The contribution of ICT to productivity focusing on intangibles and interior/exterior ICT externalities

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Artificial intelligence and the next generation of competences :

How Digital – and Artificial Intelligence will impact jobs and competences profiles?

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Introduction

- Research background
  - Ever since mid-1990s, the role of ICT was highlighted to explain the acceleration of production (US and some OECD countries).
  - From the perspective of neoclassical economics, which underlies almost all the recent discussions of this issue, there is no reason to expect acceleration in the pace of TFP growth outside of ICT production (Acharya, 2016).
  - The industry-level studies targeting US (Corrado et al., 2007; Bosworth and Triplett, 2007) showed the growth of non-ICT producing sector's acceleration in TFP.
  - The contribution of ICT to productivity is not only limited to ICT-producing industries, but also ICT-using industries.
  - *What differentiates ICT from others?*

Introduction

- Research background
  - As GPT (General Purpose Technology), ICT plays the role of ‘enabling technologies’ (Basu and Fernald, 2007; Bresnahan and Trajtenberg, 1995).
    - GPT: A new method of producing and inventing that is important enough to have a protracted aggregate impact. Ex) Electricity(Bresnahan and Trajtenberg, 1995), and artificial intelligence (Brynjolfsson, Erik; Rock, Daniel; Syverson, 2018).
    - ‘Enabling technologies’: A phenomenon of creating new opportunities rather than offering complete, final solutions (Bresnahan and Trajtenberg, 1995)

Introduction

- Research background
  - Basu et al. (2003) proposed a model based on the key assumptions for ICT features → BFOS model

  1) The advantage of ICT is likely to diffuse to others
    - As organizations can learn from watching and easily follow without actual investment, ICT externality effect on others are not ignorable.

  2) ICT causes co-invention and co-investment in sectors including those seem unrelated.
    - For instance, if a firm uses digital devices more, then it is more likely to reorganize their working process or create intangible capital in the form of organizational knowledge.

Introduction

- Problem statement

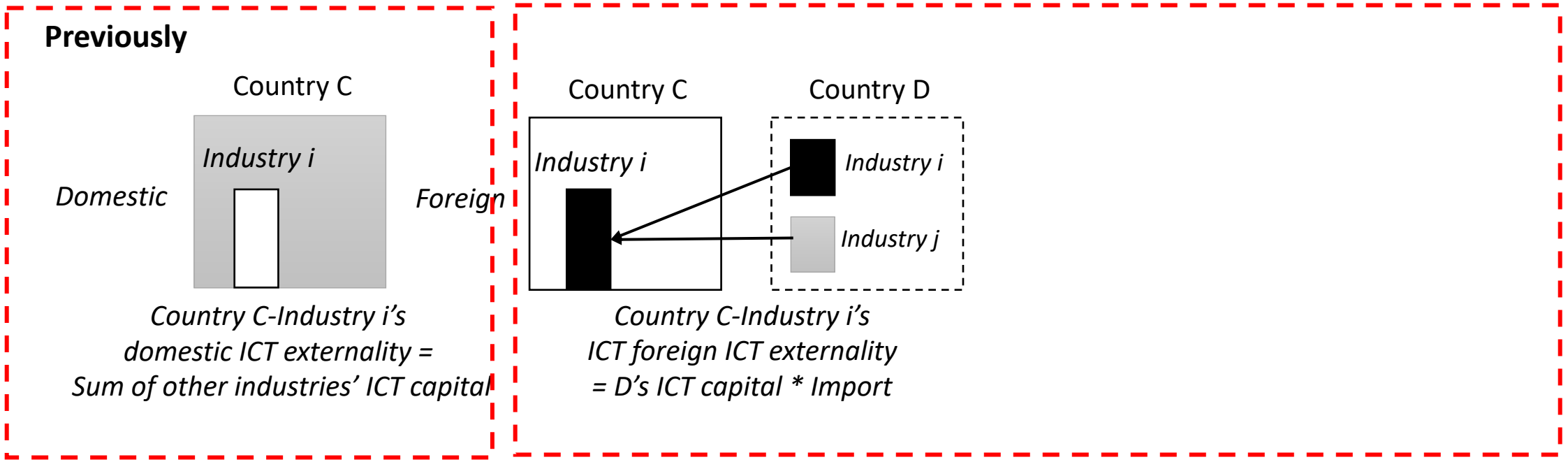
  1) Empirical study using BFOS is merely conducted (Basu et al., 2003; Acharya, 2016).

  2) Limited intangibles were considered (Acharya, 2016).
  - Due to the limitation of data, only the limited intangibles (R&D) were considered.

  3) The concept and measurement of ICT externality require reconsideration.
  - Confusion of level of analysis (firm-level and industry-level), and direction (exterior and interior)

- Research goal
  - **Address an improved empirical model to overcome the limitation of previous studies.**
  - **Analyze the contribution of ICT using BFOS model with a reexamination of ICT externalities and inclusion of intangibles**

Literature Review: ICT externality



Issue 1.
Level of analysis

Issue 2.
Direction

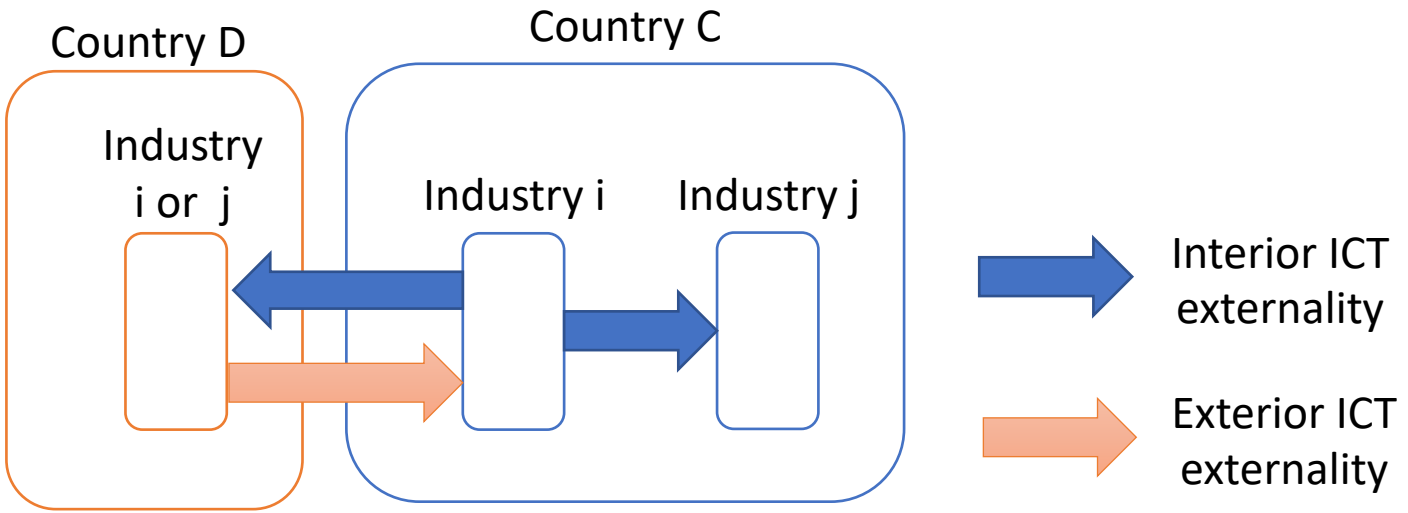
Literature Review: ICT externality

- Issue 1. Level of Analysis (Firm-level and Industry-level)
  - In firm-level studies, ICT externality was measured under assumption that it can be realized *without actual interactions*. It is acceptable as firms are restricted to those competing in the same market or industry.
  - In industry-level study, however, ICT externality requires the *interaction* between the industries. Due to the heterogeneity of productivity function and business model among industries, it is more likely to assume that those industries without interactions are not affecting each other either directly or indirectly.

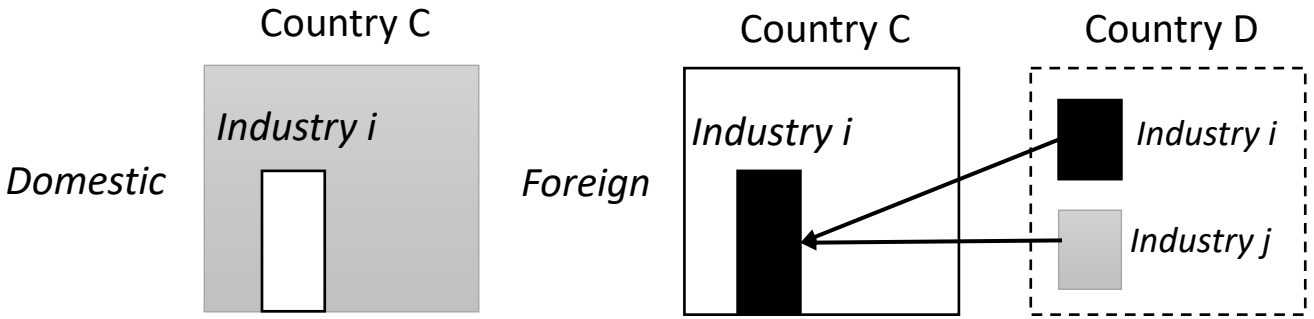
→ **Industry-level ICT externality requires the consideration of interactions**

Literature Review: ICT externality

- Issue 2. Direction (Exterior and Interior)
  - ICT externality is divided in to two parts: imported ICT externality (*exterior ICT externality*) and self ICT externality (*interior ICT externality*)
  - Exterior ICT externality (Helpman and Coe, 1995)
  - Interior ICT externality (Proposal)



Previously



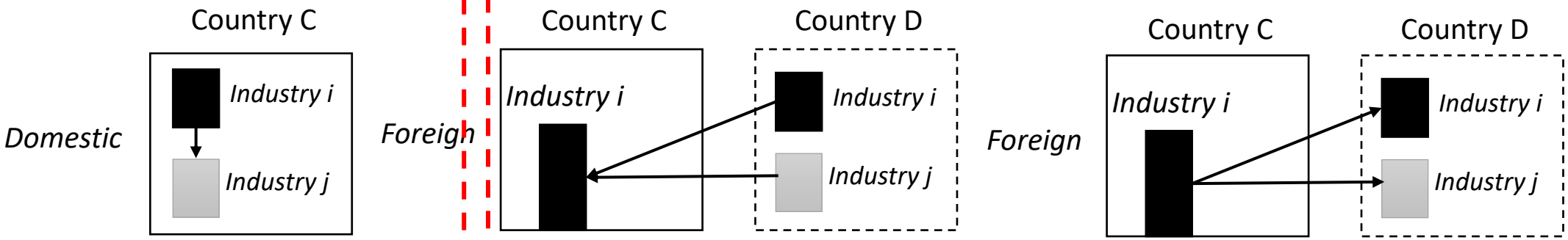
Country C-Industry i's domestic ICT externality = Sum of other industries' ICT capital

*Country C-Industry i's ICT foreign ICT externality = D's ICT capital * Import*

Issue 2. Direction

Issue 1. Level of analysis

Proposal



*Country C-Industry i's domestic ICT externality = ICT capital proportion * domestic trade*

Interior Domestic Inter-industry ICT Externality

*Country C-Industry i's ICT foreign ICT externality = D's ICT capital * Import*

Exterior Foreign Inter(intra)-industry ICT Externality

Country C-Industry i's ICT foreign ICT externality = ICT capital proportion export*

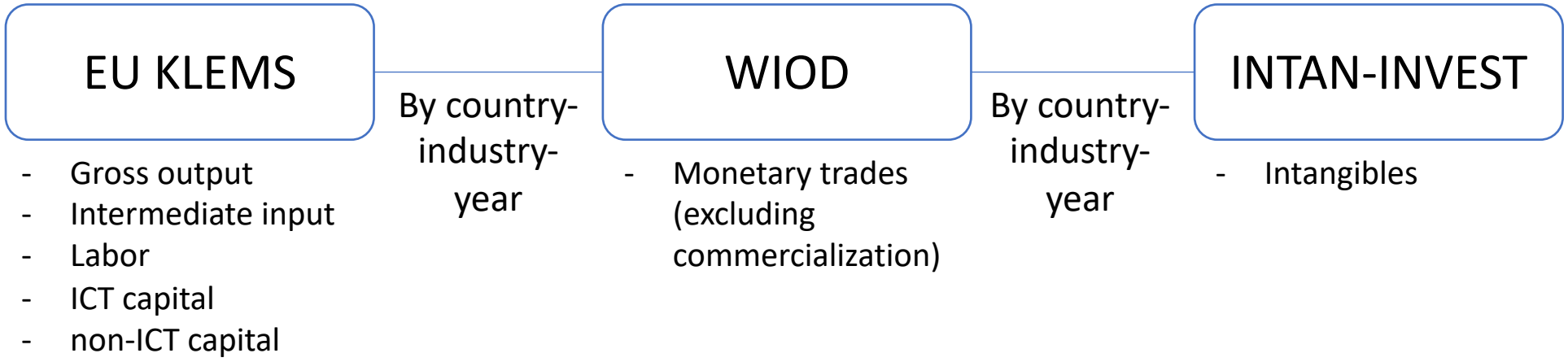
Interior Foreign Inter(intra)-industry ICT Externality

Literature Review: Intangibles

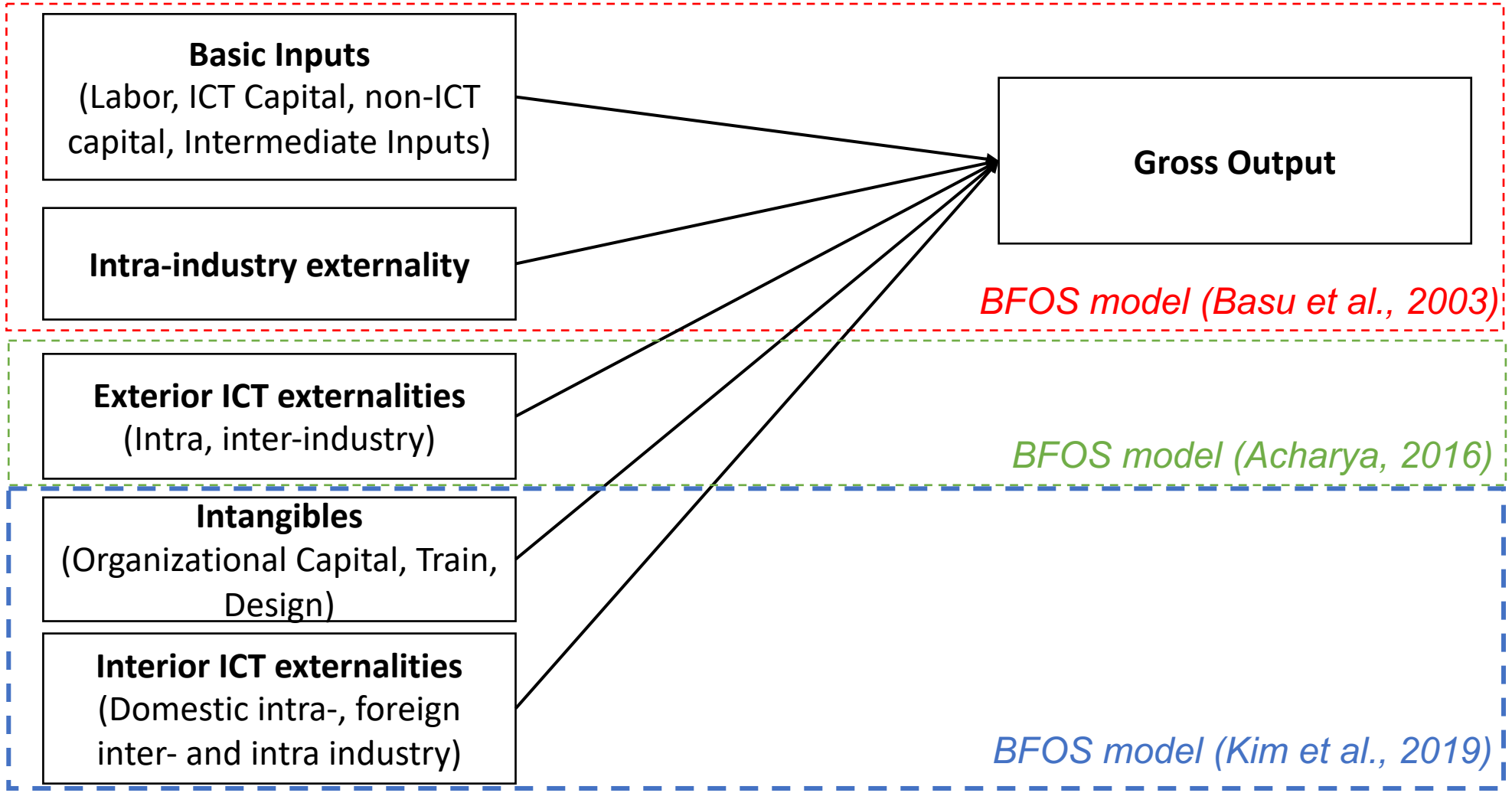
- Intangibles
  - To take full advantage of the new technology, complementary investment is necessarily. In order to realize the great potential of GPT, larger intangibles, unmeasured investment, and rethinking of the organization of production are needed (Brynjolfsson et al., 2018)
  - Intangible is classified into three factors: Computerized information, Innovative property, economic competencies.
  - *In order to avoid multi-counting issue of intangibles and keep the intangibles that are related to ICT, the only three following intangibles are selected*: **Organizational capital** (Bloom et al., 2012; Brynjolfsson, 1993; Brynjolfsson and Hitt, 2000), **Train**, **Design**

Data

- Country-industry level panel data (EU KLEMS, WIOD, INTAN-INVEST)
  - 15 countries: Austria (AT), Czech Republic (CZ), Germany (DE), Denmark (DK), Spain (ES), Finland (FI), France (FR), Hungary (HU), Italy (IT), Luxembourg (LU), Netherland (NL), Sweden (SE), Slovenia (SI), Slovakia (SK), United Kingdom (UK)
  - 16 industries: A, B, C, D-E, F, G, H, I, J, K, L, M-N, O, P, Q, R-S-T
  - 2000-2014



Research Model



Result

	Dependent variable:		
	GO.ldiff		
	(1)	(2)	(3)
Labor	0.297*** (0.018)	0.301*** (0.018)	0.301*** (0.018)
ICT capital	-0.025** (0.013)	0.012 (0.013)	0.012 (0.013)
non-ICT capital	0.131*** (0.037)	0.143*** (0.038)	0.144*** (0.038)
Intermediate Input	0.521*** (0.035)	0.534*** (0.036)	0.534*** (0.036)
ICT ratio * ICT (t)	0.113 (0.197)	0.030 (0.202)	0.021 (0.202)
ICT ratio * ICT (t-1)	-0.100 (0.215)	0.174 (0.219)	0.174 (0.219)
Intangible:Organization	0.122*** (0.014)	0.135*** (0.014)	0.134*** (0.014)
Intangible:Train	-0.001 (0.001)	-0.0001 (0.001)	-0.0001 (0.001)
Intangible:Design	0.016*** (0.004)	0.019*** (0.004)	0.019*** (0.004)
Ext.inter.ICT	-0.031*** (0.009)	-0.042*** (0.009)	-0.042*** (0.009)
Ext.intra.ICT	0.010*** (0.004)	0.010*** (0.004)	0.011*** (0.004)
Int.dm.inter.ICT	0.045*** (0.004)		
Int.fr.inter.ICT		0.004*** (0.001)	
Int.fr.intra.ICT			0.004*** (0.001)
Observations	2,134	2,134	2,134
R^2	0.372	0.340	0.341
Adjusted R^2	0.309	0.274	0.275
F Statistic (df = 12; 1939)	95.584***	83.317***	83.434***
Note:			*p<0.1; **p<0.05; ***p<0.01

Non-significant effect of Intra-industry externality

Positive effect of Intangibles (Organizational Capital and Design)

Focal industry's intra-industry externality: Externality occurring within the focal industry.
→ We are not able to separate firms within in the same industry.

Train shows negative coefficient at non-significant level.

1. Level of analysis → heterogeneity among industry due to the country-industry level analysis
2. Train is not correctly reported, which makes it difficult to measure.

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Negative exterior inter
Positive exterior intra

Positive ICT spillover

*** Positive exterior intra-industry**
- ICT externality received from the same industry can be used to complement an industry's productivity.

*** Negative exterior inter-industry**
- Firms may not use ICT in the same way and sometimes it may require an additional cost for implication.

*** Positive ICT spillovers**
Due to the closeness not only in geography but also in the systematic aspect between domestic industries, domestic ICT spillover is greater than the foreign one.

Conclusion

- We contributes to advancing BFOS model empirically.
- The result shows the evidence of positive spillover to ICT use within country and across national boundaries.
- Empirical evidence to support the importance of the specific intangibles, especially organizational capital and design.

Thank you