What determines international and inter-sectoral knowledge flows? The impact of absorptive capacity, technological distance and spillovers

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Basic idea

Knowledge absorption and knowledge flows

- Knowledge absorption might enhance a focal knowledge stock
  - ‘enriched’ knowledge flows back to spillover source
  - ‘enriched’ knowledge diffuses to other industries/firms

Conceptual framework

Absorptive capacity & spillovers

- Ability of firms to understand and exploit external knowledge and to apply it to commercial ends (Cohen and Levinthal 1989)
- Absorptive capacity can be built by conducting own R&D activities
- "Second face" of R&D: Increases absorptive capacity and allows for spillover absorption
- Broadening of knowledge base through spillovers
  - Base for **further knowledge flows** (Mukherji and Silberman 2013)
  - Private and social benefits from **recombination** of past inventions with external ideas (Belenzon 2012, Yang et al. 2010)

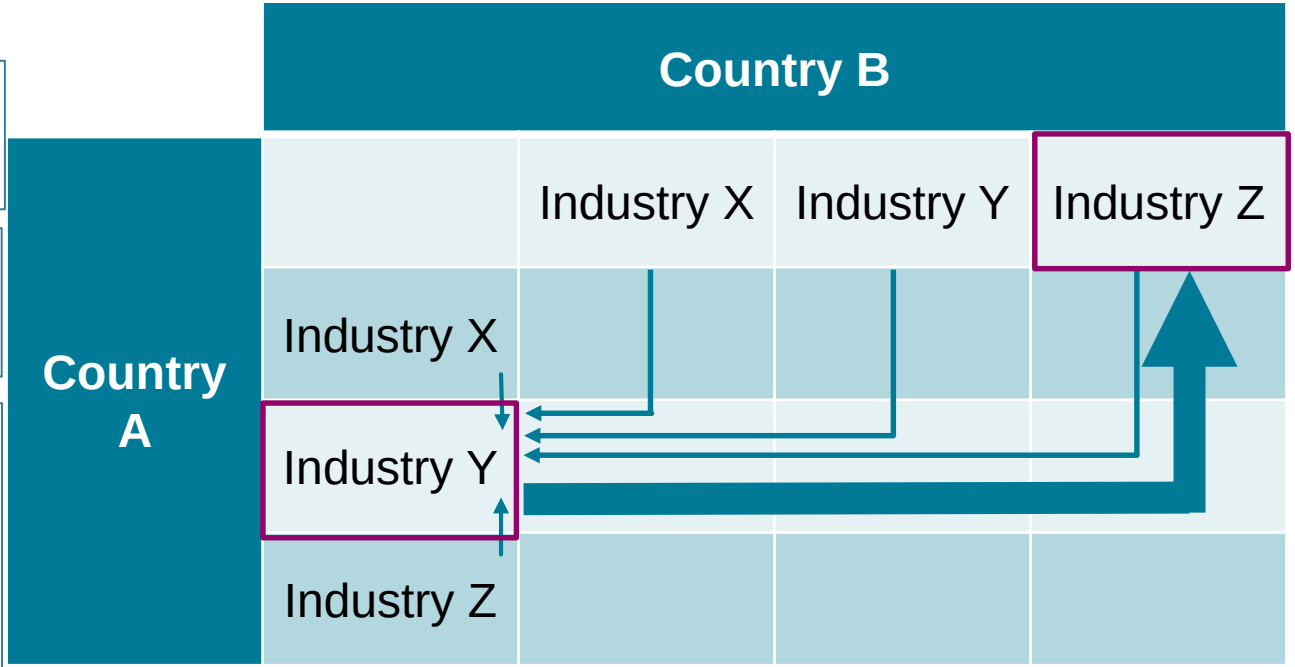
Basic idea

Knowledge flows from A,Y to B,Z

"Input" knowledge of A,Y

"Output" knowledge of B,Z

External spillovers from A,X A,Z, B,X B,Y (not part of input-output pair)



Conceptual framework

Absorptive capacity & spillovers

Hypothesis 1a

Knowledge accumulated in both the **input sector-country** and in the **output sector-country** exerts a positive impact on further knowledge flows

Hypothesis 1b

Knowledge spillovers from **external sector-countries** (i.e. sector-countries that are not part of the input-output relationship) exert a positive impact on further knowledge flows from the input to the output sector-country

Conceptual framework

Technological distance

- Higher communication and learning costs as firms are less able to recognize and absorb knowledge that is different to their own knowledge base (Malerba et al. 2013)

Conceptual framework

Technological distance

Hypothesis 2

Technological distance between countries, sectors and sector-countries has a negative impact on further knowledge flows between an input sector-country and an output sector-country

Conceptual framework

Low- vs. high-tech sectors

- High-tech sectors have larger knowledge bases
- They act as learning sources for others (laggard countries/industries/firms) (Griffith et al. 2004, Peri 2005, Mancusi 2008)
- Low-tech sectors might become more valuable knowledge source if they have enriched their knowledge base with high-tech knowledge

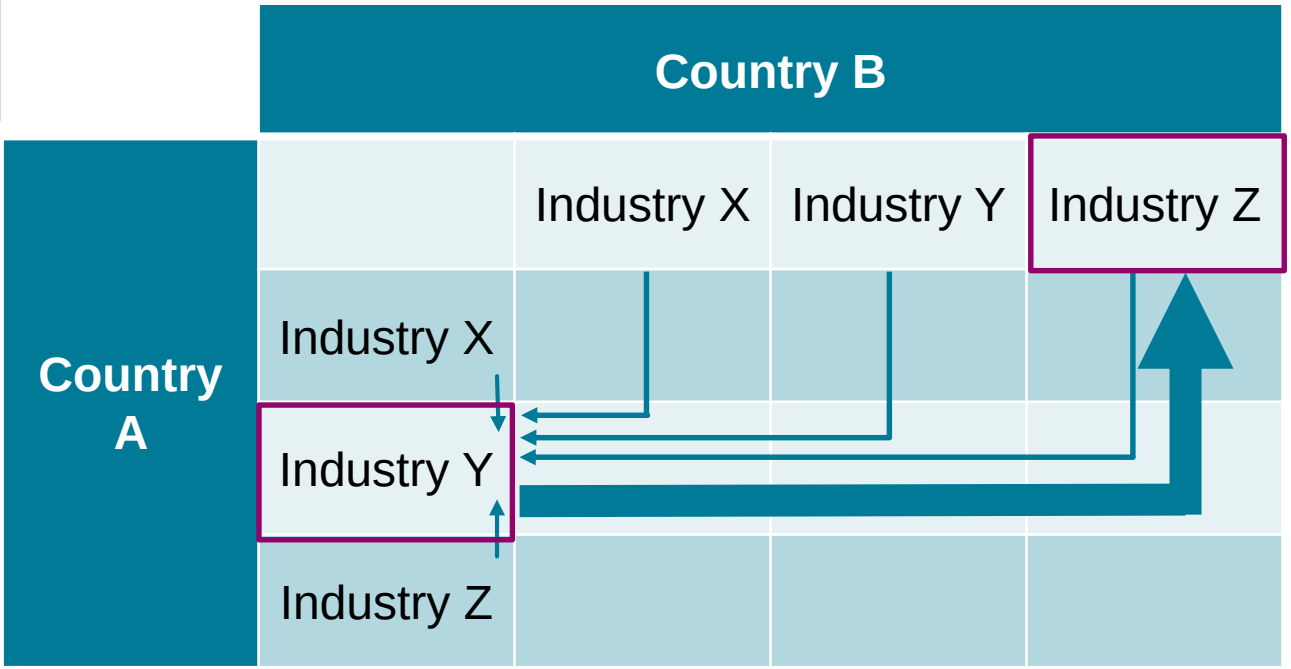
Basic idea

Knowledge flows from A,Y to B,Z

"Input" knowledge of A,Y (**low-tech)**

"Output" knowledge of B,Z (**high-tech**)

External spillovers from A,X A,Z, B,X B,Y



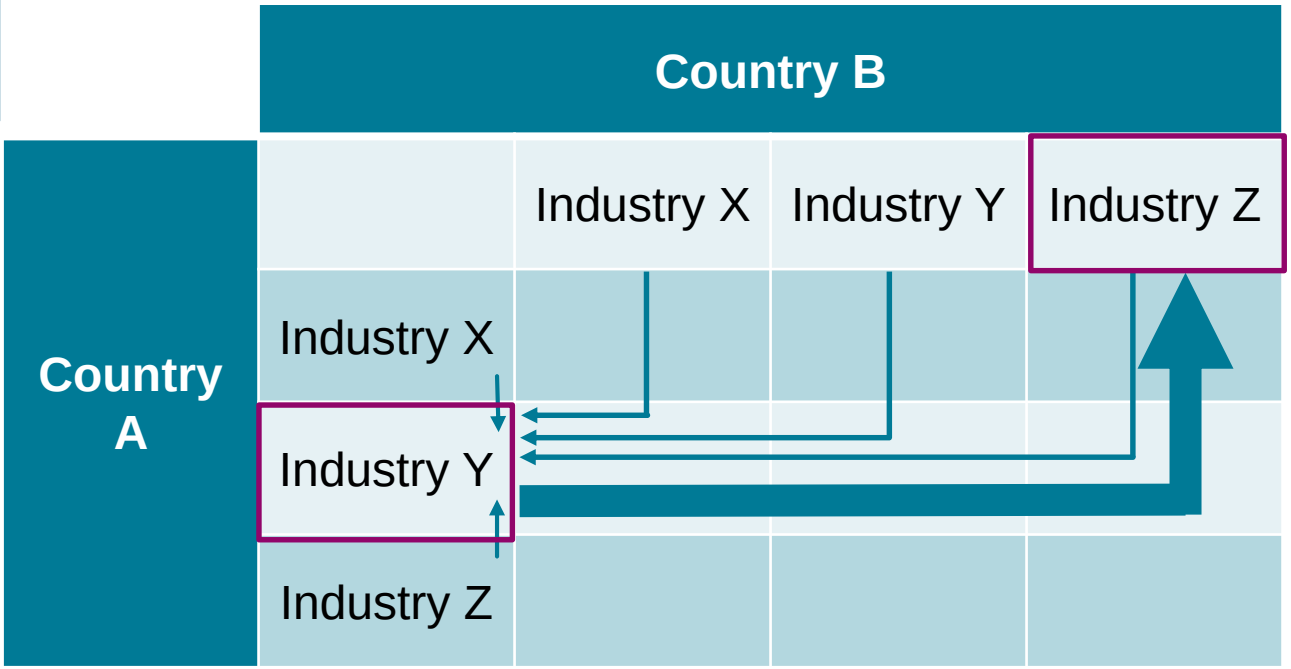
Basic idea

Knowledge flows from A,Y to B,Z

"Input" knowledge of A,Y (**high-tech)**

"Output" knowledge of B,Z (**low-tech**)

External spillovers from A,X A,Z, B,X B,Y



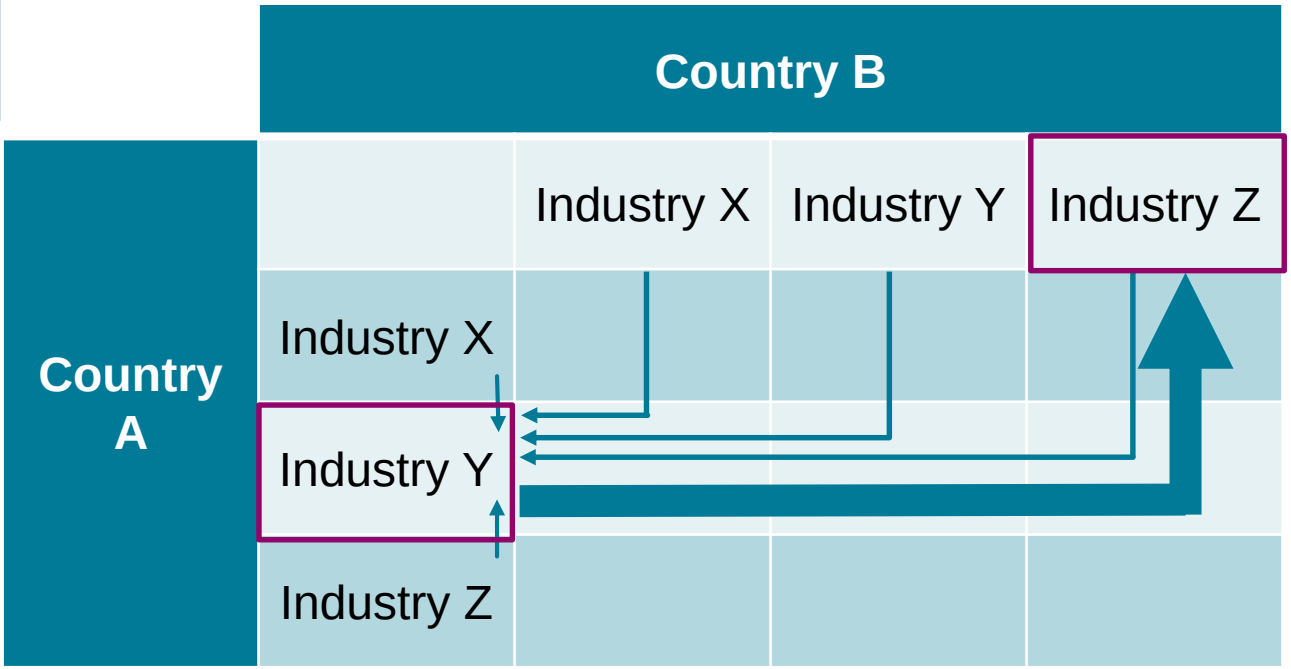
Basic idea

Knowledge flows from A,Y to B,Z

"Input" knowledge of A,Y

"Output" knowledge of B,Z

External spillovers from A,X A,Z, B,X B,Y (**high-tech component**)



Conceptual framework

Low- vs. high-tech sectors

Hypothesis 3a

Knowledge accumulated in the output sector-country only exerts a positive impact on further knowledge flows from the input to the output sector-country if the **output sector-country** is **high-tech**

Hypothesis 3b

Knowledge spillovers from external sector-countries only exert a positive impact on further input-output knowledge flows if the **external sectors** are **high-tech**

Data and variables

- Input-output tables to analyze knowledge flows (139,876 sector-country pairs)
- Patent publications for 22 countries and 17 industries applied for between 1995 and 2005, citations within 5 years, technological fields, assignee countries from **PATSTAT**
- Transformation of IPC codes to industries with concordance table (Lybbert and Zolas 2014)
- Industry and country data from **OECD** (ANBERD, STAN) and the **World Bank** (World Development Indicators)

Data and variables

Variable	Description	Source	Related literature
Citations			
$C_{ci,si,co,so,t}$	Number of forward citations within 5 years after publication of patent application in input sector-country si,ci received by output sector-country so,co	PATSTAT	**Citations as proxies for knowledge flows** Jaffe et al. 1993 Peri 2005 Maurseth & Verspagen 2004

Data and variables

Variable	Description	Source	Related Literature
R&D and spillover variables			
R&D_i_{t-1}	R&D stock of ci,si in t-1	OECD ANBERD	
R&D_o_{t-1}	R&D stock of co,so in t-1	OECD ANBERD	
Spillovers_i_{t-1}	Weighted sum of R&D stocks of cj,sj,t-1, weighted with the share of backward citations from ci,si to cj,sj *	ANBERD, PATSTAT	Hall et al. 2010 Mancusi 2008
Spillovers_o_{t-1}	Weighted sum of R&D stocks of cj,sj,t-1, weighted with the share of backward citations from co,so to cj,sj *	ANBERD, PATSTAT	

* The share of backward citations is the number of backward citations from c,s,t-1 to cj,sj,t-T divided by the total number of backward citations of c,s,t-1

Data and variables

Variable	Description	Source	Related Literature
Technological distance			
techdist_c	Technological distance between ci,t and co,t (1-uncentered correlation between share of patents of ci,t and co,t in 17 industries)	PATSTAT	Peri 2005 Jaffe 1986
techdist_s	Technological distance between si,t and so,t (1-uncentered correlation between share of patents of si,t and so,t in tech fields)		
techdist_cs	Technological distance between ci,si,t and co,so,t (1-uncentered correlation between share of patents of ci,si,t and co,so,t in tech fields)		

Data and variables

Control variables		
R&D and investment intensity, no. employees (in ln), GDP (in ln), GDP p.c., % researchers, input & output country and industry dummies, time dummies, gravity variables	OECD STAN, World Bank WDI	Egger & Pfaffermayr 2003

Empirical model

- Estimation of a gravity model with Poisson (following Peri 2005, Boesenberg & Egger 2016) *

$$C_{ci,si,co,so,t} = \exp(\alpha_{1i} lnR\&D_{ci,si,t-1} + \alpha_{1o} lnR\&D_{co,so,t-1} + \alpha_{2i} lnSPILL_{ci,si,t-1} + \alpha_{2o} lnSPILL_{co,so,t-1} + \beta_1 tech\_dist_{ci,co} + \beta_2 tech\_dist_{si,so} + \beta_3 tech\_dist_{si,so} + \boldsymbol{gravity'_{ci,co}\beta_4} + \boldsymbol{x'_{ci,t}\delta_{1i} + x'_{co,t}\delta_{1o}} + \boldsymbol{x'_{ci,si,t}\delta_{2i} + x'_{co,so,t}\delta_{2o}} + \vartheta_{ci} + \vartheta_{co} + \vartheta_{si} + \vartheta_{so} + \vartheta_t + \varepsilon_{ci,si,co,so,t})$$

* The basic gravity model includes supply factors of the export country, demand factors of the import country, and trade supporting and impeding determinants (geographical and cultural)

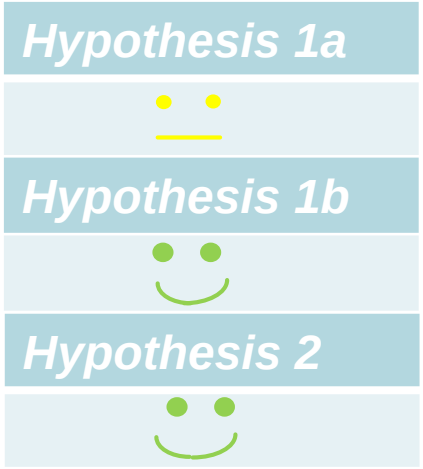
Main findings

- Knowledge from **output sector-country** or external knowledge associated with output sector-country (‘cited’ by it) most important source for the generation of further knowledge flows (especially the **high-tech output** sector-country)
- Additional external **knowledge spillovers** are most relevant if they come from **high-tech** sectors and if the recipient input sector is **low-tech**
- Evidence that knowledge flows based on an input low-tech sector-country benefit from a broader variety of knowledge sources

Main findings

Basic specification

	Number of citations
	Poisson RE
lnR&D_i_{t-1}	0.040
	(0.058)
lnR&D_o_{t-1}	0.151***
	(0.043)
lnSpillovers_i_{t-1}	0.013***
	(0.003)
lnSpillovers_o_{t-1}	0.013***
	(0.003)
techdist_s	-0.772
	(0.536)
techdist_cs	-1.394***
	(0.292)
techdist_c	-2.232***
	(0.678)
N	399,476



*, **, *** statistical significance at 10%, 5%, 1% level, cluster-robust standard errors in parentheses,
control variables, gravity variables, time, industry and country dummies included, constants and coefficients of 'remainder' spillovers (insignificant in this specification) are suppressed.
The remainder spillover component is calculated as follows:
lnSpillovers_remainder = ln((Spillovers_hightech+Spillovers-lowtech)/Spillovers_high-tech).
'Top' high-tech spillovers refer to sectors that are in the top 10% with respect to R&D intensity.

Main findings

High-tech and low-tech subsamples

	Input low-tech		Input top high-tech	
Number of citations	output low-tech	output top high-tech	output low-tech	output top high-tech
	Poisson RE	Poisson RE	Poisson RE	Poisson RE
lnR&D_i_{t-1}	-0.028	-0.083	1.071***	0.221
	(0.028)	(0.086)	(0.301)	(0.499)
lnR&D_o_{t-1}	0.063**	0.640***	-0.041	1.552***
	(0.026)	(0.234)	(0.074)	(0.418)
lnSpillovers_i_{t-1}	0.009**	0.002	0.016	0.005
	(0.004)	(0.008)	(0.010)	(0.008)
lnSpillovers_o_{t-1}	0.016***	0.025***	0.004	0.002
	(0.004)	(0.009)	(0.005)	(0.006)
techdist_s	-1.267***	-1.191*	-0.183	-8.623
	(0.359)	(0.723)	(0.946)	(6.395)
techdist_ cs	-1.463***	-1.480***	-1.355**	0.536
	(0.203)	(0.526)	(0.571)	(1.346)
techdist_c	-0.790***	-0.250	-1.404*	-3.793**
	(0.278)	(0.658)	(0.792)	(1.502)
N	345,701	56,479	45,971	7,804

Hypothesis 3a

*, **, *** statistical significance at 10%, 5%, 1% level, cluster-robust standard errors in parentheses,
control variables, gravity variables, time, industry and country dummies included, constants and coefficients of 'remainder' spillovers are suppressed (insignificant in this specification).
'Top' high-tech sectors refer to sectors that are in the top 10% with respect to R&D intensity.

Main findings

High-tech and low-tech subsamples with high-tech spillovers

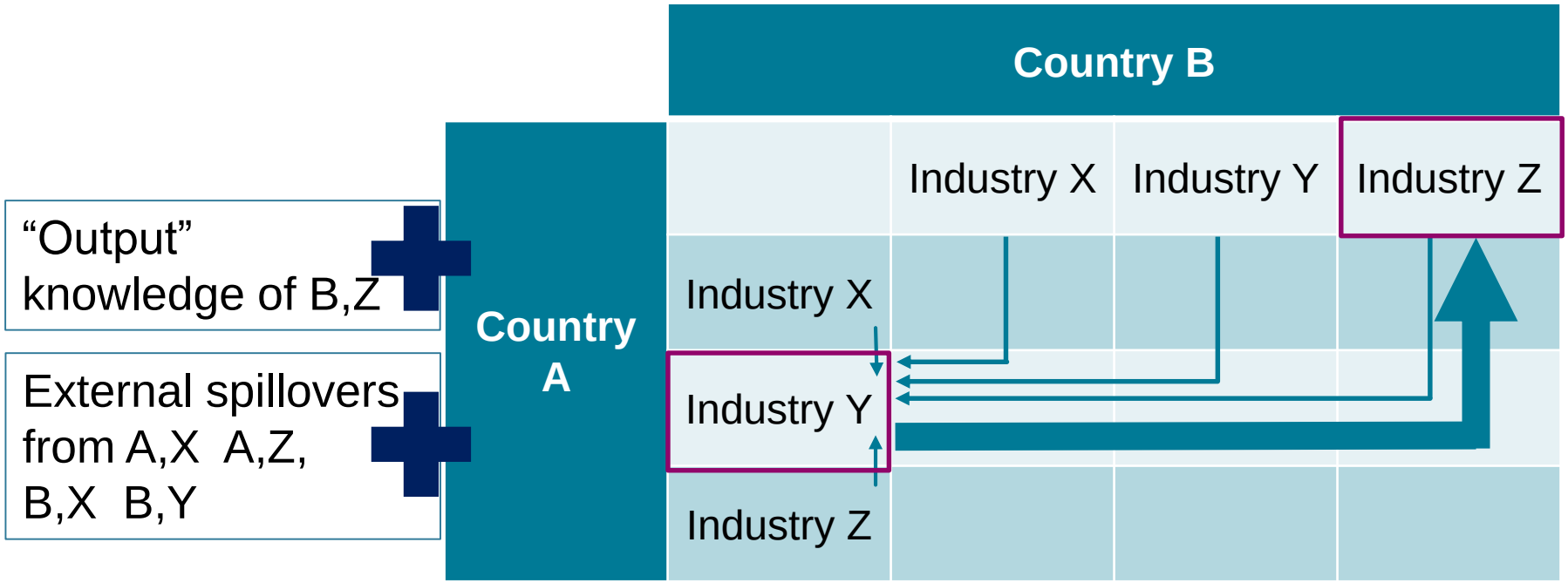
	Input low-tech		Input top high-tech	
Number of citations	output low-tech	output top high-tech	output low-tech	output top high-tech
	Poisson RE	Poisson	Poisson RE	Poisson RE
lnR&D_i$_{t-1}$	-0.028	-0.079	0.971***	0.224
	(0.028)	(0.084)	(0.303)	(0.507)
lnR&D_o$_{t-1}$	0.059**	0.705***	-0.043	1.565***
	(0.024)	(0.154)	(0.074)	(0.438)
lnSpillovers_i_tophigh$_{t-1}$	0.010**	0.003	0.016	0.008
	(0.004)	(0.008)	(0.011)	(0.007)
lnSpillovers_o_tophigh$_{t-1}$	0.017***	0.027***	0.005	0.007
	(0.004)	(0.010)	(0.005)	(0.005)
techdist_s	-1.225***	-1.208*	-0.197	-7.215
	(0.349)	(0.716)	(0.909)	(6.519)
techdist_ cs	-1.490***	-1.397***	-1.386**	0.532
	(0.201)	(0.520)	(0.553)	(1.361)
techdist_c	-0.785***	-0.344	-1.410*	-3.705**
	(0.282)	(0.660)	(0.795)	(1.469)
N	345,701	45,989	45,971	7,804

Hypothesis 3b

*, **, *** statistical significance at 10%, 5%, 1% level, cluster-robust standard errors in parentheses,
control variables, gravity variables, time, industry and country dummies included, constants and coefficients of 'remainder' spillovers are suppressed (insignificant in this specification).
The remainder spillover component is calculated as follows:
lnSpillovers_remainder = ln((Spillovers_hightech+Spillovers-lowtech)/Spillovers_high-tech).
'Top' high-tech sectors and spillovers refer to sectors that are in the top 10% with respect to R&D intensity.

Main findings

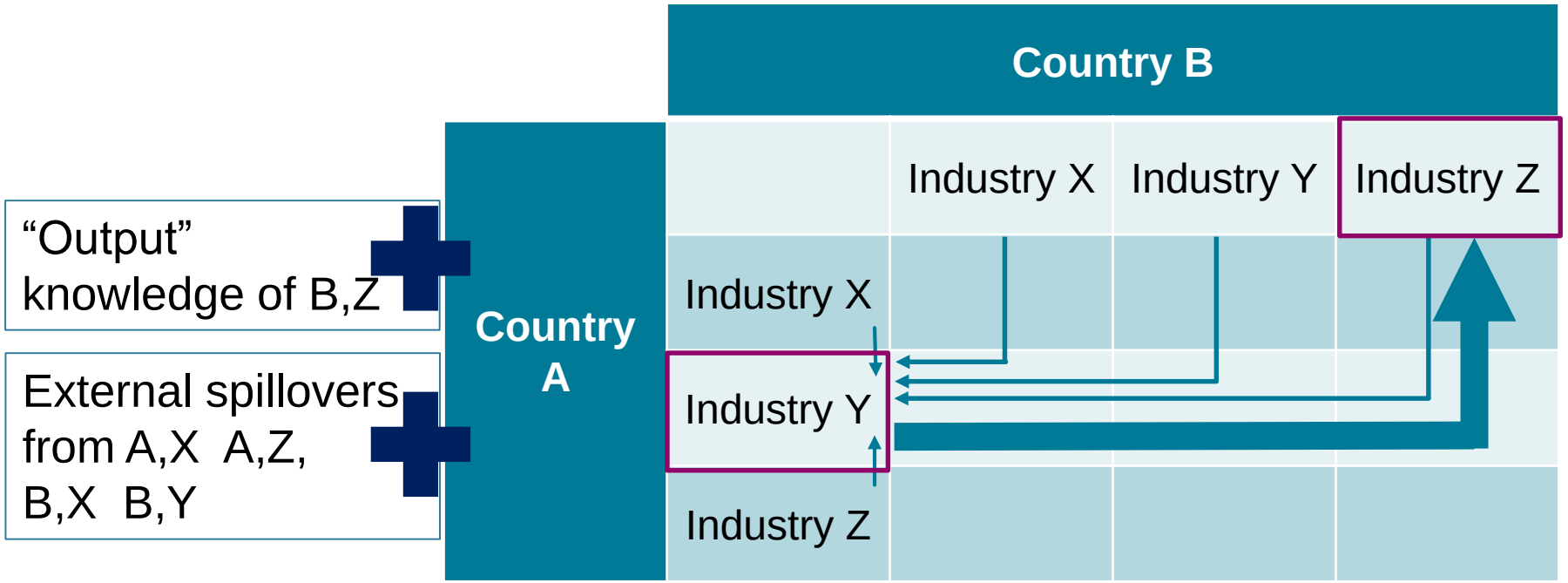
Knowledge flows from A,Y to B,Z



Main findings

Input low-tech sector

Knowledge flows from A,Y to B,Z



Main findings

Input high-tech sector

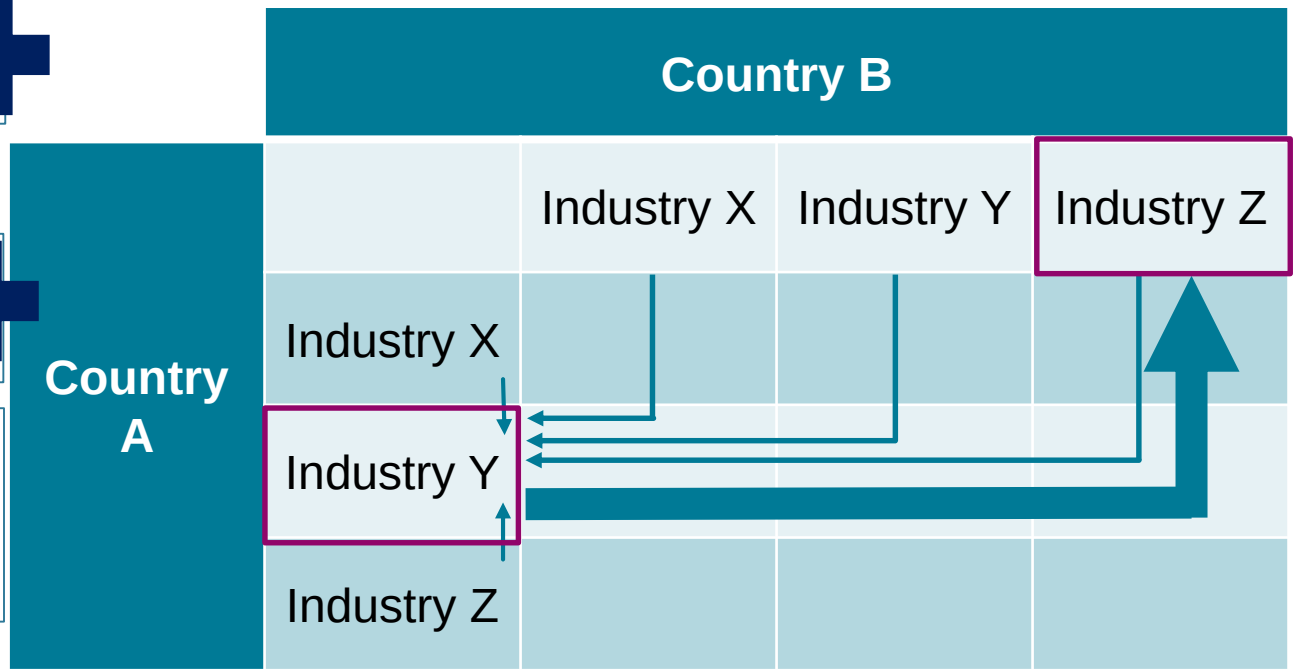
Only if output high-tech sector

Knowledge flows from A,Y to B,Z

"Input" knowledge of A,Y

"Output" knowledge of B,Z

~~External spillovers from A,X A,Z, B,X B,Y~~



Main conclusions

- Output sector-country most important knowledge source for further knowledge flows (among the determinants studied)
- More isolated knowledge absorption and generation in high-tech sectors
- In low-tech sectors, '**learning**' from a variety of sources and esp. from output sectors that are 'top' **high-tech**

Main conclusions

- Knowledge spillovers from high-tech sectors to low-tech sectors support process of knowledge absorption and generation (reverse not true)
- Existing and familiar **knowledge relationships** main drivers of further knowledge generation and absorption
- Low-tech knowledge can be made more relevant by ‘recombining’ it with high-tech knowledge

Thank you for your attention

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