Swedish Lessons: How Important are ICT and R&D to Economic Growth?

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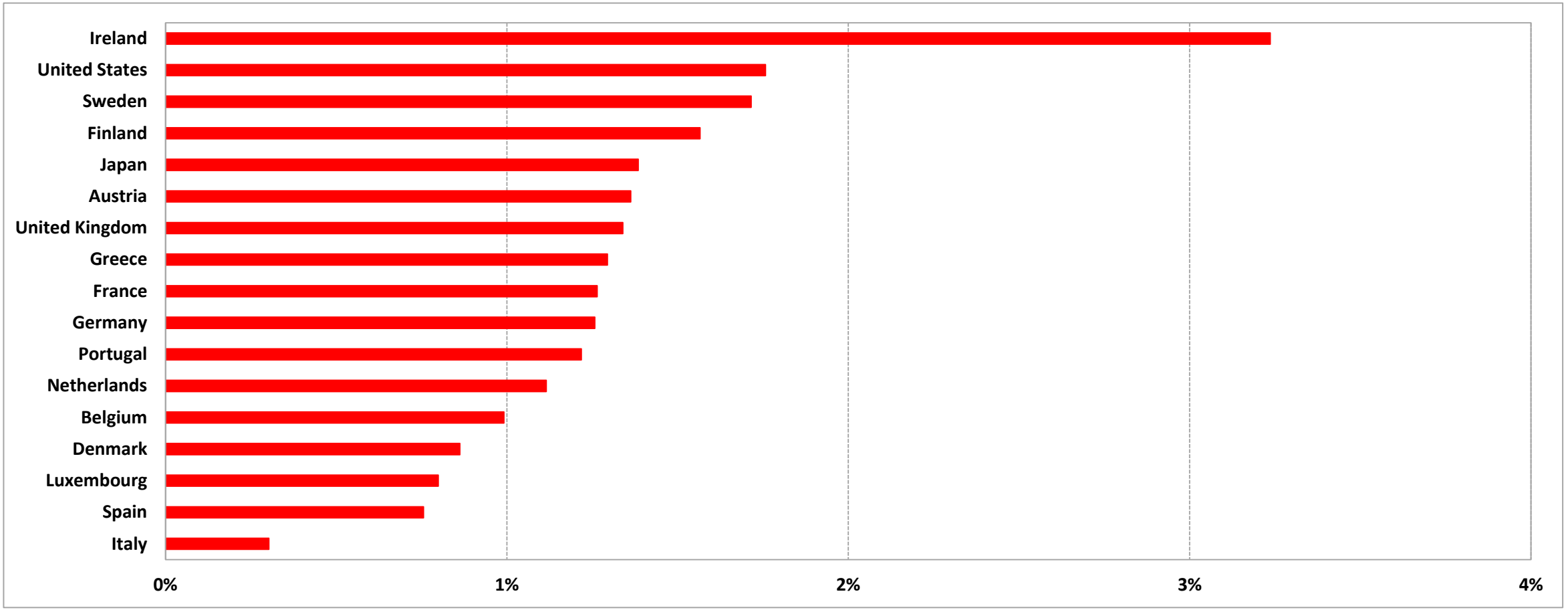
Annual Labor Productivity growth 1995–2014

EU15, Japan and the US, (GDP per hour worked)



Source: OECD (2016).

Overview

- Large ICT and R&D investments in Sweden
  - Sweden had one of the largest shares of ICT in total investment in the 2000s (Similar to US and UK)
  - Sweden has higher R&D investment as a share of GDP compared to most other countries

Questions

- Is there a positive association between high levels of ICT and R&D capital and value added at the industry level?
- Does the effect of ICT hardware differ from the effect of ICT software?
- Based on the growth accounting framework, what is the contribution from ICT and R&D when output elasticities are based on income shares or econometric estimates, respectively?

Methodology

- Uses both Econometric and growth accounting methods
- Econometric
  - Can be used to identify statistically significant and causal relationships
  - However many issues to deal with including specification and simultaneity
- Growth Accounting
  - Describes, rather than explains but Interesting from a comparative perspective
  - Requires many assumptions including perfect markets and constant returns to scale

Methodology

The methodology is based on the standard neoclassical production function. Assuming augmenting Cobb-Douglas production function:

$$\ln V_{i,t} = \beta_{ICT} \ln K_{ICT,i,t} + \beta_N \ln K_{N,i,t} + \beta_R \ln R_{i,t} + \beta_L \ln L_{i,t} + \ln A_{i,t}$$

where $V_{i,t}$ is value added, K_{ICT} is ICT related capital and K_N is non-ICT capital, R is R&D capital, L labor input and A is Hicks-neutral TFP, all for industry (i) at time (t).

It is also possible to divide ICT capital into hardware and software,

$$K_{ICT,i,t} = K_{S,i,t} + K_{H,i,t}$$

where $K_{S,i,t}$ is software capital and $K_{H,i,t}$ is computer and communications hardware capital.

Methodology

- Estimates capital services in the standard way using the PIM and geometric depreciation
- Also estimates internal rates of return
  - Note this requires assumption of constant returns to scale and competitive markets so econometric approach does not really get away from these assumptions

Data

- Based on Swedish National Accounts
- 47 industries for the period 1993–2012
- Value added based on double deflation
- Labor input defined as hours worked
- Capital services have been calculated for ICT, R&D and other capital

Results (I)

	Dependent variable: Value added					
	Basic regression OLS		Time adjustment OLS		Time adjustment WLS	
Hours worked (lnL)	0.39***	0.32***	0.39***	0.32***	0.40***	0.34***
	(0.115)	(0.117)	(0.115)	(0.118)	(0.107)	(0.112)
ICT capital (lnK_{ICT})	0.19***		0.18***		0.17***	
	(0.056)		(0.059)		(0.061)	
Software capital (lnK_S)		0.22**		0.23***		0.23**
		(0.083)		(0.084)		(0.088)
Hardware capital (lnK_H)		0.02		0.004		–0.007
		(0.048)		(0.049)		(0.049)
Non-ICT capital (lnK_N)	0.30***	0.32***	0.29***	0.32***	0.29***	0.32***
	(0.056)	(0.039)	(0.056)	(0.039)	(0.061)	(0.040)
R&D capital (lnR)	0.11*	0.10*	0.11*	0.10*	0.11*	0.10
	(0.055)	(0.055)	(0.055)	(0.056)	(0.059)	(0.059)
Time dummies	No	No	Yes	Yes	Yes	Yes
Adjusted R^2	0.72	0.74	0.72	0.74	0.71	0.74
Number of observations	940	940	940	940	940	940

Results (II)

	Dependent variable: Value added					
	Fixed effects Excl. time dummies		Fixed effects Incl. time dummies		First differences	
Hours worked (lnL)	0.33*	0.33**	0.40**	0.39**	0.62***	0.63***
	(0.168)	(0.165)	(0.164)	(0.165)	(0.098)	(0.098)
ICT capital (lnK_{ICT})	0.13**		–0.02		0.01	
	(0.049)		(0.087)		(0.060)	
Software capital (lnK_S)		0.13*		–0.004		–0.03
		(0.071)		(0.076)		(0.019)
Hardware capital (lnK_H)		0.06*		–0.004		–0.003
		(0.030)		(0.045)		(0.035)
Non-ICT capital (lnK_N)	0.27**	0.22*	0.12	0.12	0.01	0.01
	(0.113)	(0.118)	(0.120)	(0.120)	(0.082)	(0.084)
R&D capital (lnR)	0.33**	0.34**	0.29**	0.29**	0.21***	0.20***
	(0.145)	(0.141)	(0.129)	(0.129)	(0.040)	(0.040)
Time dummies	No	No	Yes	Yes	Yes	Yes
Adjusted R^2	0.50	0.51	0.53	0.53	0.23	0.23
Number of	940	940	940	940	893	893

Robustness checks

- Simultaneity bias
  - System GMM, poor specification, decreasing returns
- Also examines sensitivity to industries included, time period and a division into manufacturing and services

Results (IV) – sensitivity Analysis

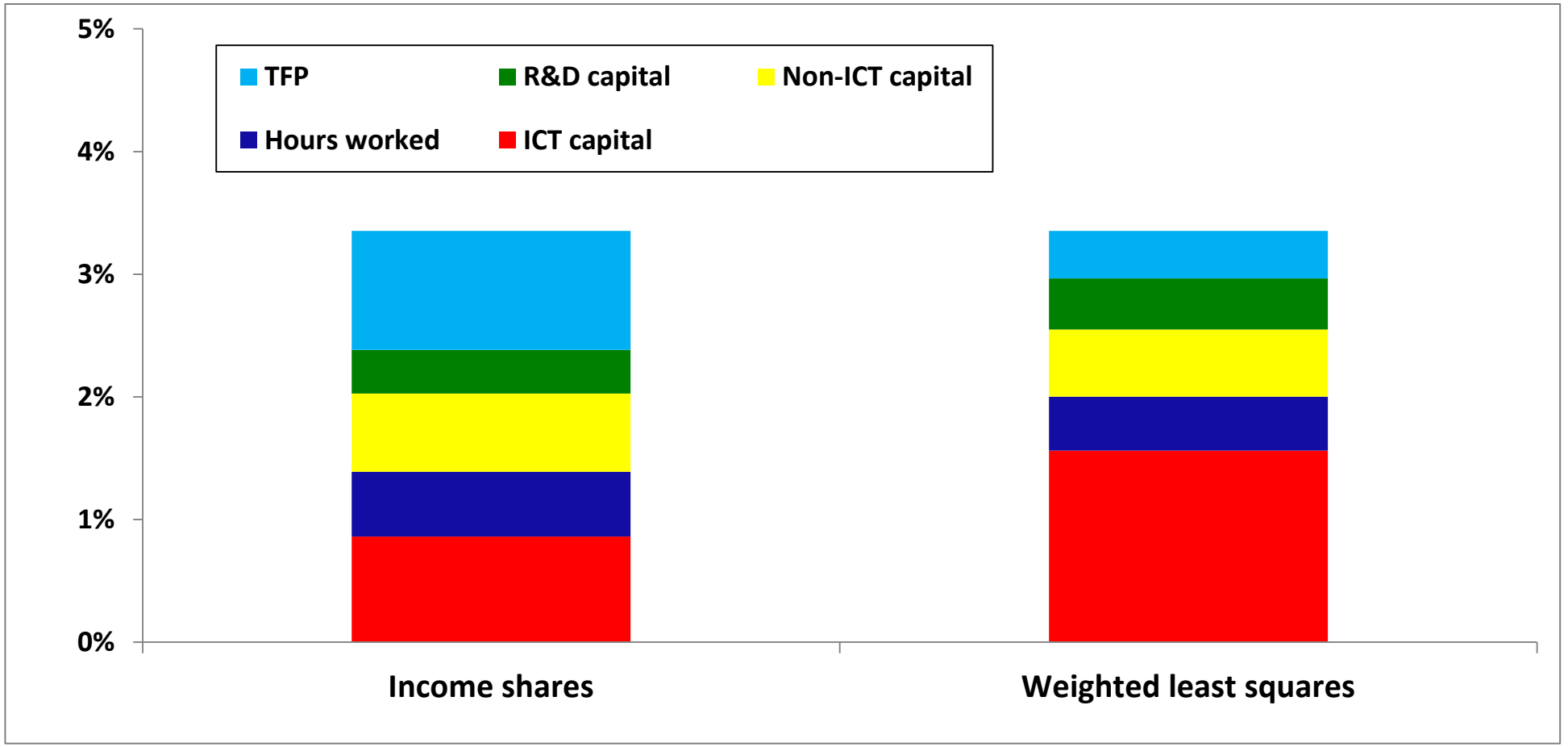
	Dependent variable: Value added			
	ICT-coefficient		R&D coefficient	
	OLS	WLS	OLS	WLS
Baseline regression	0.18***	0.17***	0.11*	0.11*
Drop ICT industries	0.19***	0.18***	0.05*	0.05
1993–2000	0.16***	0.16***	0.07*	0.07*
2001–2007	0.18***	0.17***	0.12**	0.13**
2008–2012	0.21**	0.20**	0.14*	0.14*
Manufacturing	0.48***	0.50***	0.27***	0.28***
Services	0.18**	0.19**	0.05	0.04

Econometric Results Summary

- Base specification imply a large coefficient on ICT capital
  - Although not robust to all methods used
- Software seems to matter more than hardware
  - "all industries invest in hardware, but only the ones that successfully invest in and implement the right software enjoy a positive effect from ICT"
- R&D coefficient is large and significant in most specifications
- Coefficients on ICT and R&D are quite stable over time and higher in manufacturing then services, particularly R&D
- Evaluating how big these coefficients are is aided by comparing with growth accounting results

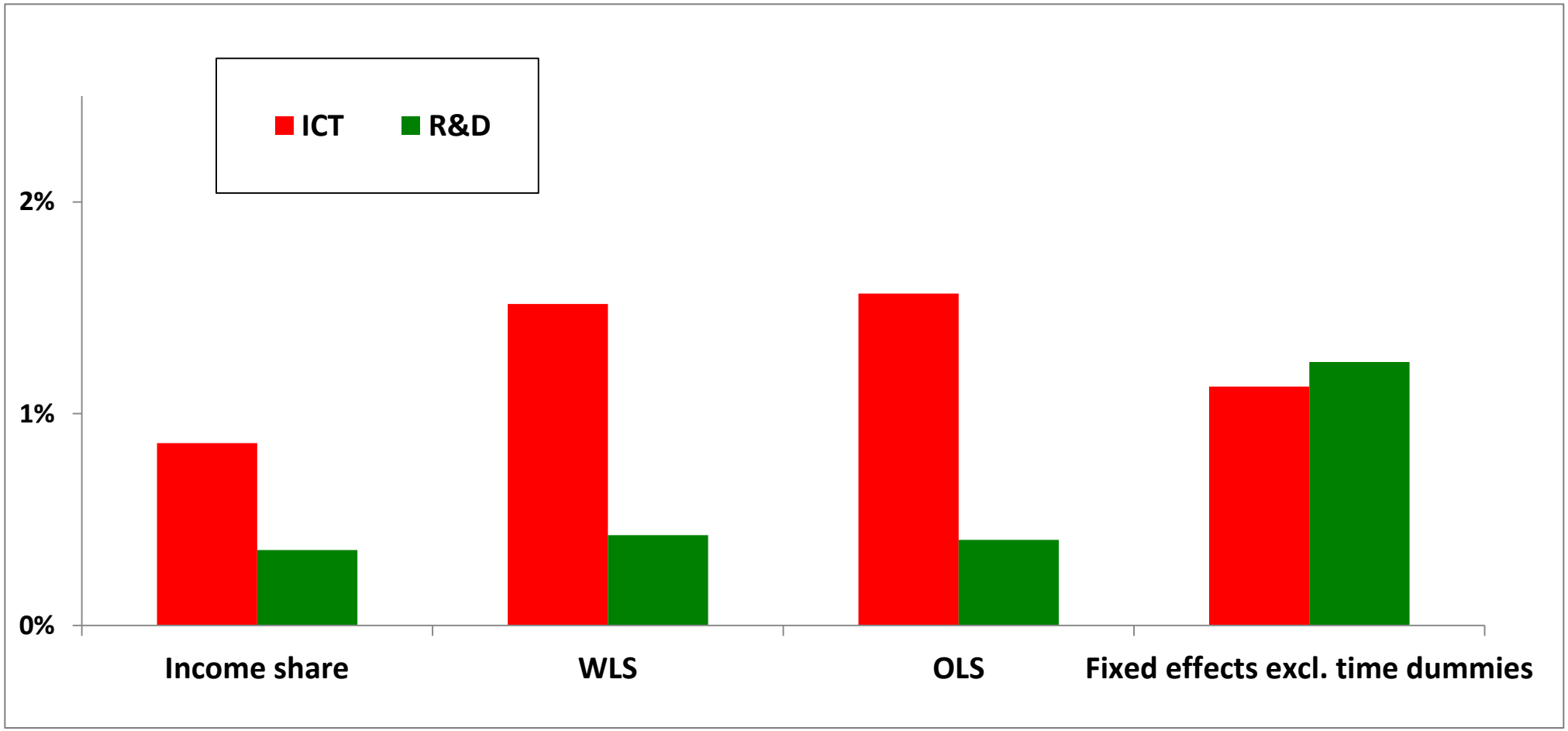
Growth accounting for the Swedish non-farm business sector in 1993–2012

Based on income shares and WLS estimates of output elasticities



Source: Statistics Sweden (2015).

Contribution from ICT and R&D on the growth accounting framework with different estimates of output elasticities



Source: Statistics Sweden (2015).

Conclusions

- ICT and R&D is positively associated with value added for most specifications.
- When ICT capital is divided into hardware and software, only software is significantly associated with value added.
- When output elasticities are based on WLS instead of income shares, the contribution of ICT to value added growth increases from 0.9 to 1.5 percentage points
- The contribution of R&D also is marginally higher with WLS
- both ICT and R&D investments have been important drivers of value added growth in the Swedish business sector in recent decades

Discussion

Econometric Issues: Endogeneity, serial correlation and other issues probably best tackled in a dynamic framework

Difficult with such a short time span

Advantages of econometric approach is that it can allow for interactions between variables and test for spillovers

What about labour force skills?

Results (III) - GMM

	Dependent variable: Value added			
	Difference GMM		System GMM	
Hours worked (lnL)	0.20***	0.24***	0.004	–0.003
	(0.065)	(0.055)	(0.056)	(0.055)
ICT capital (lnK_{ICT})	0.05		0.12***	
	(0.035)		(0.038)	
Software capital (lnK_S)		–0.09		0.06*
		(0.063)		(0.030)
Hardware capital (lnK_H)		0.01		0.05**
		(0.020)		(0.023)
Non-ICT capital (lnK_N)	0.03	0.01	–0.09**	–0.08*
	(0.066)	(0.066)	(0.046)	(0.045)
R&D capital (lnR)	0.04	0.03	0.04	0.04
	(0.073)	(0.081)	(0.031)	(0.029)
Time dummies	Yes	Yes	Yes	Yes
Sargan statistic	26.5	23.4	29.5	29.6
Sargan p-value	1.00	1.00	1.00	1.00