Private and Public Intangible Investment Spillovers, Imperfect Competition, Returns to Scale and Product and Process Innovation

Carol Corrado, (TCB, New York and Georgetown University, Washington)
Jonathan Haskel, (Imperial College, CEPR and IZA, London)
Cecilia Jona-Lasinio, (LUISS Lab and ISTAT, Rome)
Ana Rincon-Aznar (NIESR, London)

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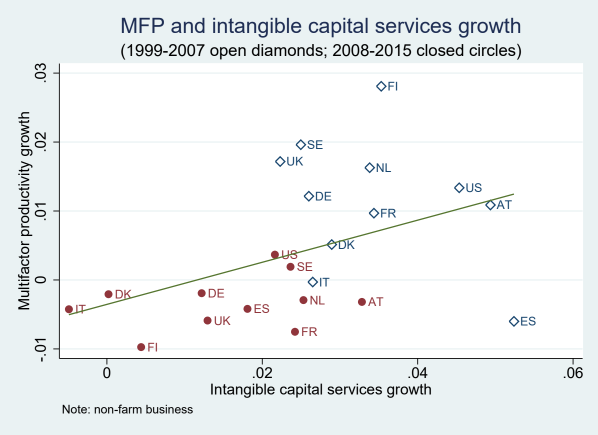
Overview

- Much work suggests productivity slowdown is TFP slowdown. What might cause that?
  - Mismeasurement?
  - If intangibles have spillovers then intang slowdown means slowdown in TFP?
- Need framework for intangibles and spillovers
- So far: put intangibles as additional arguments in a production function and consider extra outputs and inputs
  - Makes sense for intangibles like business process innovation or process R&D
  - But what about branding/marketing? Or R&D product innovation?
- Purpose of paper
  - New framework for process and product innovation
  - New data
  - Econometric issues in estimating spillovers: imperfect competition, returns to scale, division bias
  - Estimates

Intangibles and spillovers?



If ΔlnR has slowed down, less spillovers means $\Delta lnTFP$ slows down?

Upstream N^S and N^D sectors, producing process and product new intangibles

$$N_S = F^{N_S}(L^{N_S}, K^{N_S}, R_A^{N_S}) \quad (1)$$

$$dn_S = \varepsilon_L^{N_S} dl^{N_S} + \varepsilon_K^{N_S} dk^{N_S} + \varepsilon_R^{N_S} dr_A^{N_S}$$

and

$$N_D = F^{N_D}(L^{N_D}, K^{N_D}, R_A^{N_D}) \quad (2)$$

$$dn_D = \varepsilon_L^{N_D} dl^{N_D} + \varepsilon_K^{N_D} dk^{N_D} + \varepsilon_R^{N_D} dr_A^{N_D}$$

where elasticity of output is ε and lower case letters are logs and "d" is a time derivative.

Downstream C sector, renting process intangibles in production

$$C = F^C(L^C, K^C, R_S^C, R_A^C) \quad (3)$$

$$dc = \varepsilon_L^C dl^C + \varepsilon_K^C dk^C + \varepsilon_{R_S}^C dr_S^C + \varepsilon_{R_A}^C dr_A^C$$

Capital stocks and investment flows

$$R_t^a = N_t^a + (1 - \delta^{Ra})R_{t-1}^a, \quad a \epsilon S, D \quad \text{and} \quad K_t = I_t + (1 - \delta^K)K_{t-1}, \quad \mathbf{(4)}$$

Rental and asset prices

$$P_t^{Ra} = P_t^{Na}(r_t - \pi_t^{Ra} + \delta^{Ra}) \quad a \epsilon S, D \quad P_t^K = P_t^I(r_t - \pi_t^K + \delta^K) \quad \mathbf{(5)}$$

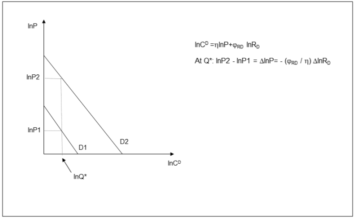
Demand and product innovation

- Quality-adjusted output C^e is "more" output.
- Let C^e trade at price P^{Ce}. Define units: $P^C C \equiv P^{Ce} C^e$, $\implies$ $C^e \equiv C(P^C / P^{Ce}) \equiv C\Theta$ $\implies$

$$dc^e = dc + d\theta \tag{6}$$

- What is Θ? $=$ endog quality price premium
- Arrow/Nerlove. Demand curve $C^D = C(P^C, R_D)$, where R_D is (intangible) stock of reputation/goodwill
- Firms sell $Q*$ of branded perfume/superior light bulb at P2>P1 for unbranded/standard bulb by spending on R_D to shift C^D.
- Log differentiation of demand $dc^D = -\eta dp + \phi_{R_D} dr_D$ ($\eta =$ elasticity of demand, $\phi =$ elasticity of output with respect to R_D. So Θ sustained by product investment R_D

$$d\theta = \frac{\phi_{R_D}}{\eta} dr^D. \tag{7}$$



Suppose output only partially quality-adjusted.
Quality-adjustment implicit and explicit

$$dc_m = dc + \nu d\theta \tag{8}$$

Demand and supply in the downstream sector. Using (1), (2), (3), (6), (7) and (8) gives

$$dc_m = \varepsilon_L^C dl^C + \varepsilon_K^C dk^C + \varepsilon_{R_S}^C dr_S^C + \nu \frac{\phi_{R_D}}{\eta} dr_D + \varepsilon_{R_A}^C dr_A^C \tag{9}$$

- Process inputs: weighted by output elasticity
- Product term: weighted by output elasticity divided by demand elasticity.
- Final term is the output effects of knowledge spillovers: free knowledge times their output elasticity.

Usually we write (9) in terms of shares...so what's the relation?

Endogenise these elasticities: firm optimisation

- First-order conditions for L, K and R_S (arguments in prod functions)

$$\varepsilon_X^C = \left(\frac{1}{1-\frac{1}{\eta}}\right)\sigma_X^C = \mu\sigma_X^C,\ X = L, K, R_S \tag{10}$$

where σ_X^C are competitive labour and capital rental payments as a share of revenue in the C sector and μ is the mark-up of price over marginal costs (μ =1/ (1-1/η).

- Arrow-Nerlove condition for R^D (demand function)

$$\phi_{R_D} = \eta\sigma_{R_D}^C = \frac{\mu}{\mu-1}\sigma_{R_D}^C \tag{11}$$

Model of downstream sector only

- Downstream equation:

$$.dc_m = \mu\sigma_L^C dl^C + \mu\sigma_K^C dk^C + \underbrace{\mu\sigma_{R_S}^C dr_S^C}_{\text{process innov}} + \nu \underbrace{\sigma_{R_D}^C dr_{R_D}^C}_{\text{product innov}} + \underbrace{\varepsilon_{R_A}^C dr_{R_A}^C}_{\text{spillovers}} \quad (12)$$

Ex ante approach: if we can measure σ we can calculate/estimate (12).

In practice we don't have raw data on capital payments. Assume

- nominal value added, $P_Q Q$ observed (correctly capitalise all investment spending)
- *Measured* labour shares are right

$$\sigma_L^C = s_L^C \tag{13}$$

- Measured factor shares add to unity (Jorgenson/Grilliches)

$$s_L^C + s_K^C + s_{R_S}^C + s_{R_D}^C = 1 \tag{14}$$

- True incomes in the economy include imperfect competition

$$\sigma_L^C + \sigma_K^C + \sigma_{R_S}^C + \sigma_{R_D}^C + \sigma_\pi^C = 1 \tag{15}$$

  where σ_π is the share of abnormal profits in the sector.

- Economies of scale (note: no term in $\varepsilon_{R_D}^C$)

$$\varepsilon_L^C + \varepsilon_K^C + \varepsilon_{R_S}^C = \psi \tag{16}$$

- Measured capital shares are residuals $= 1 - s_L$. Combining gives

$$1 - s_L^C = \sigma_K^C + \sigma_{R_S}^C + \left(1 - \frac{\psi}{\mu}\right) \tag{17}$$

Downstream, ex post shares

- Substituting in elasticities gives

$$\boxed{\begin{aligned} dq^C &= \mu\left(s_L^C dl^C - (1 - s_L^C)dk^{+,C}\right) + (\psi - \mu)dk^{+,C} \\ &+ \nu\sigma^C_{R_D} dr^C_{R_D} + \varepsilon^C_{R_A} dr^C_{R_A} \end{aligned}} \tag{18}$$

(where dk^+ is dk and dr_S weighted by the rental shares of total payments to K and R_S).

- *Ex post* Q grows with spillovers and
- first two terms because if $\mu > 1$, output elasticities differ from factor shares, and if $\psi \neq 1$ then dc is affected by capital
- Product innovation.
  - no quality adjustment, $\nu = 0$ so firms spending to boost quality, but the statistics office is missing the extra output (in terms of TFP, measured TFP is too small)
  - full quality adjustment, $\nu = 1$: in which case measured Q reflects product innovation spend
- Sector aggregation gives similar result, see paper

Data are by industry, country, institutional sector, year

	Industry (NACE, Revision 2)	Sector		
		All	**Market**	**Nonmarket**
A	*Agriculture, forestry and fishing*	*X*	*X*	*X*
B	Mining and quarrying	y	y	n
C	Manufacturing	y	y	n
D	Electricity, gas, steam and air conditioning supply	y	y	n
E	Water supply; sewerage, waste management and remediation activities	y	y	n
F	Construction	y	y	n
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	y	y	n
H	Transportation and storage	y	y	n
I	Accommodation and food service activities	y	y	n
J	Information and communication	y	y	n
K	Financial and insurance activities	y	y	n
L	*Real estate activities*	*X*	*X*	*X*
M	Professional, scientific and technical activities	y	y	n
N	Administrative and support service activities	y	y	n
O	Public administration and defence; compulsory social security	y	n	y
P	Education	y	n	y
Q	Human health and social work activities	y	n	y
R	Arts, entertainment and recreation	y	n	y
S	Other service activities	y	y	n
T	*Activities of households*	*X*	*X*	*X*
U	*Activities of extraterritorial organisations and bodies*	*X*	*X*	*X*

- Years: 1995-2013.
- Countries: United States (US), big Northern European (DE, FR and UK), Scandinavian (FI, SE), Small European (AT, NL) Mediterranean (IT, ES).
- Inputs and outputs: Tornquist-weighted ln growth rates

- Knowledge term

$$\left(\varepsilon_{R_A} dr_{R_A}\right)_i = \gamma_1^{MKT}(\Delta lnR_i^{MKT}) + \gamma_{i,}^{MKT}(\Sigma\omega_{i,j\neq i}^{MKT}\Delta lnR_j^{MKT}) + \gamma_i^{NonMKT}(\omega_i^{NonMKT}\Delta lnR^{NonMKT}) \quad (29)$$

- Zero public sector depreciation

$$\left(\varepsilon_{R_A} dr_{R_A}\right)_{i,c,t} = \gamma_1^{MKT}(\Delta lnR_i^{MKT}) + \gamma^{MKT}\left(\Sigma\omega_{i,j\neq i}^{MKT}\Delta lnR_i^{MKT}\right) + \rho_{i,c,t}\left(\omega_{i,c,t}^{NonMKT}\frac{N_{c,t}^{NonMKT}}{Q_{i,c,t}}\right) \quad (30)$$

  - $\Sigma\omega_{i,j\neq i}^{MKT}$ from I/O tables
  - ω_i^{NonMKT} share of ind R&D, co-operation

Estimating equation

- See paper for discussion of endogeneity, meas error/division bias
- Estimating equation, for long and short differences n and lags s

$$\begin{aligned}
\Delta_n lnQ_{c,i,t} = {} & a_t + a_c + a_i + \gamma_1^{MKT} \Delta_n lnR^{MKT}_{i,c,t-s} \\
& + \gamma \Delta_n lnR^{OUT,MKT}_{i,c,t-s} + \rho \left(\frac{N^{NonMKT}}{Q^{MKT}} \right)_{\Sigma n,i,c,t-s} \\
& + \rho_1 \Delta_N \left(\left(\frac{N^{NonMKT}}{Q^{MKT}} \right)_{\Sigma n,i,c,t-s} \right) \\
& + (\mu - 1) \left(s_L^Q \Delta_n ln(L/K^+) \right)_{c,i,t} + (\psi - 1) \left(\Delta_n lnK^+ \right)_{c,i,t} \\
& + (\nu \zeta_{R_D} - 1) \left(s^Q_{R_D} \Delta_n lnR_D \right)_{c,i,t} + u_{c,i,t}
\end{aligned} \tag{36}$$

- Consistently find that change in N(nonMKT) appears
- In principle should be able to estimate rates of return (γ, ρ), μ, ψ, ν.
- Useful if we think e.g. μ has risen post 2007. Meas error biases suggest μ, ψ, ν biased downwards
- Substantial policy interest in γ, ρ; e.g. does ρ vary by country?

Regressions: Dependent variable $\Delta lnQ_{i,c,t}$

Industries	Mfr	Mfr	Non-mfr	Non-mfr
Year dummies	yes	yes	yes	yes
Country dum	yes	yes	yes	yes
Industry dummies	no	no	no	no
$\Delta lnR^{rd}_{i,c,t-3}$	0.25**	0.25**		0.00
	(2.24)	(2.20)		(0.13)
$\Delta lnR^{rd}_{outside\, i,c,t-3}$	-0.05	-0.06		-0.09*
	(-0.28)	(-0.35)		(-1.88)
$\Delta lnR^{intan}_{xrd}\,{}_{i,c,t}$		-0.01	0.20***	0.21***
		(-0.08)	(5.28)	(5.36)
$\Delta lnR^{intan}_{xrd}\,{}_{outside\, i,c,t}$		-0.04	0.09*	0.09**
		(-0.21)	(1.88)	(2.03)
shRD*(GovRD/PqQ)$_{i,c,t-2}$	-0.44	-0.45	0.30**	0.32***
	(-0.62)	(-0.63)	(2.50)	(2.65)
$\Delta shRD * (GovRD/PqQ)_{i,c,t-2}$	4.15***	4.03***	0.34	0.33
	(3.04)	(2.85)	(0.34)	(0.33)
$s^Q_L \Delta ln(L/K+)_{i,c,t}$	0.75***	0.76***	0.39***	0.40***
	(5.01)	(4.97)	(10.16)	(10.28)
$\Delta ln(K+)_{i,c,t}$	0.64***	0.64***	0.42***	0.42***
	(3.68)	(3.42)	(10.84)	(10.58)
$s^Q_{RD} \Delta lnR^D_{i,c,t}$	0.26	0.27	0.87*	0.87*
	(0.33)	(0.32)	(1.71)	(1.71)

Summary

- Framework for estimating spillovers, taking account of imperfect competition and different roles for intangibles, process and product innovation
- New data
- Findings
  - Suggestion of spillovers/excess returns to intangibles both public and private varying by manufacturing and services
  - Point estimates outside manufacturing suggest negative mark-ups: measurement, DRS, biased?
- Scope for further investigation e.g. by industry, country