Spillovers from public intangibles

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Background

- The global productivity slowdown has generated renewed interest in policies that might boost economic growth with a special focus on spillovers from public sector investments.
- The public sector is a major investor in intangible assets, especially human and scientific knowledge capital via its public investments in education and R&D.
- Investments in these assets, both tangible and intangible, are believed to exert positive macroeconomic effects in the long run.

Regarding intangibles, the analysis of public sector spillovers in OECD countries typically looks (in isolation) at R&D and education:

- Spillovers from publicly performed R&D to market sector productivity were studied by, e.g., Guellec and van Pottelsberghe (2002, and 2004), who found strongly positive effects in their cross-country work.
- The literature on the positive effects of R&D is extensive but largely pertains to R&D that is privately performed (yet possibly publicly funded) (see Hall, Mairesse, and Mohnen (2009) and Eberhardt, Helmers, and Strauss (2013) for reviews).
- ......but there are very few studies of possible spillovers from a wider set of public intangibles to productivity growth.

- Spillovers from public sector R&D are but one dimension of possible spillovers from investments in knowledge/intangible assets. For example, O'Mahony and Riley (2012) examine whether employer-provided training may facilitate the generation of spillovers from education.
- Further, besides the well documented spillovers from the conduct of corporate R&D, there might be pure spillovers from business investments in nonR&D intangibles.
  - These forms of investments grew dramatically in relative importance in the United States from the late 1970s to the mid-2000s (Corrado and Hulten, 2010).
  - After 2007, the divergent paths of tangible and intangible investment in both the US and EU are especially striking.
- The empirical analysis of spillovers from nonR&D intangibles is a relatively new and largely unexplored territory.

To examine the possible spillovers between public sector intangibles and business sector productivity performance, we:

- Explore the correlation between TFP growth and different measures of public sector knowledge creation using a new cross-country industry-level database that includes data on both market and nonmarket intangible investment at the industry level.
    - we find evidence of spillovers from public sector R&D to productivity in the market sector.
    - our earlier finding of spillovers to private nonR&D intangible capital holds in the extended dataset, i.e., the finding is robust to the inclusion of additional countries (United States), additional years of data (2008 to 2013), and additional controls (public R&D, **financial conditions**)

Data

- Database with multiple dimensions: **country, industry, institutional sector, time**
- Tangible and intangible assets (NA, INTAN Invest and SPINTAN)
- 20 industries (A-U Nace Rev 2), 1995-2013, so far 12 countries:
  - US
  - Big Northern Europe: DE, FR, UK
  - Scandinavian: DK FI, SE
  - Small Europe: AT, CZ, NL
  - Mediterranean: ES, IT

Suppose that industry value added in country c, industry i and time t, $Q_{c,i,t}$ can be written as:

$$Q_{c,i,t} = A_{c,i,t}F_{c,i}(L_{c,i,t}, K_{c,i,t}, R_{c,i,t}) \tag{1}$$

Log differentiating equation (1) per (Solow, 1957) gives:

$$\Delta lnQ_{c,i,t} = \epsilon^{L}_{c,i,t}\Delta lnL_{c,i,t} + \epsilon^{K}_{c,i,t}\Delta lnK_{c,i,t} + \epsilon^{R}_{c,i,t}\Delta lnR_{c,i,t} + \Delta lnA_{c,i,t} \tag{2}$$

where ϵ^X denotes the output elasticity of an input X, which in principle varies by input, country, industry and time.

For a cost-minimizing firm we may write

$$\epsilon^X_{c,i,t} = s^X_{c,i,t}, \; X = L, K, R \tag{3}$$

where s^X is the share of factor X's payments in value added. Now suppose a firm can benefit from the L, K or R in other firms, industries, or countries. Then, as Griliches (1979, 1992) notes the industry elasticity of ΔlnR on ΔlnQ is a mix of both internal and external elasticities so that we can write following (Stiroh, 2002)

$$\epsilon^X_{c,i,t} = s^X_{c,i,t} + d^X_{c,i,t}, \; X = L, K, R \tag{4}$$

which says that output elasticities equal factor shares plus d, where d is any deviation of elasticities from factor shares due to e.g., spillovers.

To examine spillovers, that is $d > 0$, we note that following (Caves, Christen and Dwiert, 1982) a Divisia $\Delta lnTFP$ index can be constructed that is robust to an underlying translog production function such that we can write (2) as

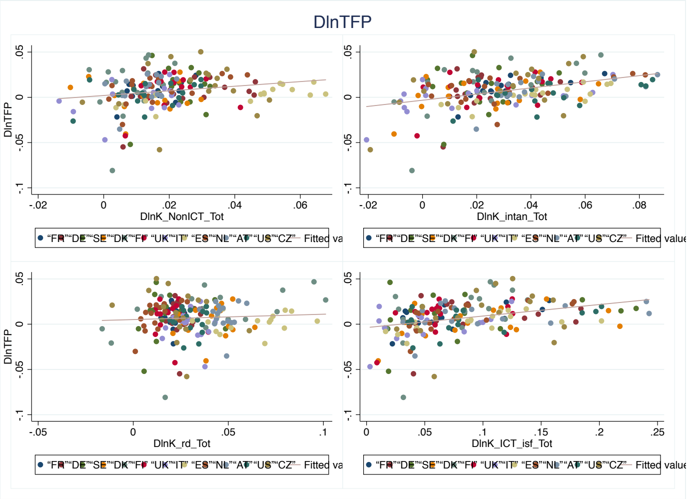
$$\Delta lnTFP^{Q}_{c,i,t} = d^{L}_{c,i,t}\Delta lnL_{c,i,t} + d^{K}_{c,i,t}\Delta lnK_{c,i,t} + d^{R}_{c,i,t}\Delta lnR_{c,i,t} + \Delta lnA_{c,i,t} \quad (5)$$

where $\Delta lnTFP^{Q}_{c,i,t}$ is calculated as

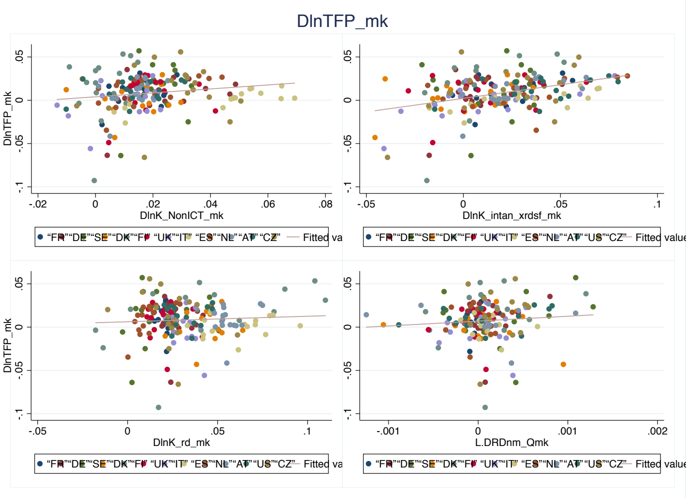
$$\Delta lnTFP^{Q}_{c,i,t} = \Delta lnQ_{c,i,t} - s^{L}_{c,i,t}\Delta lnL_{c,i,t} - s^{K}_{c,i,t}\Delta lnK_{c,i,t} - s^{R}_{c,i,t}\Delta lnR_{c,i,t} \quad (6)$$

From equation (5) therefore, a regression of $\Delta lnTFP^{Q}$ on the inputs recovers the spillover terms.

Total economy productivity growth and capital input growth by major type



Market sector productivity growth, capital input growth, and nonmarket R&D



$$\Delta \ln TFP^{Q}_{c,t} = a_c + a_t + d^L \Delta lnL_{c,t} + d^{ICT} \Delta lnK^{ICT}_{c,t} + \\ + d^{NonICT} \Delta lnK^{NonICT}_{c,t} + d^R \Delta lnR_{c,t} + v_{c,t} \quad (7)$$

Country and time effects are added to control for elements of unobserved heterogeneity, and $v_{c,t}$ is an $i.i.d.$ error term.

- The interpretation of this equation depends upon what is included in TFP.
- Recall that R is capitalised into $\Delta \ln TFP^Q$ via value added and via inputs that are given a rate of return when calculating factor shares (with market sector given an ex-post rate of return and non-market sector a rate of return equal to the social rate of time preference, as previously mentioned).
- Thus the d^R is an "excess" output elasticity in the sense of excess over that elasticity implied by the private and social time preference-based rates of return.

To explore knowledge spillovers from non-market knowledge we test two models:

$$\Delta lnTFP_{c,t}^{Q,MKT} = a_c + a_t + d^L \Delta lnL_{c,t}^{MKT} + d^K \Delta lnK_{c,t}^{MKT} + d^{R_{NonR\&D}} \Delta lnR_{c,t}^{NonR\&DMKT} + d^{R_{R\&D}} \Delta lnR_{c,t}^{R\&DNonMKT} + v_{c,t}$$

and

$$\Delta lnTFP_{c,t}^{Q,MKT} = a_c + a_t + d^L \Delta lnL_{c,t}^{MKT} + d^K \Delta lnK_{c,t}^{MKT} + d^R \Delta lnR_{c,t}^{MKT} + \rho(N^{NonMKT}/Q^{MKT})_{c,t} + v_{c,t}$$

Here we have written the elasticity times the log change in the non-market stock of R in terms of its flow i.e. $\gamma_c \Delta lnR_{c,t}^{NonMKT} = \rho(N^{NonMKT}/Q^{MKT})_{c,t}$ where N^{NonMKT} is the flow of investment by the non-market sector in R.

Econometric results: 1

VARIABLES	(1)	(2)	(3)	(4)	(5)
	D.DlnTFP				
	1998-2013				1998-2007
D.DlnK_NonICT	-0.232	-0.117	-0.244	-0.257*	-0.215
	(0.165)	(0.162)	(0.155)	(0.155)	(0.176)
D.DlnK_ICT	0.036	0.012	0.012	0.007	0.040
	(0.051)	(0.051)	(0.053)	(0.052)	(0.046)
D.DlnR	**0.307*** **	**0.271*** **			
	(0.076)	**(0.072)**			
D.DlnR$^{R\&D}$			**0.302** **	**0.316** **	**0.144**
			(0.132)	**(0.129)**	**(0.103)**
D.DlnR$^{nonR\&D}$			**0.203*** **	**0.199*** **	**0.307*** **
			(0.059)	**(0.058)**	**(0.066)**
D.DlnLCH(t-1)				**0.301** **	**0.358*** **
				(0.121)	**(0.103)**
D.DlnH(t-1)				0.008	0.005
				(0.022)	(0.012)
D.DlnL(t-1)			0.026		
			(0.037)		
D.DlnL(t-2)					
lnLRINTR		**0.009*** **	**0.010*** **	**0.010*** **	0.003
		(0.002)	**(0.003)**	**(0.002)**	(0.003)
lnLRINTR(t-1)		**-0.009*** **	**-0.007** **	**-0.006** **	**0.007***
		(0.003)	**(0.003)**	**(0.003)**	**(0.004)**
lnLRINTR(t-2)		-0.000	-0.004	-0.005	**-0.010*** **
		(0.003)	(0.003)	(0.003)	**(0.003)**
Observations	160	150	150	150	97

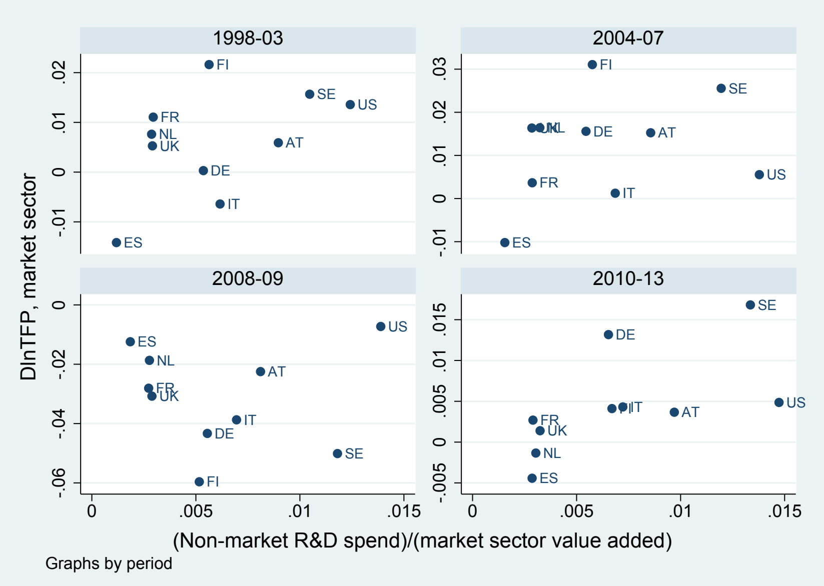
Standard errors in parentheses

***** p<0.01, ** p<0.05, * p<0.1**

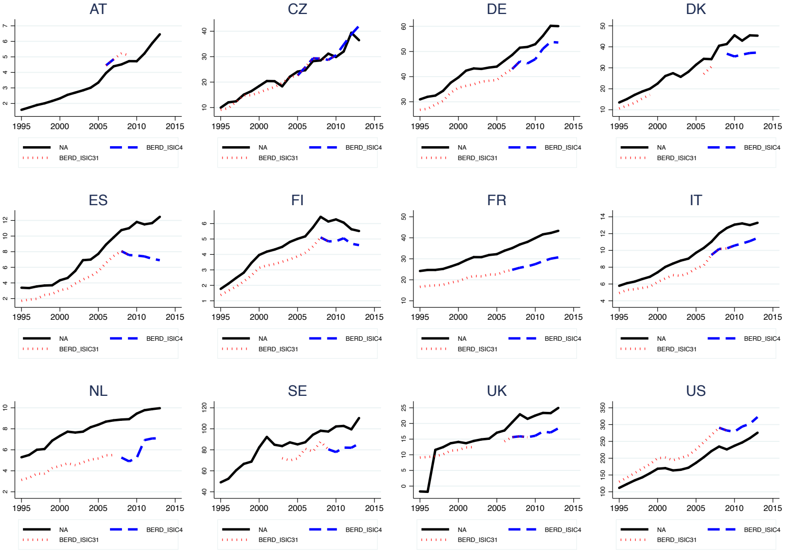
Econometric results: 2

VARIABLES	(1)	(2)	(3)	(4)	(5)
	D.DlnTFP^{mkt}				
	1998-2013				1998-2007
D.DlnK_NonICT^{mkt}	-0.212	-0.097	-0.116	-0.102	-0.11
	(0.175)	(0.170)	(0.169)	(0.188)	(0.169)
D.DlnK_ICT^{mkt}	-0.008	-0.036	-0.036	-0.041	-0.001
	(0.058)	(0.057)	(0.057)	(0.070)	(0.058)
D.DlnR$^{R\&D_mkt}$	0.142	0.223	0.218	**0.254***	**0.245****
	(0.135)	(0.137)	(0.138)	**(0.146)**	(0.123)
D.DlnR$^{R\&D_nmkt}_{(t-3)}$				**0.200***	0.089
				(0.112)	(0.085)
D.DlnR$^{nonR\&D}$	**0.268*****	**0.229*****	**0.227*****	**0.205*****	**0.216*****
	(0.068)	(0.063)	(0.064)	**(0.066)**	(0.078)
D.DlnLCH$^{mkt}_{(t-3)}$				0.183	0.080
				(0.145)	(0.184)
D.DlnH$^{mk}_{(t-3)}$				0.011	-0.084
				(0.026)	(0.106)
lnLRINTR		**0.011*****	**0.011*****	**0.011*****	**0.006***
		(0.003)	**(0.003)**	**(0.003)**	**(0.003)**
lnLRINTR$_{(t-1)}$		-0.011***	-0.011***	-0.007*	0.002
		(0.004)	(0.004)	(0.004)	(0.005)
lnLRINTR$_{(t-2)}$		-0.001	-0.001	-0.006*	-0.009**
		(0.004)	(0.004)	(0.004)	(0.004)
D.RDnm_Qmk			-1.326		
			(3.758)		
Observations	160	150	150	130	77

DlnTFP, market sector and Nonmarket R&D



BERD and National Accounts/SPINTAN Market Sector R&D data

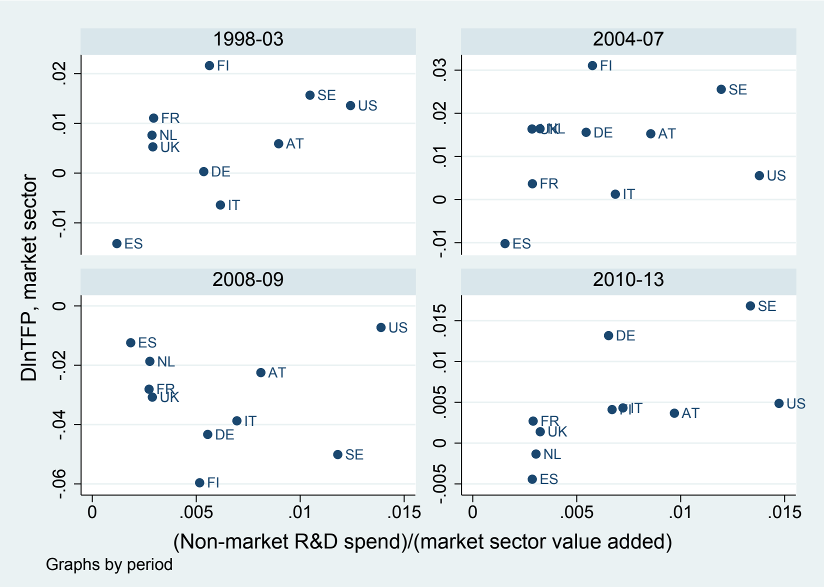


Econometric results: 3

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	DlnTFP^{mk}					
	no time dummies				All lagged	Fixed effects
D.RDnm_Qmk$_{(t-1)}$	**0.802*** **	**0.726*** **	**0.736** **	**0.713** **		5.483
	(0.234)	**(0.250)**	**(0.295)**	**(0.355)**		(4.414)
DlnK_intan_xrdsf_mk			-0.054	-0.055		
			(0.094)	(0.094)		
DlnK_rd_mk			0.010	0.007		
			(0.089)	(0.090)		
DlnLCH_mk				-0.143		
				(0.662)		
L.LRDnm_Qmk					**0.633** **	
					(0.320)	
L.DlnK_intan_xrdsf_mk					**0.119* **	
					(0.070)	
L.DlnK_rd_mk					0.095	
					(0.078)	
L.DlnLCH_mk					0.876	
					(1.180)	
periodcode1		0.002	0.003	0.003		0.008
		(0.003)	(0.003)	(0.004)		(0.007)
periodcode2		**0.008** **	**0.009*** **	**0.008*** **	**0.006* **	**0.012* **
		(0.003)	**(0.003)**	**(0.003)**	**(0.003)**	**(0.005)**
periodcode3		**-0.035*** **	**-0.035*** **	**-0.035*** **	**-0.036*** **	**-0.031*** **
		(0.007)	**(0.008)**	**(0.008)**	**(0.009)**	**(0.008)**
Constant	-0.007***	-0.001	-0.000	0.001	-0.007	-0.034
	(0.002)	(0.003)	(0.003)	(0.005)	(0.009)	(0.031)
Observations	40	40	40	40	30	40
R-squared	0.0231	0.707	0.708	0.708	0.747	0.392

ust standard errors in parenthe
***** p<0.01, ** p<0.05, * p<0.1**

DlnTFP, market sector and Nonmarket R&D

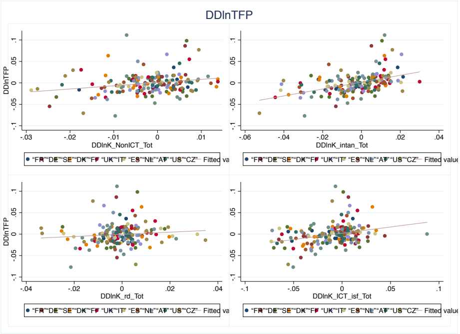


- Using R&D investment time series newly developed for national accounts, we find support for earlier findings in the literature (e.g. Guellec and van Pottelsberghe (2002, and 2004)),) that there are spillovers from public sector R&D to market sector productivity.
- Our findings suggest a rate of return of around 50% to public sector R&D spend.
- We also find that market sector investments in nonR&D intangible capital generate spillovers to productivity.
- Finally, we do not find evidence that non-market non-R&D intangible investment has spillover benefits to the market sector.

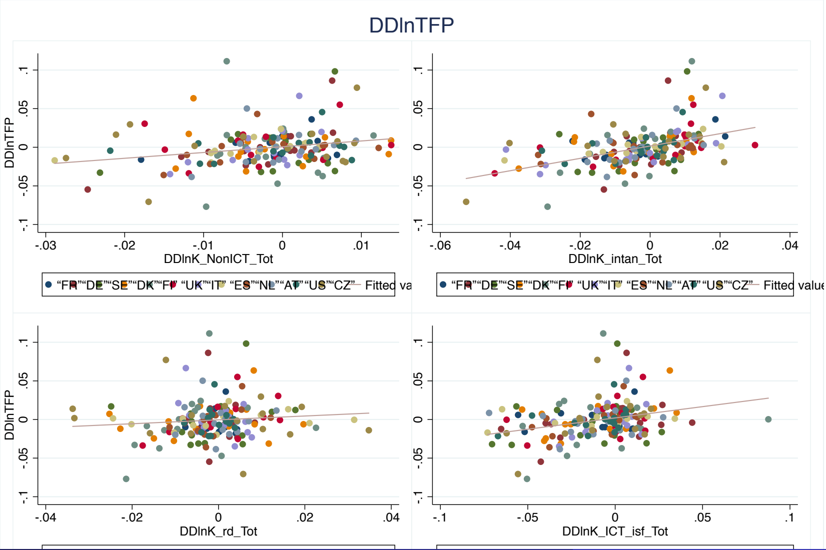
- A primary characteristic of intangible capital, widely supported by growth accounting exercises and macroeconomic studies, is to be growth-promoting.
- This is because intangible investments likely generate spillovers to the economic system being non-rival and possibly non-excludable. Such spillovers, if they exist, might be within the private sector and/or between the public and private sector.
- In the light of the prolonged productivity slowdown experienced by many advanced countries after the financial crisis, it would be vital to know which, if any, public sector intangibles had positive spillovers to the rest of the economy.

Backup slides

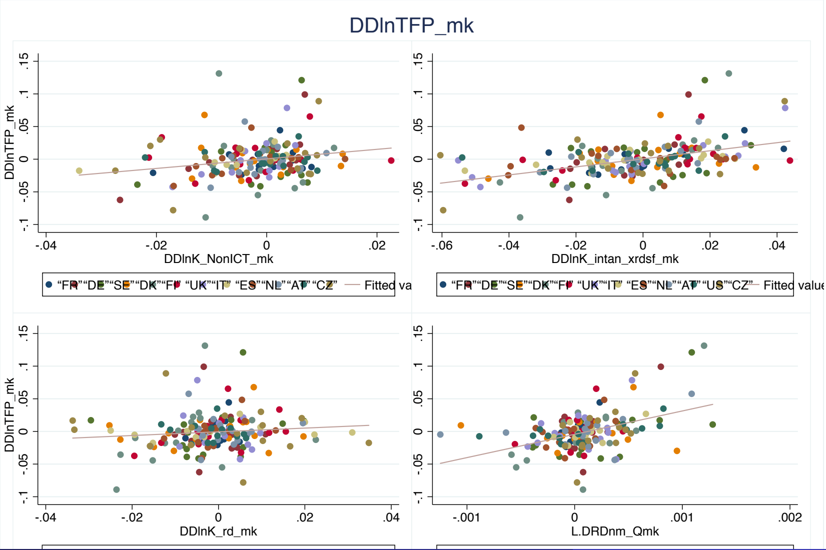
Changes in total economy productivity growth and capital input growth by major type



Changes in total economy productivity growth and capital input growth by major type



Changes in market sector productivity growth, capital input growth, and nonmarket R&D



- Assume that public R&D does not depreciate (to the extent it is "basic" then is likely to at least become less obsolete than private R&D; the ONS report using a depreciation rate of 5% for government R&D for example.)
- From the perpetual inventory model, $\Delta lnR_t^{NonMKT} = N^{NonMKT}/R_{t-1}^{NonMKT}$ when $\delta^{NonMKT} = 0$.
- Thus the elasticity of market output $(\partial Q/\partial R^{NonMKT})(R^{NonMKT}/Q)$ times this term can be written=$(\rho_{it})(R^{PUB}/Q)$ where $\rho_{it} = (\partial Q/\partial R^{NonMKT})$