Introduction

Introduction

- Development gap h and A
- Getting under the hood of the Aggregate production function
- Key issues: reallocation and transmission of knowledge.
- Two sides of the same coin?

Introduction

Reallocation

- Quantititatively important
- Contributes to productivity and diffusion of new ideas
- Recent contributions: barriers to reallocation very costly
- Results are very sensitive to assumptions about returns to scale or demand elasticity

Introduction

Returns to scale and knowledge transmission

- Fixed factors.vs. replication
- What is fixed or not may depend on incentives for knowledge transmission
- Develop a deeper theory of replication/knowledge transmission

Roadmap

Roadmap

1. Background: example on reallocation and returns to scale
2. Existing theories of heterogeneity and reallocation
3. Theory of learning and replication of knowledge
4. Policy experiment - sensitive to incentives for knowledge accumulation
5. Links to reallocation data
6. Further developments of the theory

Background

Example

Example: gains to reallocation and returns to scale

- firm i has technology $q_i = z_i n_i^\alpha$
- $z_1 = 1,\ z_2 = z > 1$

  Total labor endowment = 2
- Initial situation: $n_1 = n_2 = 1,\ q = (1+z)$

  after reallocation marginal products equalized.
- Upper bound for gains: $\alpha = 1$

  $n_1 = 0, n_2 = 2$ and $q = 2z$.
- $\alpha < 1,$ then smaller gains.

Example: productivity gains

	$z = 1.5$	$z = 2$	$z = 4$
$\alpha = 0.5$	2%	5%	17%
$\alpha = 0.8$	7%	17%	39%
$\alpha = 1$	20%	33%	60%

- Gains depend on returns to scale and speed of reallocation.
- Maximum with CRS (case $\alpha = 1$)
- Models explicitly or implicitly make assumptions about this.

Theories of heterogeneity and reallocation

Theories of heterogeneity and reallocation

- Lucas span of control: $q = zg(f(k,n))$
- z is managerial talent, a fixed non-reproducible asset.
- Equilibrium maximizes aggregate productivity
- Size distribution of firms ⇔ talent distribution

Firm dynamics, entry and exit

- Hopenhayn and Rogerson: extend to entry/exit and firm dynamics
- Decreasing returns at firm level (CRS in the aggregate)
- perfect competition (infinitely elastic demand at firm level)
- Significant gains from reallocation.

The world production function and reallocation

- Eaton/Kortum:/Melitz: exogenous draws for marginal cost:
  - constant marginal cost at product level (CRS)
  - constant elasticity demand.
- Trade liberalization: reallocation of world production.
- Potentially very large gains.

General observations: learning, replication and returns to scale

Learning, replication and returns to scale

- Constant returns to scale implicitly assumes costless replication: immediate transmission.
- If CRS, most efficient should be only supplier
- Opposite extreme: no replication possible. Difference in productivity ⇔ fixed non reproducible factors.
- *What is the fixed factor*? If knowledge, embedded in HK / possible to teach.

Evidence on replication

Evidence on replication across locations

- Globalization
- FDI: over the last two decades:
  - exports have doubled
  - sales of affiliates increased more than seven times (Ramondo)
- Role of large chains in retail (Jarmin, Klimek and Miranda)

	single location firms	large retail firms (>100)
1948	70.%	12%
1967	60%	19%
1997	39%	37%

Explicit models of replication/learning

1. Non-rivalrous transmission

- Chari-Hopenhayn: Learning by working with skilled workers
- Franco and Filson: Theory of spinoffs
- Ramondo: FDI – immediate transmission with a cost that depends on distance/ no competing alternatives

2. Rivalrous transmission

A model of learning and diffusion

A model of learning and diffusion

- Solow (vintage model) meets Lucas (adjustment cost)
- Basic component: knowledge capital pair (z, k) : z is knowledge embodied in this k
- production technology $zf(k, n)$, CRS
- $f(k, n) = \min(k, n)$

Technology for replication

- $\dot{k}(z)$ has cost $C\left(\frac{\dot{k}}{k}\right)zk$, depreciation δk.
- $C(\bullet)$ increasing, convex.
- CRS in $k, \dot{k}$
- More costly to replicate better knowledge

Optimal replication

Optimal Accumulation

- $v(z, t)$ value of one unit of $k(z)$ at time t
- Bellman equation:

$$(r + \delta)v(z, t) = z - w(t) + \left(\max_{\dot{k}} v(z, t)\dot{k} - C\left(\dot{k}\right)z\right) + v_2(z, t)$$

- Optimal replication:
- $v(z, t) = C'\left(\dot{k}\right)z$
- $\dot{k}(z)/k(z)$ increasing in z

Equilibrium

Equilibrium with no new arrivals of z

- Fixed labor endowment N
- Initial distribution $k(z)$ with highest $\bar{z}$
- Converge to steady state: $k(\bar{z}) = N$
- Complete reallocation: all resources flow to most productive

Equilibrium with new arrivals

- Constant flow m of units of new knowledge $z\gamma(t)$
- $0 \leq z \leq 1 \sim F(dz)$
- $\gamma(t)$ grows at constant rate g.
- Heteterogeneity in productivity within a cohort
- Coexistence of several cohorts

Balanced growth path

Balanced growth path

- $w(t) = w_0\gamma(t)$
- knowlege capital z is discontinued when $w(t) > z$
  Figure
- $\dot{k}/k$ declines overtime with growth of $w(t)$

Life cycle of new innovation

- Innovator starts with k_0 units of knowledge capital $z_0 \in [0,1], \gamma(t) = 1$
- Active only if $z_0 > w(t)$.
- Replicates at declining rate
- Shut down after s periods when $z_0 = e^{gs}w(t)$

Stationary distribution of knowledge capital

Stationary distribution of knowledge capital

- Normalize $\gamma(t) = 1$
- Steady state – stationary distribution $k(z)$
- entry,exit, growth and decline of $z's$

Policy experiment

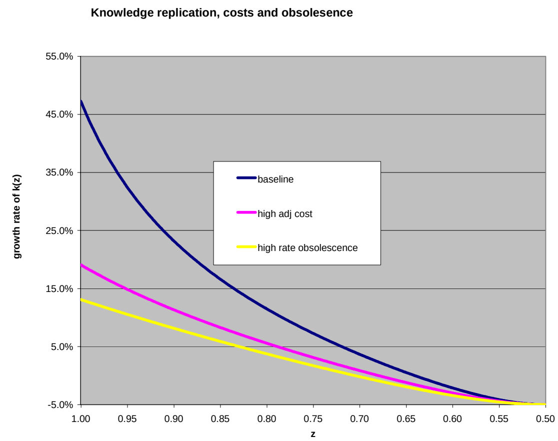
Policy experiment

- Tax on investment $tC\left(\dot{k}(z)\right)z$
- Tax decreases investment and reallocation from less to more productive
- Impact: depends on importance of reallocation
- 3 scenarios: baseline, high adjustment cost, high g

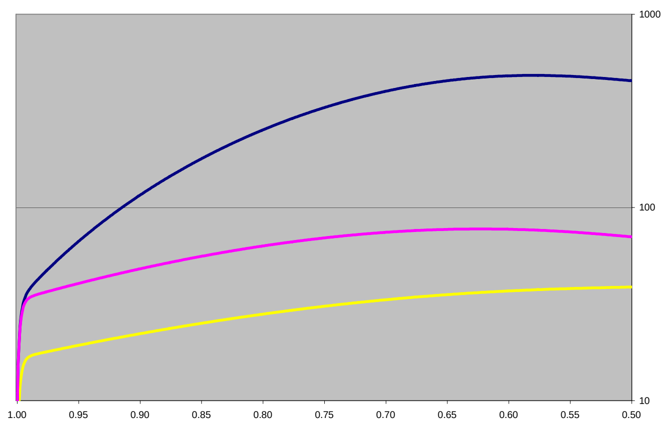
Scenarios

Scenarios

- Baseline, high adjustment cost, high g



Path of Capital Accumulation from $z = 1$



Reallocation

Reallocation

- Reallocation to growing $z's$ in unit time period as % of total capital/employment
- Reallocation to growing $z's$

baseline	high g	high c
3.4%	0.9%	1.5%

- Effect of taxing investment should be lower in the last two cases

Endogenous wage

Endogenous wage

- Direct effects and equilibrium effects (lowering $w_0 = w(t)/\gamma(t)$)
- Technology for entry: flow input $n_0 \rightarrow$ rate of arrival m of a unit k of type $z\gamma(t)$, $z \sim F$
- Free entry condition: cost of innovation = expected value.
- Unique equilibrium value w_0.
- Duration of a new entry and replication decreases with w_0.
- Standard comparative statics

Impact of tax

- Higher taxes reduce the incentive to invest.
- But also lowers equilibrium wage
- Lower exit threshold, so less turnover
- Lower average productivity

Impact of tax

	Base case		high adj. cost		high g	
	w_0	prod	w_0	prod	w_0	prod
$t = 0$	100	100	93.7	93.7	83.9	80.7
$t = 0.5$	–6.5%	–2.1%	–3.5%	–0.9%	–3.9%	–0.8%
$t = 1.0$	–9.8%	–4.1%	–6.1%	–2%	–6.4%	–1.7%

Connection to returns to scale

- Welfare effect: depends on aggregate supply elasticity to tax on $\dot{k}$
- Supply=$N\ (Q/N)$, and N fixed
- Effect of tax on average productivity depends on how elastic is investment/replicaton to this tax
- High cost of adjustment or obsolescence behaves as an economy with low returns to scale (low α).

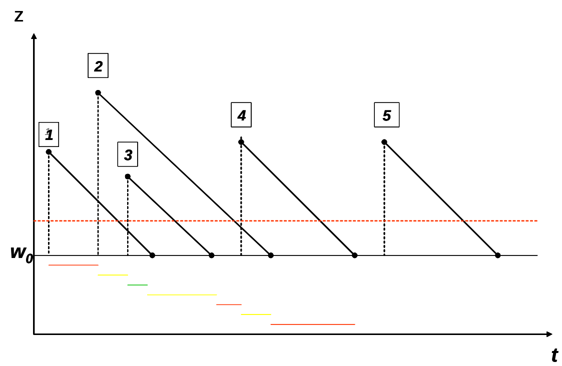
Firms and Knowledge Capital

Firms and Knowledge Capital

- Above considers only allocations. Data is based on firms/plants.

- Firms as portfolios of knowledge capital. (Klette/Kortum: collections of products)
- State of the firm $(z_1, k_1, z_2, k_2 \ldots, z_n, k_n)$, new draws arrival rate m.
- Firm grows or contracts. When number of $z's$ in operation goes to zero, consider an exit. Substituted by a draw for an outsider.
- Simple aggregation procedure - no change in behavior.

Firm's life-cycle



Firm dynamics - properties

- Gibrat's law
- Growth declines with age
- *Survival:* Firms running more vintages are less likely to exit - also tend to be larger:
- Exiting firms 45% size of incumbents (US 35%)
- Rate of entry/exit: 5% (determined by w0) - slightly less than US (7%)
- Total creation (and destruction) rates: 7% (US = 10%)
- Share of entry/exit: 30% (US=20%)
- Productivity decomposition (Bailey, Bartelsman & Haltiwanger): very similar to US data
- Counterfactual: age and exit rates.

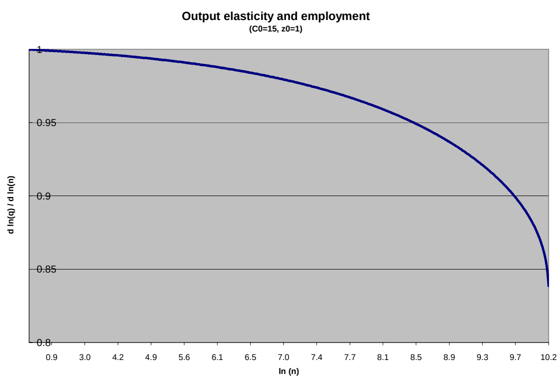
Productivity decomposition

- Bailey, Bartelsman & Haltiwanger

Productivity decomposition	model	data
within establishments term	47.2	48
between establishments term	7.5	-8
interaction term	26.7	34
net entry	15.5	26

Costly adjustable knowledge and curvature

- Reduced form decreasing returns technology?
- Suppose a firm has $k(z)$ knowledge capital for different $z's$.
- Desired expansion of capital (and employment) $\dot{k}$.
- Suppose limit exogenously firm's expansion to $\dot{k}_{\max} \in [0, \dot{k}]$.
- Look at $d \ln q / d \ln n$ for values of $\dot{k}_{\max}/\dot{k}$



Extensions: Economic Geography

- Knowledge can be replicated at different locations (e.g. retail chains)
- Evidence suggests distance matters: gravity equation
  - Ramondo: countries twice as far → 45% higher cost to FDI
  - Evidence from Walmart's sequential location
  - Diversity of sizes of retail chains

Replication through locations

- Locations $l = 1, \ldots, L$
- For $i, j \in L$, $c_{ij}z$ is cost of creating k_0 units of capital at j if have one unit of capital at i.
- $\max(0, v_j(z) - c_{ij}z)$ gives $L_i(z)$ locations to which choose to replicate from i
- Conjectured properties: transfers will occur for high $z's$ and low $c'_{ij}s$
- Model generates *chains of knowledge capital*

Origin and destination of knowledge capital

- Assume cost of adjustment are lower in more dense areas
- Implies that -all things equal- w_0 higher in more dense areas and more entry

- So distribution of active $z's$ will be better
- Larger chances of originating knowledge capital

Final Remarks

- The study of diffusion through replication of knowledge important area.
- Important to understand the gains from reallocation and overall productivity.
- Reduced-form returns to scale have implicit assumptions about replication.
- Incentives to replicate may vary signficantly across economies, time and space
- Need for deeper models to understand overall process and incentives for knowledge transmission across time and space.