}}\times$ Size group	**0.0524******	**0.0570******	**0.0564******	**0.0148******	**0.0170******	**0.0145******
	(0.0118)	(0.0118)	(0.0195)	(0.0028)	(0.0028)	(0.0046)
Average D.I.		0.00156***	0.00155***		0.000528***	0.000516***
		(0.0004)	(0.0004)		(0.0001)	(0.0001)
Industry RS		(0.0024)	(0.0024)		-0.00766**	-0.00768**
		(0.0144)	(0.0143)		(0.0034)	(0.0034)
Constant	0.0881***	0.133	0.133	0.0211***	0.123***	0.123***
	(0.0125)	(0.1830)	(0.1810)	(0.0030)	(0.0429)	(0.0426)
Year/Industry FE	yes/yes	yes/yes	yes/yes	yes/yes	yes/yes	yes/yes
Obs.	2940	2880	2880	2940	2880	2880
$\bar{R}^2$	0.179	0.181	0.181	0.27	0.289	0.289
Underidentification			798.2			796.9
Weak identification			83.43			83.25

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Model Ingredients

- Endogenous growth with firm heterogeneity (Lentz and Mortensen, 2005, 2008)
  - Multi-product firms
  - Creative destruction. Innovation ability (size of quality update) is ex ante heterogeneous.

- Menu cost (Oikawa and Ueda, 2015ab)
  - Because inflation/deflation reduces real firm values under nominal rigidity, monetary policy affects innovation incentives and real growth.

Model

- Households; Firms with different innovation ability q; Central bank
  - Firms: entrants and incumbents
  - A firm draws q at entry. Once drawn, q does not change.

- Focus on a balanced growth path.
  - n: nominal growth rate. We focus on $n \geq 0$. $\leftarrow$ exogenous
  - g: real growth rate $\leftarrow$ endogenous
  - δ: creative destruction rate $\leftarrow$ endogenous

Note:

- n is equivalent to the quality-unadjusted inflation rate;
- $\pi = n - g$ is the quality-adjusted inflation rate.

Household

- Household consumes version $a \in \{0, 1, ..., A_t(j)\}$ of final goods $j \in [0, 1]$ whose qualities are $Q(j, a)$. The welfare of the representative household is

$$U_t = \int_t^{\infty} e^{-\rho(t'-t)} \log C_{t'} dt',$$

$$\log C_t = \int_0^1 \log \left[\sum_{a=0}^{A_t(j)} Q(j, a) x_t(j, a) \right] dj,$$

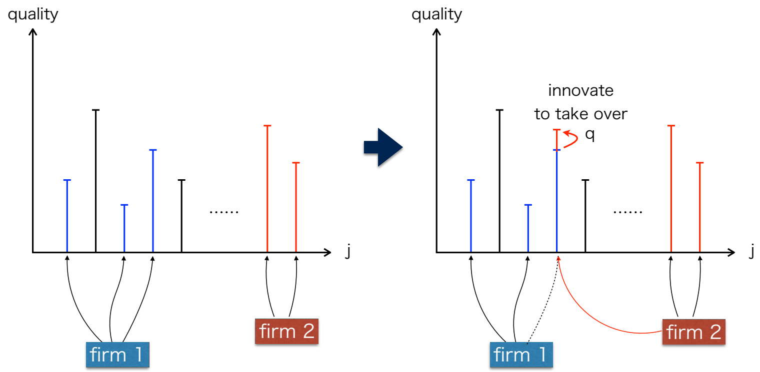
- Quality evolves as

$$Q(j, a) = \prod_{a'=0}^{a} q(j, a'), \qquad q(j, a') > 1 \quad \forall j, a'$$

- Inelastic labor supply.

Incumbent Firms and Creative Destruction

Incumbents produce multiple products for which they compete through innovation (quality updates).



Incumbents' Decision

1. Pricing under menu cost
   - Find the optimal Ss rule to maximize the value of a product line.
2. R&D investment
   - To maximize firm value (bundle of product lines).

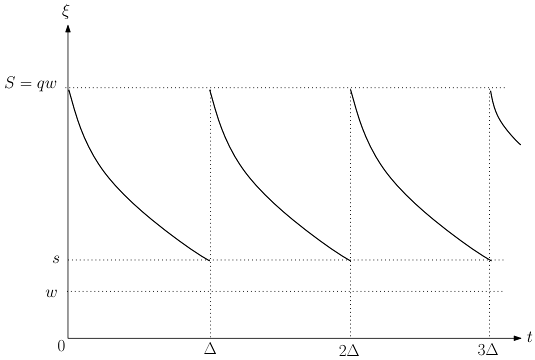
Ss-pricing and Product Line Value

- Fix $q > 1$.
- Linear one-to-one production from labor. Bertrand competition in each product line.
- Posted price: p_t. Relative price: $\xi_t \equiv p_t e^{-nt}$.
- Menu cost: $\kappa E_t / P_t$, where $\kappa > 0$. Entrants must pay at entry.
- We write $E_0 \equiv E$, $P_0 \equiv P$, $W_0 \equiv W$.

(E_t: nominal expenditure; P_t: general price; W_t:nominal wage)

Then,

- The optimal pricing follows an Ss-rule.
- The upper bound of ξ is the limit price, qW.



- Higher nominal growth → relative price is going down more rapidly → higher frerquency of price reset → lower product line value.

The damage from $n \uparrow$ is relatively small for high-q firms

- Let $\nu_\tau(q|\delta, n)$ be the value of product line with elapsed time of τ from the previous price reset.

Proposition

If $\nu_0 > 0$, $\nu_0(q|\delta, n)$ is increasing in q and decreasing in n. Moreover,

$$\frac{\partial^2 \nu_0(q|\delta, n)}{\partial q \partial n} > 0.$$

- The loss caused by faster nominal growth (high inflation) is relatively small for more creative firms (high q).
- The cross impact occurs because the cost of price reset is independent of q while the return of price reset is increasing in q.

n also affects the threshold of q

Let $\underline{q}(\delta, n)$ is the threshold below which $\nu_0 < 0$.

Proposition

If $\kappa < (\rho + \delta)^{-1}$, then $\underline{q}(\delta, n)$ uniquely exists and is increasing in n.

- Under greater n, less creative firms cannot survive.
- One of the main sources of reallocation effect.

Firm Value and Incumbents' R&D (1/4)

- The probability of success in R&D is $k\gamma$, where k is the number of product lines and γ is R&D intensity.
  - This property is often assumed to have Gibrat's law: The growth rate of firm is independent of firm size.
- Real R&D cost is $kwc(\gamma)$, where $c' > 0$, $c'' > 0$, $c(0) = 0$. $(w \equiv \frac{W}{E})$

Firm Value and Incumbents' R&D (2/4)

Bellman Equation

$$\begin{aligned}
\rho v_k(T_k, q|\delta, w, n) = \max_{\gamma} \sum_{i \notin \Omega} & \left[\Pi^0(\xi_0 e^{-n\tau_i}) + \frac{\partial v_k(T'_k, q|\delta, w, n)}{\partial \tau_i} \right] \\
& + \sum_{i \in \Omega} \left[\Pi^0(\xi_0 e^{-n\tau_i}) - \kappa + \frac{\partial v_k(T'_k, q|\delta, w, n)}{\partial \tau_i} \right] \\
& - kwc(\gamma) + k\gamma \left[v_{k+1}(\{T'_k, 0\}, q|\delta, w, n) - v_k(T'_k, q|\delta, w, n) \right] \\
& + k\delta \left[\frac{1}{k} \sum_{i=1}^{k} v_{k-1}(T'_{k-1,<i>}, q|\delta, w, n) - v_k(T'_k, q|\delta, w, n) \right],
\end{aligned}$$

- $T_k \equiv \{\tau_i\}_{i=1}^k$. $T_{k-1,<i>}$ is the set of elapsed time of the firm when it exits from i-th product market.
- $\Omega \equiv \{i|\tau_i = \Delta(q|\delta, n)\}$, the set of products whose prices are revised. T'_k is $\{\tau'_i\}_{i=1}^k$ and

$$\tau'_i = \begin{cases} \tau_i & \text{for } \tau_i \in [0, \Delta(q|\delta, n)), \\ 0 & \text{for } \tau_i = \Delta(q|\delta, n). \end{cases} \quad (1)$$

Firm Value and Incumbents' R&D (3/4)

The Maximized Firm Value

- Firm value:

$$v_k(T_k, q|\delta, w, n) = \sum_{i=1}^{k} \nu_{\tau_i}(q|\delta, n) + k \underbrace{\psi(q|\delta, w, n)}_{\text{future R\&D return}}$$

- FOC about R&D intensity (γ):

$$\nu_0(q|\delta, n) + \psi(q|\delta, w, n) = wc'(\gamma).$$

Firm Value and Incumbents' R&D (4/4)

Heterogeneous impact of $n \uparrow$ on R&D

Proposition

Fix $n \geq 0$ and $\delta > 0$. $\gamma(q|\delta, w, n)$ uniquely exists for sufficiently large w. Being well-defined, $\gamma(q|\delta, w, n)$ is increasing in q and decreasing in n, δ, and w. Moreover, for $n \neq 0$,

$$\frac{\partial^2 \gamma(q|\delta, w, n)}{\partial q \partial n} > 0 \quad \text{and} \quad \frac{\partial^2 \gamma(q|\delta, w, n)}{\partial q \partial w} < 0.$$

The decline in R&D intensity under higher n is relatively small for firms with greater q.

Impact of $n\uparrow$ on Distribution

Let $K(q|\delta, w, n)$ be the the measure of product lines produced by type-q firms.

- $\underline{q}(\delta, n)\uparrow$. Low R&D quality firms exit.
- R&D intensity is less sensitive for firms with greater q.
  $\Rightarrow$ The product line share of firms with higher q increases.
- The average quality improvement by each innovation is higher under greater n.

Firm Entry

- A measure h of potential entrants do R&D without knowing its q. Their types are drawn from density $\bar{\phi}(q)$ on $(1, \infty)$.
- If an entrant draws $q < \underline{q}(\delta, n)$, it gives up entry.
- **Free entry condition** (FE):

$$\int_{\underline{q}(\delta,n)}^{\infty} \bar{\phi}(q) v_1(\{0\}, q|\delta, w, n) dq = wc'\left(\gamma_\eta(\delta, w, n)\right),$$

where $\gamma_\eta(\delta, w, n)$ is entrants' R&D intensity to have the ex-post entry rate of η.

Labor Market

- Relative price distribution for a product line with q: $f(\xi(\tau))$
- Labor demand from the production sector is

$$L_X = \int_{\underline{q}(\delta,n)}^{\infty} K(q|\delta, w, n) \left[\int_0^{\Delta(q|\delta,n)} f(\xi(\tau)) \frac{1}{\xi(\tau)} d\tau \right] dq$$

- Labor demands from the R&D sector:

$$L_R = hc\left(\gamma_\eta(n)\right) + \int_{\underline{q}(\delta,n)}^{\infty} K(q|\delta, w, n) c(\gamma(q|\delta, w, n)) dq$$

- **The labor market clearing condition** (LMC):

$$L = L_X + L_R$$

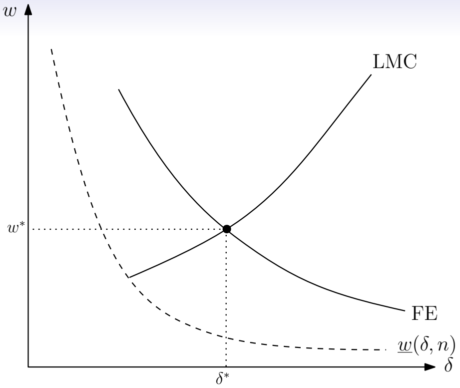
Stationary Equilibrium

Equilibrium conditions:

1. FE
2. LMC

Proposition

For given $n \geq 0$, there exists a stationary equilibrium with a positive entry rate.



- $\delta \uparrow \Rightarrow \eta \uparrow$ and $v_1 \downarrow$. To satisfy FE, $w \downarrow$ should compensate the decline of innovation reward.
- $\delta \uparrow \Rightarrow L_{R,entrant} \uparrow$, $L_{R,incumbent} \downarrow$, and $L_X \uparrow\downarrow$ (?). The total impact is ambiguous but LMC is basically upward-sloping under typical distributions.

Impacts of $n \uparrow$ on Real Growth

- Real growth effect:
  - $n \uparrow \Rightarrow$ Average quality update $\uparrow$.
  - $n \uparrow \Rightarrow \delta \downarrow$ ($\because$ R&D reward $\downarrow$)
  - The overall impact on real growth,

$$\delta \times \int_{\underline{q}(n,\delta)}^{\infty} K(q|\delta, w, n) \log q \, dq$$

    is ambiguous.

- Note: If $\kappa = 0$, the model conforms to Lentz-Mortensen. Firm distribution, real growth, and welfare are independent of n.

Impacts of $n \uparrow$ on Welfare

$$U = \frac{\log C}{\rho} + \frac{g}{\rho^2}$$

$$C \propto \frac{1 - \text{menu costs}}{P}$$

- Consumption
  - Menu cost $\uparrow$ $(-)$
  - Markup $\uparrow\downarrow$ $(\pm?)$
- Real growth $\uparrow\downarrow$ $(\pm?)$
  - Spillover effect
  - Business-stealing effect: Innovators ignore what the previous producers lose. This negative externality is decreasing in q.
- The overall impact on welfare is ambiguous.

Optimal Inflation Rate

- Standard New Keynesian: $n = 0$ is the best.
- Oikawa and Ueda (2015a), w/o firm heterogeneity: $n > 0$ could be optimal if R&D is overinvested.
  - Chu and Cozzi (2014): the same mechanism to get out of the Friedman rule.

- With firm heterogeneity and reallocation, $n > 0$ improves welfare if the reallocation effect is sufficiently strong (even when R&D is underinvested).

Introduction

Motivating Facts

Model

Impacts of MP

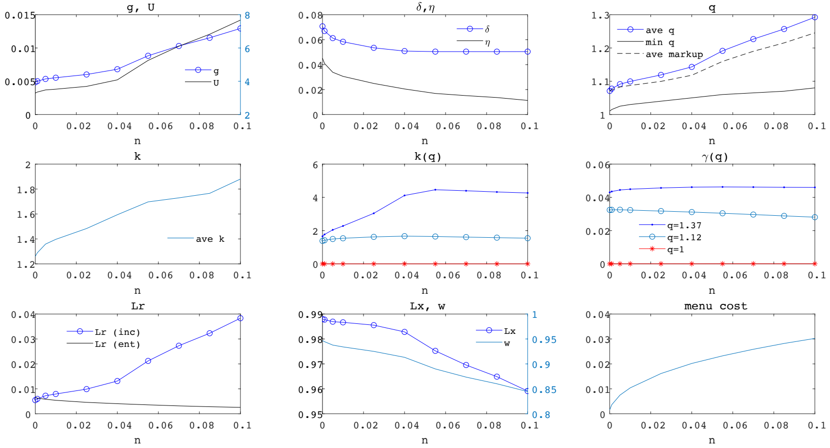
Simulation

Simulation: Parameter Setting

Denmark Economy

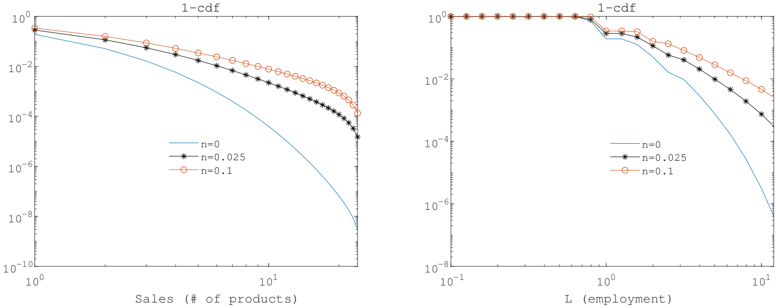
- Menu cost: $\kappa = 0.022$ (Midrigan, 2011)
- We assume $\bar{\phi}(q) = \zeta q^{-\zeta-1}$ is Pareto.
  - Set $\zeta = 17.5$ to have the same variance as in the estimated distribution (a discrete distribution with three q's) in Lentz and Mortensen (2008).
- Other parameters are set to be consistent with Lentz and Mortensen (2008) when $n = 0$.
  - $L = 1$.
  - R&D cost: $c_0 = 1.02 \cdot 10^5$, $c_1 = 3.728$ where $c(\gamma) = c_0 \gamma^{c_1}$.
  - $\rho = 0.0361$ to attain $g = 0.0139$ when $n = 0$.
  - Potential entrants: $h = 1.1667$.

Impact of Nominal Growth



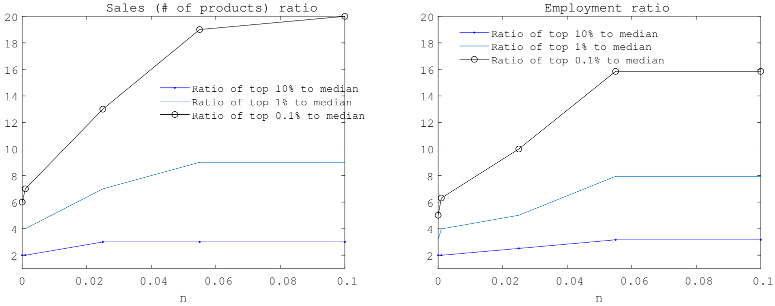
Firm size distribution and nominal growth in the model

Tail distributions of sales and employment. n is the nominal growth rate.



Firm size distribution and nominal growth in the model

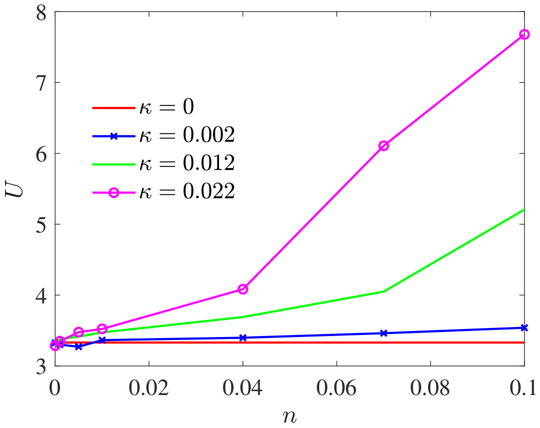
Sales and Employment dispersion



Various Menu Cost Parameters

Changes in welfare under various κ.

$\kappa = 0$ means no nominal rigidity.



It reminds me a phrase in Keynes (1936)...

It is sometimes said that it would be illogical for labour to resist a reduction of money-wages but not to resist a reduction of real wages. For reasons given below, this might not be so illogical as it appears at first; and, as we shall see later, **fortunately so***.*

General Theory (Ch.2)

—We might be fortunate to have nominal rigidity.

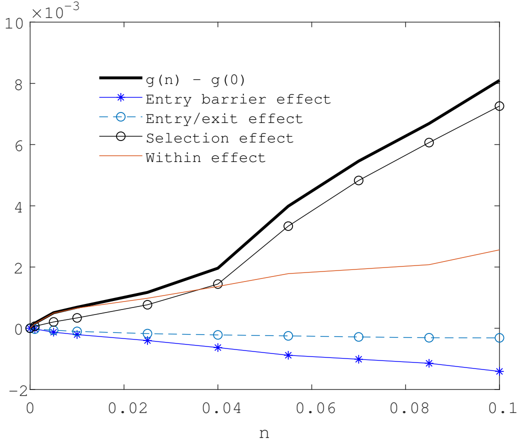
Growth Decomposition

The impact of n on real growth can be decomposed into four components:

- Entry barrier effect ($n \uparrow \Rightarrow \underline{q} \uparrow$)
- Entry/exit effect ($n \uparrow \Rightarrow$ entrants' contribution $\downarrow$)
- Selection effect ($n \uparrow \Rightarrow$ product line share of high type $\uparrow$)
- Within effect ($n \uparrow \Rightarrow$ average growth without selection $\uparrow$)

$$
\begin{aligned}
g(n) - g(0) = & -\delta(0) \int_{\underline{q}(0)}^{\underline{q}(n)} K(q|0) \log q \, dq \\
& + \int_{\underline{q}(n)}^{\infty} \{\eta(n)\phi(q|n) - \eta(0)\phi(q|0)\} \log q \, dq \\
& + \int_{\underline{q}(n)}^{\infty} \{[K(q|n) - \phi(q|n)]\,\gamma(q|n) - [K(q|0) - \phi(q|0)]\,\gamma(q|0)\} \log q \, dq \\
& + \int_{\underline{q}(n)}^{\infty} \{\phi(q|n)\gamma(q|n) - \phi(q|0)\gamma(q|0)\} \log q \, dq
\end{aligned}
$$

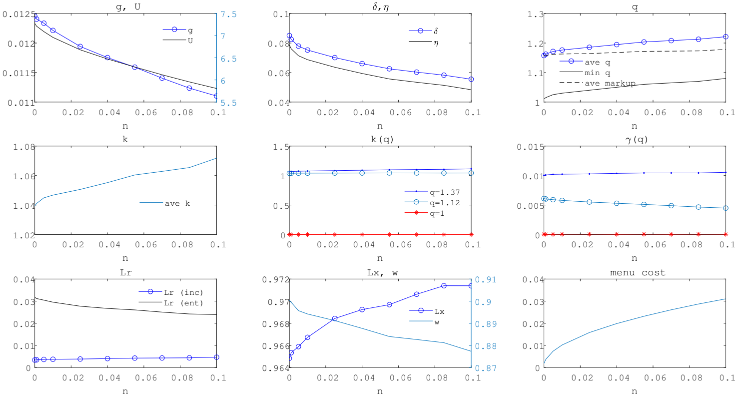
Growth Decomposition



In the Danish economy, the selection effect is dominant especially under higher inflation.

Reallocation effects in Japanese Economy

- Murao and Nirei (2011) apply an extended model of Lentz and Mortensen (2008) to Japanese economy. We use their results to calibrate our model to Japanese economy.
- Parameters:
  - $\rho = 0.0385$;
  - $c_1 = 1.923$; $h = 11.682$
  - Pareto coefficient of $\bar{\phi}$: 4.821.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Concluding Reamrks

- Larger firms tend to grow faster than small firms under inflation in Japan.
- We developed a model to analyze long-run effect of monetary policy (like trend inflation) in an endogenous growth model with nominal rigidity, firm heterogeneity, and reallocation.
- Positive nominal growth improves real economic growth and welfare if the reallocation effect is sufficiently large. Thus, the optimal inflation rate can be strictly positive.
- Inflation may improve welfare with nominal rigidity because it hinders R&D by firms whose quality updates are small.