Knowledge Spillovers, Absorptive Capacity and Growth

Ioannis Bournakis[⊥],Dimitris Christopoulos [⊥],Sushanta Mallick [⋄]

[⊥]Middlesex University London [⊥]Panteion University,Athens [⋄]Queen Mary University London

7th FIW Research Conference
Vienna Institute for International Economics, Austria
12th December 2014

Outline

- Aims of the Research
- Motivation and References to Existing Studies
- Demonstration of the Analytical Model
- Measurement Issues
- Empirics
- Concluding Remarks

Aims

- The role of RD on Output Growth at the Industry Level.
- Identify the importance of industry's own RD activity as well as the role of knowledge spillovers.
- The role of human capital and absorptive capacity in general in the implementation of knowledge gains.
- The scope of knowledge diffusion can be either national or international.
- The use of various knowledge indices to capture alternative scenarios concerning the "publicness" of knowledge and knowledge spillover.

Motivation I

- The role of spillovers can be (usually) upward biased if the level of data aggregation is too high (Hall (2009)).
- The existing bibliography is not abundant in industry level studies for the role of knowledge spillovers.
- Additionally, most of the recent studies implicitly assume that knowledge and the associated knowledge spillover are always pure public goods. It is assumed *ex ante* that the entire amount of available information in the foreign country is embodied in the importing commodity.
- They neglect the degree of "publicness" in knowledge and knowledge spillover in the sender and the recipient economy. (Falvey et al.2004 is an exception).
- Key papers in the literature (Coe and Helpman (1995), Coe et al.(1997), Keller (1998),van Pottelsberghe(2001).
- The above studies overlook the possibility that spillovers can also be intra-national (domestic).

Motivation II

- Another crucial aspect is the amount of tacit knowledge embodied in foreign RD spillovers.
- This indicates that the recipient country needs to have available a certain amount of human capital in order to exploit the available information.
- Knowledge gains from foreign RD stock can be utilized without enough human capital in the domestic industry.
- This consideration highlights the role of absorptive capacity, which is important in any channel of knowledge spillover (both trade and FDI).

Analytical Model I

- A primal approach used to identify whether knowledge has a twofold role whereby industries exploit benefits from either own RD or the RD effort of other national counterparts.
- We build upon a behavioral model initially suggested by Griliches (1979), incorporating in the analysis the factor of knowledge spillovers, which is usually treated in the literature as an unobserved parameter (Doraszelski and Jaumandreu (2013), Markus (2013)).
- We rely on two *ad hoc* assumptions that trade and FDI are the two main conduits of international knowledge transmission.

Analytical Model II, The Set Up

- An aggregate production function:

$$Q_{i,c,t} = A_{i,c,t}(L)^{\alpha_1}_{i,c,t}(K)^{\alpha_2}_{i,c,t}(M)^{\alpha_3}_{i,c,t}(H)^{\alpha_4}_{i,c,t} \tag{1}$$

  where A, L, K, M and H stand for Hicks neutral technical progress, labour, fixed capital, intermediates and human capital.

- We index industry, country and time with i, c and t.
- Shares of inputs are denoted by α.
- The validity of the constant returns to scale assumption is tested econometrically.

Analytical Model III, The Derivation of the Baseline Model

- Takings Logs and re-writing equation (1) into intensive form (in per capita terms).The specification becomes:

$$\Delta ln\left(\frac{Q}{L}\right)_{i,c,t} = \Delta lnA_{i,c,t} + \alpha_2 \Delta ln\left(\frac{K}{L}\right)_{i,c,t} + \alpha_3 \Delta ln\left(\frac{M}{L}\right)_{i,c,t} + \alpha_4 \Delta ln\left(\frac{H}{L}\right)_{i,c,t} \quad (2)$$

- The term $\Delta lnA_{i,c,t}$ represents total Factor Productivity (TFP) growth which can be made endogenous as:

$$\Delta lnA_{i,c,t} \equiv \Delta lnTFP_{i,c,t} = \lambda_i + \eta_c + \gamma ln\left(\frac{R}{L}\right)_{i,c,t=0}$$

$$+\theta_h ln\left(\sum_{c\neq f}^{C-1} w^i_{c,f} R_{i,f,t}\right) + \rho_h\left[H_{i,c,t} \times ln\left(\sum_{c\neq f}^{C-1} w^i_{c,f} R_{i,f,t}\right)\right] + u_{i,c,t} \quad (3)$$

- The above equation states that TFP growth in industry *i* at year *t* depends on industry's initial knowledge capital stock $R_{t=0}$ and cross-industry knowledge spillovers from country *f*, denoted by $R_{i,f}$.
- Cross-industry knowledge spillovers are weighted with w to capture the importance of different channels of knowledge transfer.

Analytical Model IV, The Estimating Equation

- Augmenting the equivalent of TFP, equation(3) in the production function (2), we obtain:

$$\Delta ln\left(\frac{Q}{L}\right)_{i,c,t} = \lambda_i + \eta_c + \mu\left[\Delta ln F_{i,c,t}\right] + \kappa \Delta ln U_{i,c,t} + \gamma ln\left(\frac{R}{L}\right)_{i,c,t=0}$$
$$+\theta_h ln\left(\sum_{c\neq f}^{C-1} w^i_{c,f} R_{i,f,t}\right) + \rho_h\left[H_{i,c,t} \times ln\left(\sum_{c\neq f}^{C-1} w^i_{c,f} R_{i,f,t}\right)\right] + u_{i,c,t} \quad (4)$$

- The term $\Delta ln F_{i,c,t}$ compacts standard production inputs, capital and materials and μ is a measure of market power to be estimated.Similarly, $\Delta ln U_{i,c,t}$ is a measure capacity utilization.
- Parameters of special interest are:
  - γ that approximates the private return to RD, with respect to industry's *i* initial stock of knowledge.
  - θ_h that accounts for the elasticity of output with reference to foreign spillovers via channel h.
  - ρ_h that measures responsiveness of output with reference to the degree of absorptive capacity (i.e. the interaction term between human capital and spillover index).

Measurement Issues I

- The perpetual inventory method to accumulate RD stock is as follows:

$$R_{i,t} = (1-\delta)R_{i,t-1} + RDS_{i,t-1}$$

- The initial RD stock is generated by:

$$R_{i,t=0} = \frac{RDS_{i,t=0}}{g_i + \delta}$$

- where where g is the average growth rate of RD spending in the sample period and δ the physical depreciation rate assumed to be equal to 15 percent.

National Spillovers

- We construct the pool of national spillovers as follows:

$$NR_{i,c,t} = \sum \omega_{i,c,t} R_{j,c,t}$$

  for every industry $i \neq j$
- parameter ω includes the elements of the Leontief inverse matrix.
- the latter describes describes sales and purchases of commodities between industry *i* and *j* within the same country.

International Spillovers I

- We construct a set of 4 different International knowledge spillover indices.
- Each of them account for a different degree of "publicness" in the nature of knowledge spillover.

$$ISP^1_{i,c,t} = \sum s^i_{c,f,t} R_{i,f,t}$$

where s is the bilateral import share between country c and f in industry i

- This index assumes that knowledge is a public good in both sender and recipient country.

$$ISP^2_{i,c,t} = \frac{m_{i,c,t}}{x_{i,c,t}} \sum s^i_{c,f,t} R_{i,f,t}$$

the ratio $\frac{m_{i,c,t}}{x_{i,c,t}}$ stands for industry's i penetration.

- This index assumes that knowledge spillover is a private good in the recipient country by weighting foreign RD stock with the degree of import penetration in the recipient country.

International Spillovers II

- The third index accounts for the possibility that knowledge spillover is a private good both in the recipient and the sender country

$$ISP^3_{i,c,t} = \sum s^i_{c,f,t} \frac{R_{i,f,t}}{x_{i,f,t}}$$

- To capture this view we weight the amount of knowledge embodied in imports by the total level of economic activity in the industry of the sender country.

$$ISP^4_{i,c,t} = \frac{m_{i,c,t}}{x_{i,c,t}} \sum s^i_{c,f,t} \frac{R_{i,f,t}}{x_{i,f,t}}$$

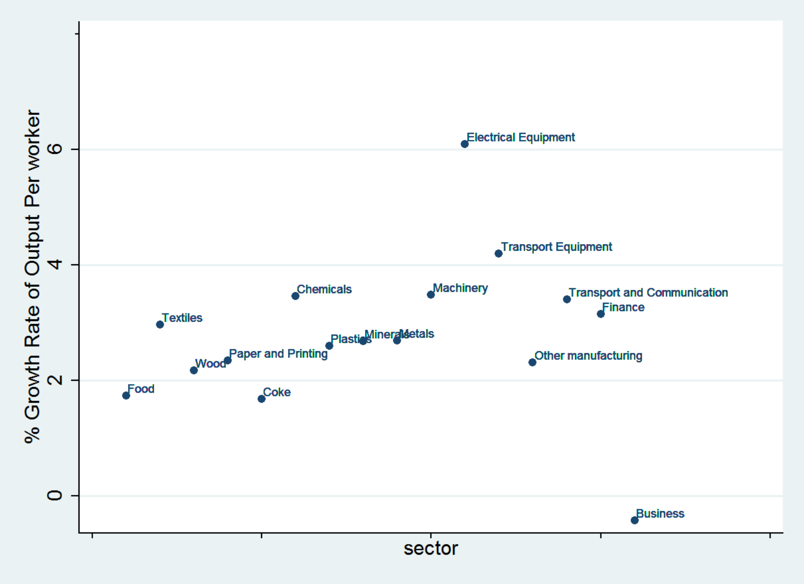
- The last index takes the case of having both private knowledge and private RD spillover.

Country	Code	Description	Partner
Australia	15t16	Food and Beverages	Australia
Austria	17t19	Textiles	Austria
Canada	20	Wood	Belgium
Denmark	21t22	Printing	Canada
Spain	23	Coke	Denmark
Finland	24	Chemicals	Finland
Germany	25	Rubber and Plastics	France
Italy	26	Other Mineral	Germany
Japan	27t28	Metals	Italy
Netherlands	29 Machinery	Ireland	
Slovenia	30t33	Electrical Equip.	Korea
Sweden	34t35	Transport	Japan
UK	36t37	Other Manufacturing	Netherlands
USA	I	Communication	Portugal
	J	Financial Intermediation	Spain
	K	Business Activities	UK
			USA

Data

- Time period covered is from 1987-2007 .
- 13 manufacturing industries (ISIC Rev.3 Classification) and 3 broader sectors, Transport and communication, Financial Intermediation and Business activities.
- Production data are taken from EUKLEMS data base (2009 release).
- Data for RD expenditure are taken form OECD- ANBERD database.
- Bilateral import shares are taken from STAN Bilateral Trade Data Base

Spillovers and Output/Graphs/Growth Rates of Output per Worker.png



Baseline OLS Estimations

- Parametric techniques in estimating a production function offers the flexibility in exchange of the cost to produce spurious econometric results.
- We address these potential issues by controlling for panel heterogeneity,spatial correlation and endogeneity.
- The paper present results from three different estimators: Panel Corrected Standard Errors (PCSE), Within Fixed Effects (FE) and Instrumental Variable (IV).

OLS with Panel Corrected Standard Errors

	DlnQ	DlnQ	DlnQ	DlnQ	DlnQ	DlnQ	DlnQ	DlnQ
ΔlnF	1.128***	1.140***	1.131***	1.144***	1.128***	1.140***	1.132***	1.144***
	(75.46)	(66.29)	(76.36)	(66.88)	(75.57)	(66.19)	(76.57)	(66.80)
ΔlnU	0.082	0.078	0.075	0.070	0.083	0.078	0.075	0.070
	(1.62)	(1.49)	(1.50)	(1.38)	(1.63)	(1.50)	(1.50)	(1.38)
ΔlnH	0.012***	0.007*	0.012***	0.007*	0.010**	0.006	0.010**	0.007
	(2.68)	(1.65)	(2.68)	(1.65)	(2.31)	(1.36)	(2.41)	(1.46)
RD$_{t=0}$	-0.024	-0.030	-0.031	-0.039	-0.008	-0.017	-0.018	-0.032
	(-0.51)	(-0.66)	(-0.67)	(-0.84)	(-0.17)	(-0.36)	(-0.39)	(-0.69)
National Spillovers	0.095	0.142**	0.086	0.118*	0.129*	0.154**	0.094	0.090
	(1.41)	(2.20)	(1.26)	(1.78)	(1.85)	(2.28)	(1.38)	(1.32)
ISP1	-0.001				-0.059			
	(-0.01)				(-0.50)			
ISP2		-0.025				-0.096		
		(-0.30)				(-1.05)		
ISP3			-0.029				-0.131	
			(-0.27)				(-1.17)	
ISP4				-0.061				-0.156**
				(-0.83)				(-1.96)
National Spillovers $\times HC$					-0.007**	-0.006**	-0.003	-0.000
					(-2.23)	(-1.97)	(-1.55)	(-0.30)
ISP1 $\times HC$					0.004***			
					(2.93)			
ISP2 $\times HC$						0.003***		
						(2.73)		
ISP3 $\times HC$							0.014***	
							(3.62)	
ISP4 $\times HC$								0.009***
								(3.16)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

IV Estimations

	DlnQ	DlnQ	DlnQ	DlnQ	DlnQ	DlnQ	DlnQ	DlnQ
ΔlnF	1.118***	1.146***	1.242***	1.167***	1.123***	1.177***	1.251***	1.214***
	(12.52)	(17.09)	(12.50)	(16.81)	(12.02)	(14.00)	(12.99)	(14.80)
ΔlnU	-0.031	-0.041	-0.085	-0.047	-0.027	-0.050	-0.092	-0.070
	(-0.30)	(-0.36)	(-0.76)	(-0.42)	(-0.26)	(-0.43)	(-0.87)	(-0.59)
$\Delta lnHC$	0.023	0.023	0.013	0.013	0.038	0.048	0.028	0.054
	(1.08)	(0.87)	(0.47)	(0.44)	(1.57)	(1.42)	(0.93)	(1.31)
RD$_{t=0}$	1.074	0.833	-0.459	-0.625	1.473	1.708	0.836	1.197
	(0.85)	(0.62)	(-0.23)	(-0.66)	(1.09)	(1.04)	(0.34)	(0.73)
Natiotal Spillovers	0.066	0.089	-0.068	-0.037	0.153	0.152	-0.011	-0.009
	(0.65)	(1.03)	(-0.76)	(-0.61)	(1.33)	(1.39)	(-0.10)	(-0.12)
ISP1	-0.014				-0.051**			
	(-0.46)				(-1.98)			
ISP2		-0.020				-0.048*		
		(-0.56)				(-1.66)		
ISP3			-0.111				-0.146	
			(-0.54)				(-0.78)	
ISP4				-0.169				-0.021
				(-1.07)				(-0.09)
National Spillovers $\times HC$					-0.012*	-0.013	-0.004	-0.001
					(-1.74)	(-1.52)	(-1.40)	(-0.29)
ISP1 $\times HC$					0.006*			
					(1.89)			
ISP2 $\times HC$						0.006		
						(1.62)		
ISP3 $\times HC$							0.019	
							(1.63)	
ISP4 $\times HC$								0.014**
								(2.47)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

OLS with PCSE

	DlnQ	DlnQ	DlnQ	DlnQ	DlnQ	DlnQ
ΔlnF	1.139***	1.142***	1.138***	1.137***	1.007***	0.929***
	(49.77)	(49.20)	(49.26)	(49.16)	(9.30)	(5.98)
ΔlnU	0.097	0.095	0.098	0.097	0.085	0.129
	(1.42)	(1.38)	(1.46)	(1.45)	(0.62)	(0.76)
$\Delta lnHC$	0.010**	0.009*	0.010**	0.010**	0.006	-0.016
	(1.98)	(1.85)	(2.11)	(2.03)	(0.18)	(-0.35)
RD$_{t=0}$	-0.046	-0.069	-0.060	-0.063	-1.028	-2.657
	(-0.69)	(-1.08)	(-0.97)	(-1.01)	(-0.99)	(-1.16)
Natiotal Spillovers	0.103	0.103	0.096	0.093	-0.020	-0.043
	(1.50)	(1.52)	(1.40)	(1.35)	(-0.30)	(-0.49)
FDI	0.003	-0.004			-0.016*	
	(0.50)	(-0.79)			(-1.85)	
Vertical FDI			0.066	-0.061		-0.362
			(1.18)	(-0.76)		(-1.55)
National Spillovers $\times HC$	0.000	0.000	0.000	0.000	0.001	0.002
	(0.04)	(0.14)	(0.27)	(0.12)	(0.67)	(0.91)
FDI $\times HC$		0.001			0.006**	
		(1.18)			(2.21)	
Vertical FDI $\times HC$				0.027*		0.092**
				(1.79)		(2.23)

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Conclusions

- The key objective of the paper is to identify the importance of domestic and international spillovers and whether their effect on output growth depends on the degree of human capital.
- International knowledge spillovers are an important source of industry output growth via the absorptive-capacity hypothesis.
- Skilled workers turns out to be a key channel through which knowledge spillovers tend to occur.
- Knowledge and respective spillovers are not pure public goods, which imply that the potential of knowledge gains from research activity of international counterparts improves as the degree of import intensity increases
- The importance of international spillovers in the presence of better human capital is more crucial for the high tech group while they do not seem to matter for the low tech group.
- FDI boosts output growth at the industry level only in conjunction with the presence of skilled workers.