

IV Conference on Global Value Chains, Trade and Development

Appropriability of Intellectual Assets and the Organization of Global Supply Chains

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Background

Modern supply chains becoming more and more “global” in nature (suppliers located across different countries).

► **Integration** vs. **outsourcing** decision (‘make or buy’)

Central issue: **incomplete contracts** and **contract enforcement** (Antràs 2003, 2005; Antràs & Helpman 2004, 2008; Grossman & Helpman 2002, 2003, 2005).

Transaction cost theory stresses trade-off between gains from specialized outsourced supply and associated losses from hold-up problems → ***better contracting institutions** increase incidences of **outsourcing***

► Williamson (1971, 1975, 1985): better institutions **reduce hold-up problems** associated with outsourcing

Property right theory stresses trade-off between gains from stronger outsourced supplier’s incentives and associated losses from weaker rent extraction → ***better contracting institutions** increase incidences of **integration***

► Grossman & Hart (1986); Hart & Moore (1990): better institutions **reduce the need to create investment incentives** through outsourcing

Evidence? Most find support for **property right theory** (from Corcos et al. , 2013, to Eppinger & Kukharsky, 2017)

Few (e.g. Defever & Toubal, 2013) find support for **transaction cost theory**.

Our contribution

The focus of all existing works is on the contractual enforcement of input specifications.

Our aim is to highlight the parallel importance of the appropriability of intellectual property.

- ▶ *Incomplete protection of **Intellectual Property Rights (IPR)** entails additional **imitation risk** from outside competitors **on top of hold-up problem** between firm and supplier.*

In particular, we study how **IPR protection** in the country of input production **may affect the optimal allocation of ownership rights** along the value chain.

Two building blocks:

- ✓ A simple theory of knowledge creation/dissipation in sequential production
- ✓ Property rights model of sequential production à la Antràs & Chor (2013), Alfaro et al. (2017)

Our contribution

Model the **risk of imitation** in sequential global supply chains based on strength of IPRs in production location.

► Bring this concept into the Antràs & Chor (2013) **property rights model** of the sequential supply chain.

The firm's decision to integrate or to outsource a given stage in production depends on:

- ✓ **Relative position of stage** within the production line
- ✓ **Sequential substitutability/complementarity** of supplier investments along the chain
- + **Possibility of imitation** by competitors distorting suppliers' investment incentive structure under both integration and outsourcing (same set of available contracts)

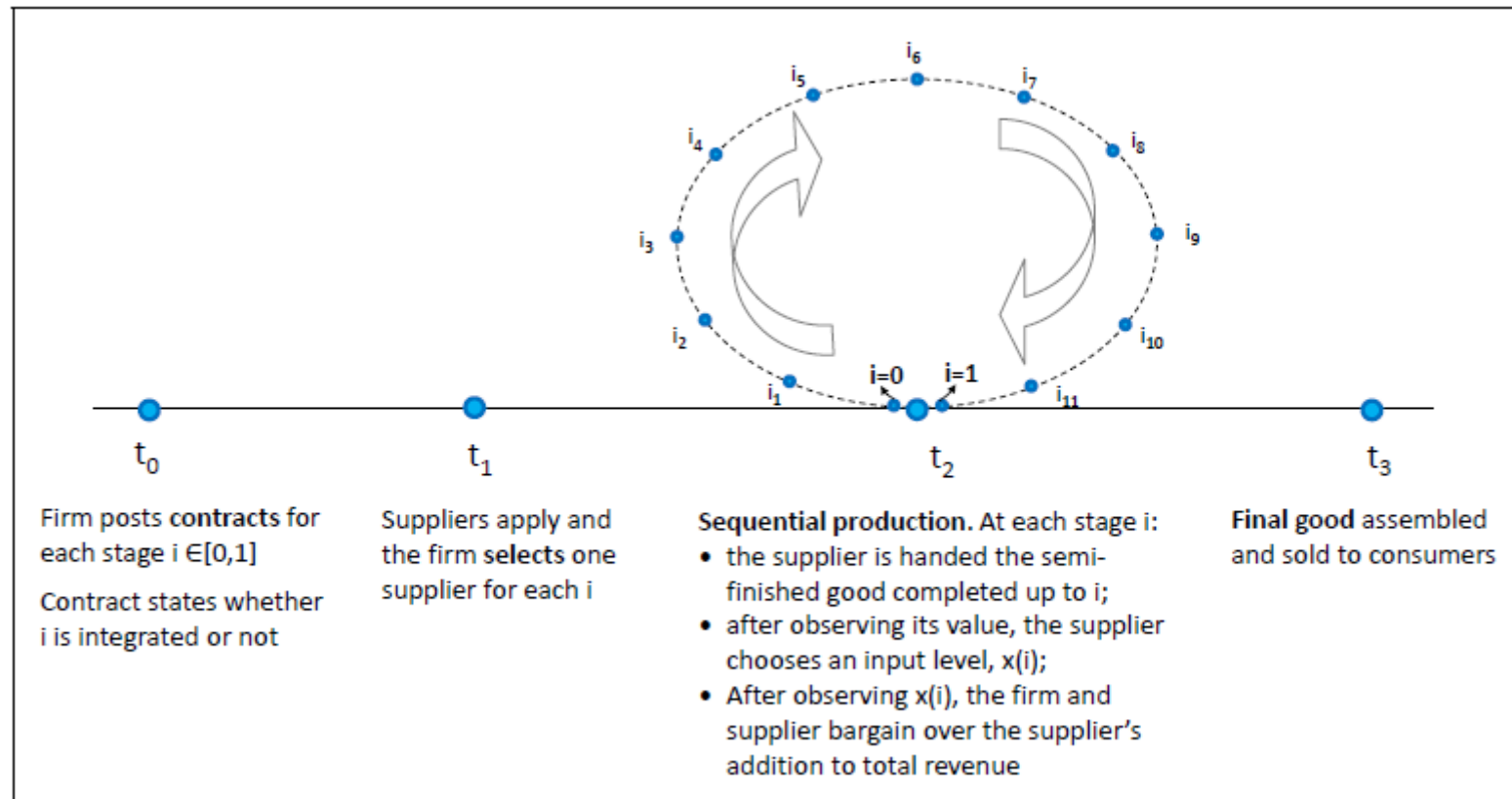
Theoretical predictions tested on firm-level data, using **trade, FDI and financial data on Slovenian firms and their subsidiaries** to measure propensity to integrate a given stage based on (i) upstreamness, (ii) complementarity of inputs, and (iii) IPR protection in the host country.

Imitation and sequential production

- ▶ Firm knows the '**production possibilities**' at each stage of the value chain → **at each stage problems must be solved** to transform production possibilities into actual input production → solving problems creates knowledge ('know-how'; Caliendo & Rossi-Hansberg, 2012).
- ▶ Depending on IPR protection, at each stage **technology may leak** ('imitation') → stage production possibilities and know-how become public knowledge → perfectly substitutable 'generic input' becomes available at that stage giving the firm an outside option in ex post bargaining with its supplier → hold up problem becomes more severe.
- ▶ The **probability of imitation** thus affects the incentives of suppliers to invest in the relationship with the firm.
- ▶ How this probability varies **across stages and countries** has crucial **implications for the firm's organization of the value chain**.

A model of sequential production

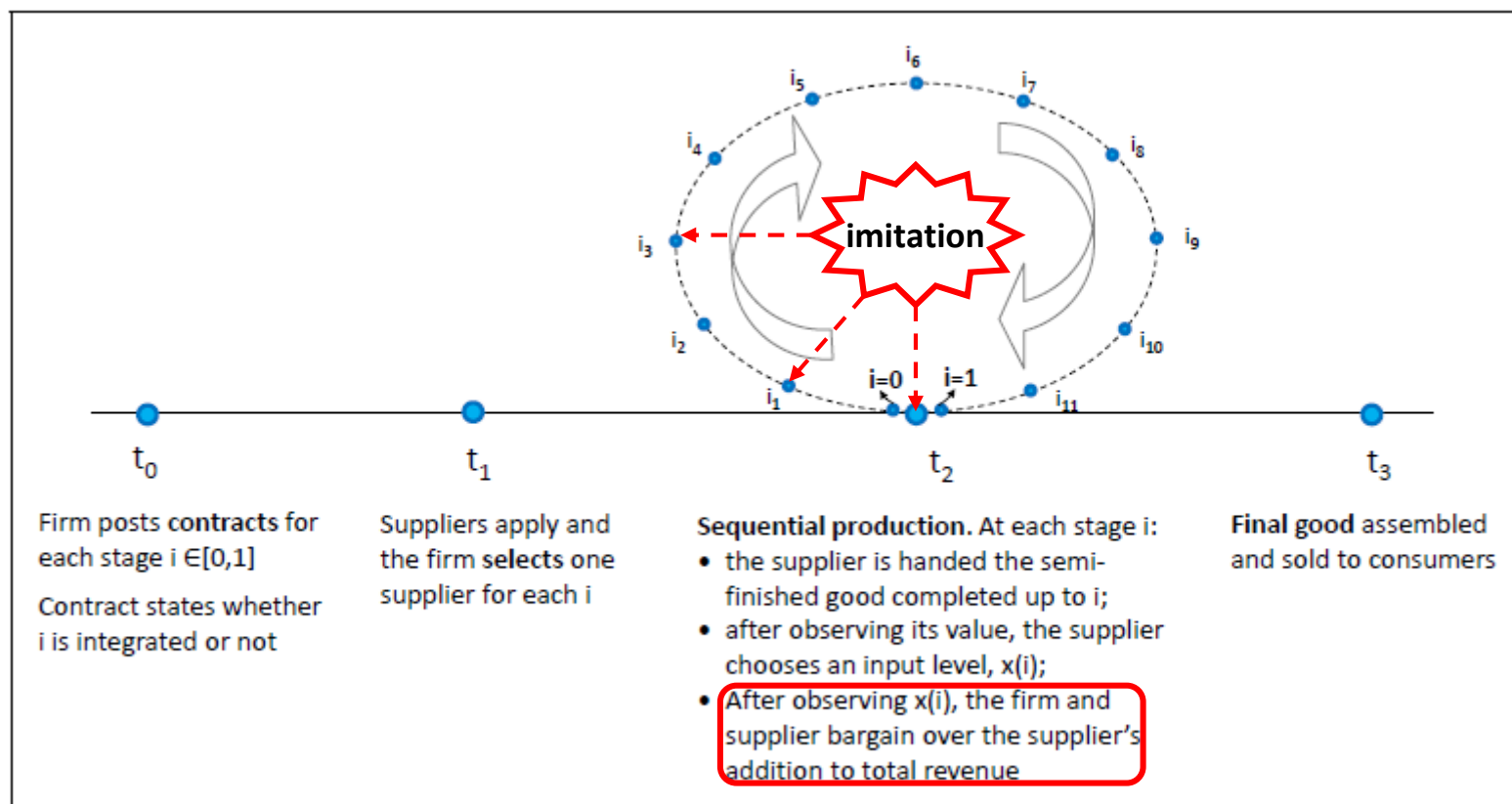
Antràs and Chor (2013), Alfaro et al. (2017) → property rights theory, sequential production, incomplete contracts.



Source: Alfaro et al (2017), Figure 2 Timing of Events

A model of sequential production with imitation

Antràs and Chor (2013), Alfaro et al. (2017) → sequential production, incomplete contracts.



Source: Alfaro et al (2017), Figure 2 Timing of Events

Property rights and sequential production

At any given stage of production, **integration allows the firm to extract more surplus** from its supplier, but...

...outsourcing leads supplier to invest relatively more as it gets a larger size of surplus → this is the **positive direct differential effect** of outsourcing on supplier compared to integration.

Indirect differential effect ('spillover'): investment by an independent supplier affects the incentives for all suppliers performing the subsequent stages in a way that depends on whether inputs are:

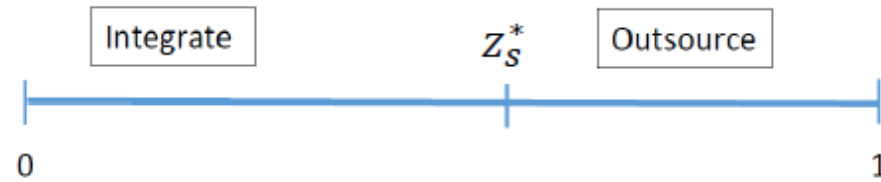
- ▶ **seq. complements** ($\rho > \alpha$) \Rightarrow indirect differential effect of outsourcing is **positive**.
- ▶ **seq. substitutes** ($\rho < \alpha$) \Rightarrow indirect differential effect of outsourcing is **negative**.

ρ = measure of output demand elasticity; α = measure of inputs substitutability

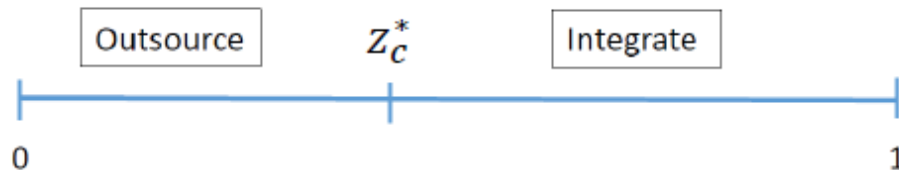
Property rights and sequential production

Position of and **inter-relation** between **stages** affect firm organization via **supplier incentive structure**.

- **Sequential Substitutes** → *upstream investment reduces marginal return of downstream investments.*



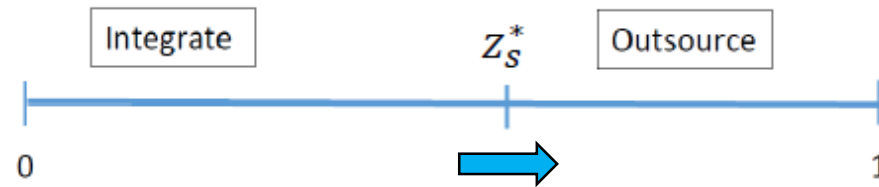
- **Sequential Complements** → *upstream investment increases marginal return of downstream investments*



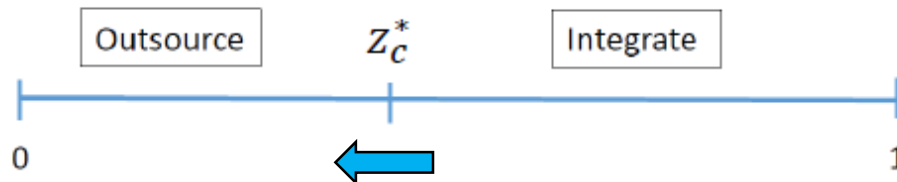
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Position of and **inter-relation** between **stages** affect firm organization via **supplier incentive structure**.

- **Sequential Substitutes** → *upstream investment reduces marginal return of downstream investments.*



- **Sequential Complements** → *upstream investment increases marginal return of downstream investments*



Alfaro et al. (2017): **improved contractibility reduces reliance on outsourcing** to overcome distortions associated with inefficient investment in the upstream part of the process.

Sequential production and imitation: Reprise

- ▶ Contract between firm and supplier is **incomplete in terms of input specifications, not in terms of intellectual property** → no risk of dissipation of technological knowledge within the relationship (i.e. no value of knowledge for supplier outside its relation with the firm)
 - ▶ There is however risk of imitation from outsiders
- Let $z \in (0, 1)$ index the sequence of inputs along the supply chain ($z=0$ most upstream) and $\varphi(z, \mu) \in (0, 1)$ be the probability that input z is not imitated when the strength of IPR protection is (inversely) indexed by $\mu \in (0, 1)$
- ▶ Firm decides organization for every stage before production starts, based on the expected contribution of each supplier
- Internalizing the effects of possible imitation

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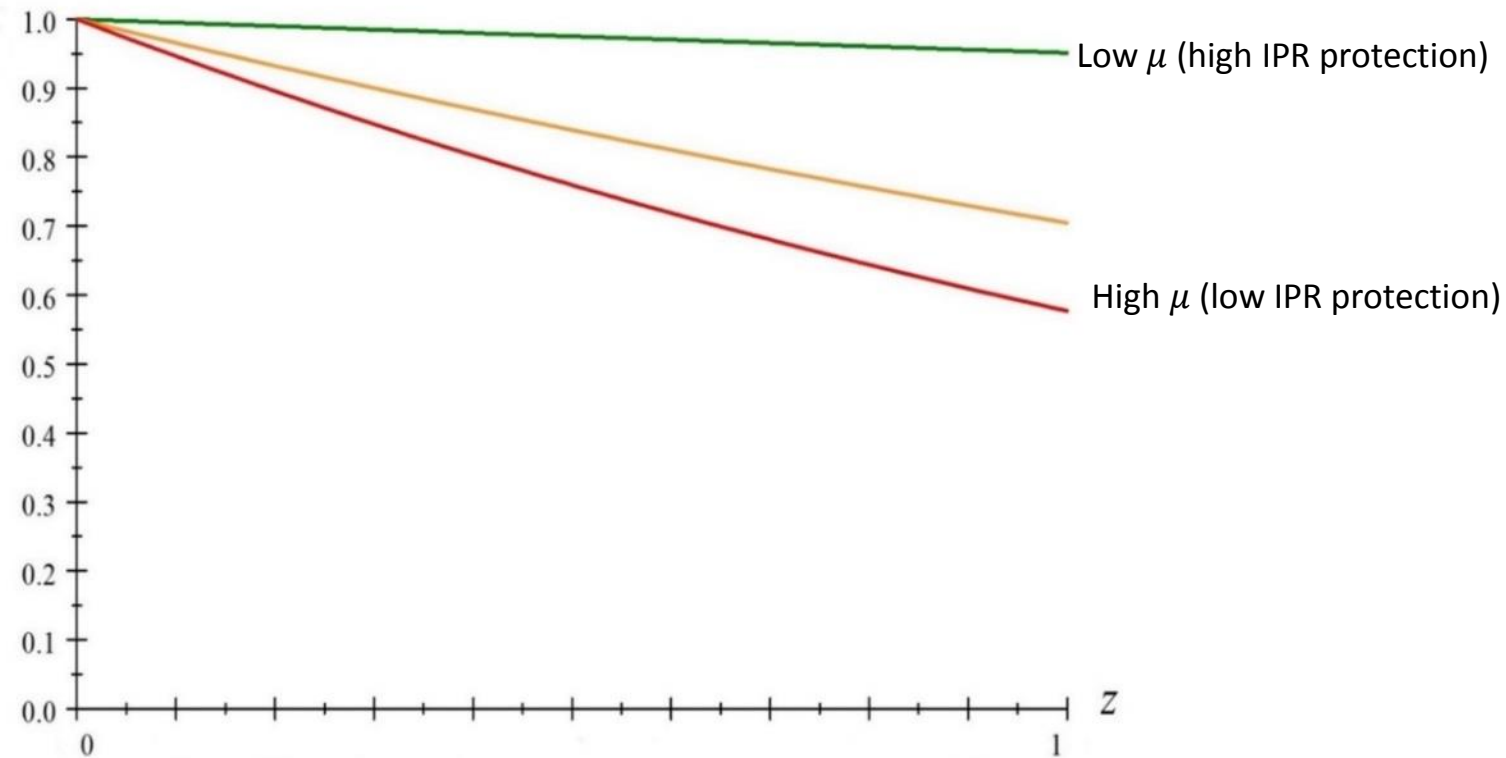
At time 0, when the firm decides organization mode for $\forall z$, the expected value of the final output is

$$q = \theta \left(\int_0^1 (\varphi(z, \mu) x(z))^\alpha I(z) dz \right)^{1/\alpha}$$

Sequential production and imitation: An example

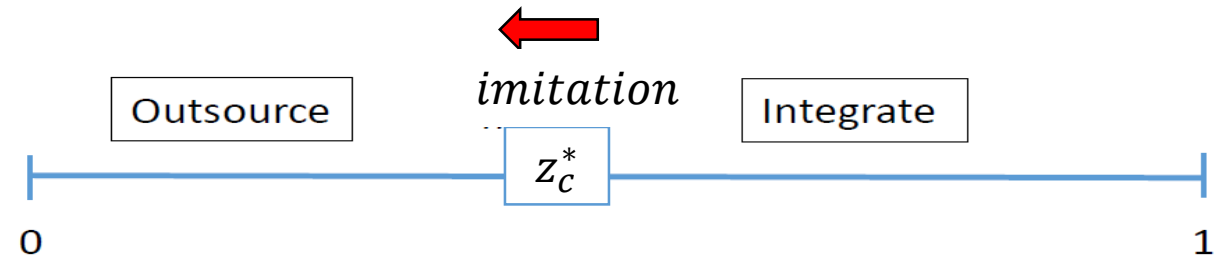
Ex-ante value of suppliers' input per unit of investment:

$\varphi_z(z, \mu) < 0$, $\varphi_\mu(z, \mu) < 0$, $\varphi_{z\mu}(z, \mu) > 0$ -- e.g. Poisson $\varphi_z(z, \mu) = \exp(-\mu x)$



Predictions on the role of IPR (i)

Seq. complements case ($\rho > \alpha$):

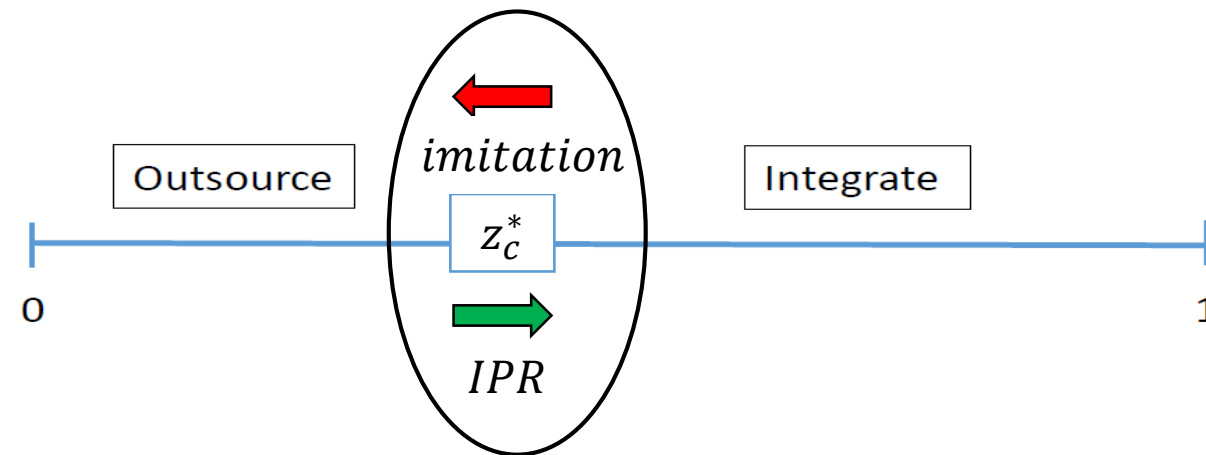


Lack of IPR shifts the cut-off stage z_c^* towards left

- ▶ Trade-off between upstream incentives provision through outsourcing and downstream rent extraction through integration.
- ▶ **Direct effect:** imitation reduces the ability to use outsourcing to incentivize suppliers at all stages → **z_c^* falls (-)**
- ▶ **Indirect effect:** as for given cut-off z_s^* imitation reduces the 'weight' of downstream rent extraction, the number of integrated stages increases to restore balance → **z_c^* falls (-)**

Predictions on the role of IPR (i)

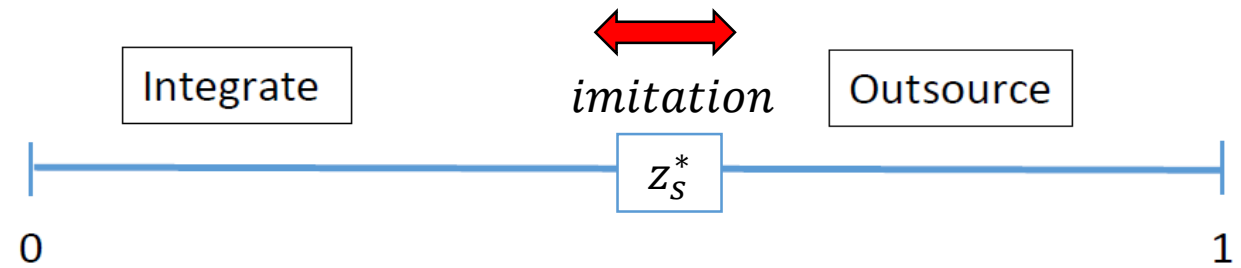
Seq. complements case ($\rho > \alpha$):



Stronger IPR protection favors outsourcing by increasing the average *downstreamness* of integrated stages relative to outsourced stages

Predictions on the role of IPR (ii)

Seq. substitutes case ($\rho < \alpha$):

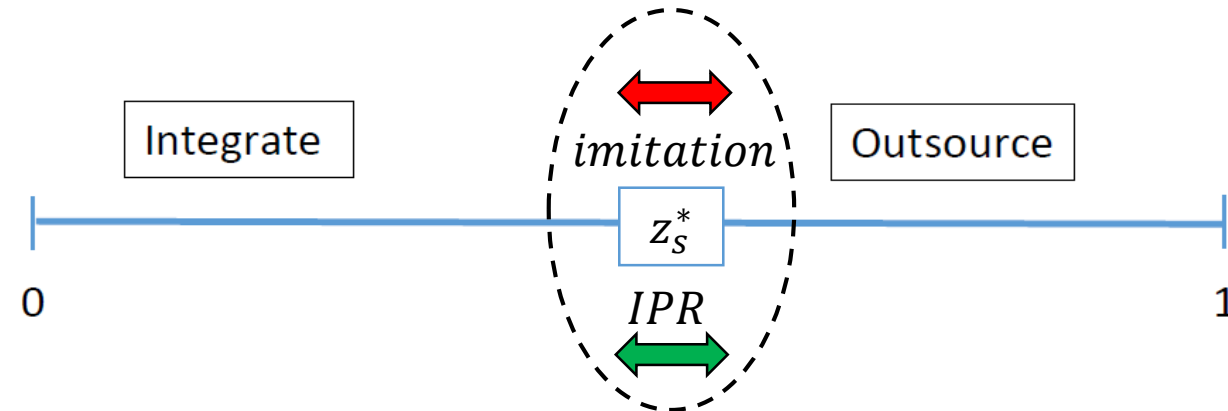


Lack of IPR shifts the cut-off stage z_s^* towards left:

- ▶ Trade-off between upstream rent extraction through integration and downstream incentives provision through outsourcing.
- ▶ **Direct effect:** imitation reduces the ability to use outsourcing to incentivize suppliers at all stages → **z_s^* rises (+)**
- ▶ **Indirect effect:** as for given cut-off z_s^* imitation reduces the 'weight' of downstream incentive provision, the number of outsourced stages increases to restore balance → **z_s^* falls (-)**

Predictions on the role of IPR (ii)

Seq. substitutes case ($\rho > \alpha$):



Stronger IPR protection has an ambiguous effect

Data and outcome variable

We test our results using **transaction-level trade data on Slovenian manufacturing firms (2007-2010)**, matched with:

- (i) detailed information of origin/destination of inward/outward **FDI**
- (ii) firm balance sheets

► 5,766 firms, imports from 87 countries, outward FDI with 37 partner countries

Slovenia → 2004 EU member, 2007 adopted the euro; **increasing involvement in GVC** (WTO index: 58.7 in 2011 – top OECD quartile), mostly strong **backward** participation (WTO, 2016)

- ✓ Exploit info on core activity of firm's affiliate
- ✓ Inputs imported that are classified under core activity of affiliate (at 4-digit industry level) regarded as integrated (as in Alfaro et al, 2017) → **dependent variable**: probability a firm i integrates input h for product k when sourcing from country j at time t ('probability of integration') → **$(1 - z_c^*)$ for complements and $(z_s^* - 1)$ for substitutes**
- ✓ Accounts for firms being able to engage in both integration and outsourcing in a host country

Explanatory variables

Upstreamness. We identify position of imported input in GVC with respect to firm's output (core export product at 6-digit HS) from **Alfaro et al. (2017)** → input output tables

IPR Protection. Log of **Park (2008)** index of patent protection in each host country (coverage, membership in international treaties, duration of protection, enforcement mechanisms, restrictions of patents rights)

Complementarity. Baseline → **ρ measure** of Antràs & Chor (2013): **complements** ($d_{compl} = 1$): above-median import demand elasticity for a firm's core export product; **substitutes** ($d_{compl} = 0$) otherwise.

Robustness with

► **(industry-level) proxy for α** → inputs classified within same industry feature higher technological substitutability

-- *Herfindahl index, how (6-digit) inputs are spread across different (3-digit) industries, above/below median*

► **$\rho \# \alpha$ (ind.)** → product of the above two measures, still industry-level

► **$\rho - \alpha$ (elast.)** → demand elasticity of the core products vs. weighted average demand elasticity of all intermediates for the firms, firm-level (variant of the proxy of Alfaro et al, 2017)

Controls

- ✓ **Firm-specific controls** → age, size, capital intensity of production, labor productivity, export orientation and financial leverage (debt-to-assets ratio).
- ✓ **Annual dummy variables** → control for macroeconomic shocks.
- ✓ **Partner-country dummies** → country-specific time-invariant effects.
- ✓ **Industry fixed effects** → industry: core export product at 1-digit HS level.

Descriptive statistics

	Substitutes (d_compl =0)		Complements (d_compl =1)	
	Mean	Std. Dev.	Mean	Std. Dev.
d_OutFDI	0.1856	0.389	0.1942	0.396
d_OutFDI_bilateral	0.0371	0.189	0.0431	0.203
d integr	0.0007	0.027	0.0009	0.029
d integr_vert	0.0006	0.025	0.0007	0.026
Upstreamness	2.527	1.076	2.513	1.075
Import demand elasticity	0.869	0.194	1.582	4.550
Inputs demand elasticity	1.128	1.946	1.220	1.107
Industry Herfindahl index	0.714	0.077	0.689	0.115
IPR index	4.410	0.357	4.413	0.354
Rule of law index	1.045	0.780	1.011	0.794
Age	14.350	7.385	14.194	7.463
Employment	61.857	369.294	49.708	171.058
Ex-Propensity	0.302	0.322	0.301	0.322
K-intensity	84,363	388882	80,424	280194
L-productivity	42,799	83407	41,026	60307
Debt assets ratio	0.645	0.836	0.650	0.368
No of observations	475,861		360,531	

Results - Full sample specification ('triple interaction')

► Disaggregated at firm-year-product-country level: integration of an input from a country in a given year by a firm

	(1) Probit, ρ	(2) Probit C-M, ρ	(3) RE probit, ρ	(4) RE probit, ρ	(5) RE probit, ρ
Comp	11.927** (5.479)	12.244** (5.526)	25.370*** (8.399)	39.761*** (12.300)	38.648*** (12.917)
lnIPR	0.774 (2.256)	0.751 (2.364)	-1.864 (3.845)	-3.157 (5.530)	4.198 (9.447)
Comp*lnIPR	-7.793** (3.737)	-8.001** (3.764)	-16.553*** (5.626)	-26.118*** (8.177)	-25.323*** (8.688)
Upstr	0.634 (0.945)	0.669 (0.932)	0.099 (2.077)	-0.787 (3.265)	0.725 (4.124)
Comp*Upstr	-6.430* (3.498)	-6.619* (3.565)	-12.371** (5.153)	-17.426** (7.386)	-18.409*** (6.993)
lnIPR*Upstr	-0.579 (0.698)	-0.602 (0.690)	-0.401 (1.423)	0.152 (2.221)	-0.999 (2.809)
Comp*lnIPR*Upstr	4.186* (2.318)	4.308* (2.360)	8.078** (3.426)	11.505** (4.882)	12.180*** (4.673)
Country dummies	yes	yes	no	no	yes
time dummies	yes	yes	yes	yes	yes
Industry dummies	yes	yes	no	yes	yes
Observations	615,847	611,495	791,911	725,141	615,847

As in Antràs & Chor
(2013): for **complements**,
outsourcing → upstream
integration → downstream

► Includes lagged firm characteristics (1-5), firm characteristics (2); gravity variables (3-4); constant term (1-5)

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For **complements**, IPRs increase reliance on outsourcing

This is **more so**, the **more downstream** we go along the supply chain.

► Includes lagged firm characteristics (1-5), firm characteristics (2); gravity variables (3-4); constant term (1-5)

Results - Split sample specification

	(1)	(2)	(3)	(4)
	RE prob, ρ	RE prob, ρ	RE prob, ρ	RE prob, ρ
	Comp	Subst	Comp	Subst
InIPR	-26.81*** (5.498)	-2.503 (5.975)	-22.36* (12.489)	-16.45 (17.889)
Upstr	-14.58*** (5.169)	-1.773 (3.870)	-20.91*** (6.347)	-2.092 (5.672)
InIPR*Upstr	8.822** (3.430)	0.730 (2.647)	13.050*** (4.200)	0.786 (3.813)
Rule_of_law				
Rule_of_law *Upstr				
Country dummies	no	no	yes	yes
Time dummies	yes	yes	yes	yes
Industry dummies	yes	yes	yes	yes
Observations	308,518	390,751	246,902	312,789

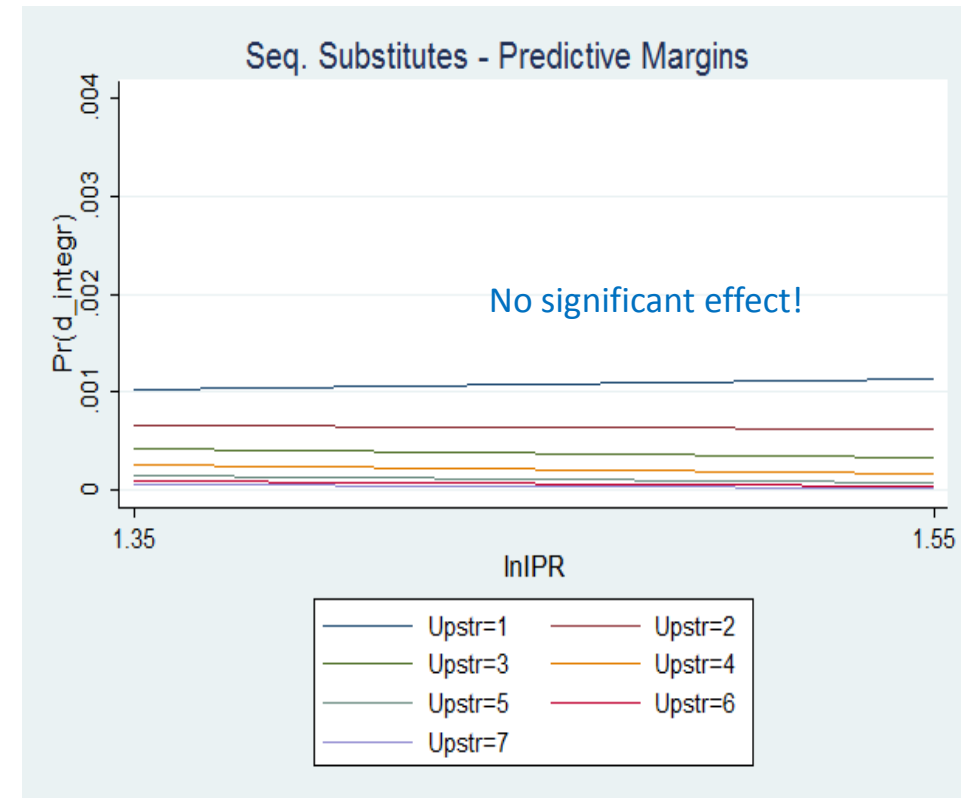
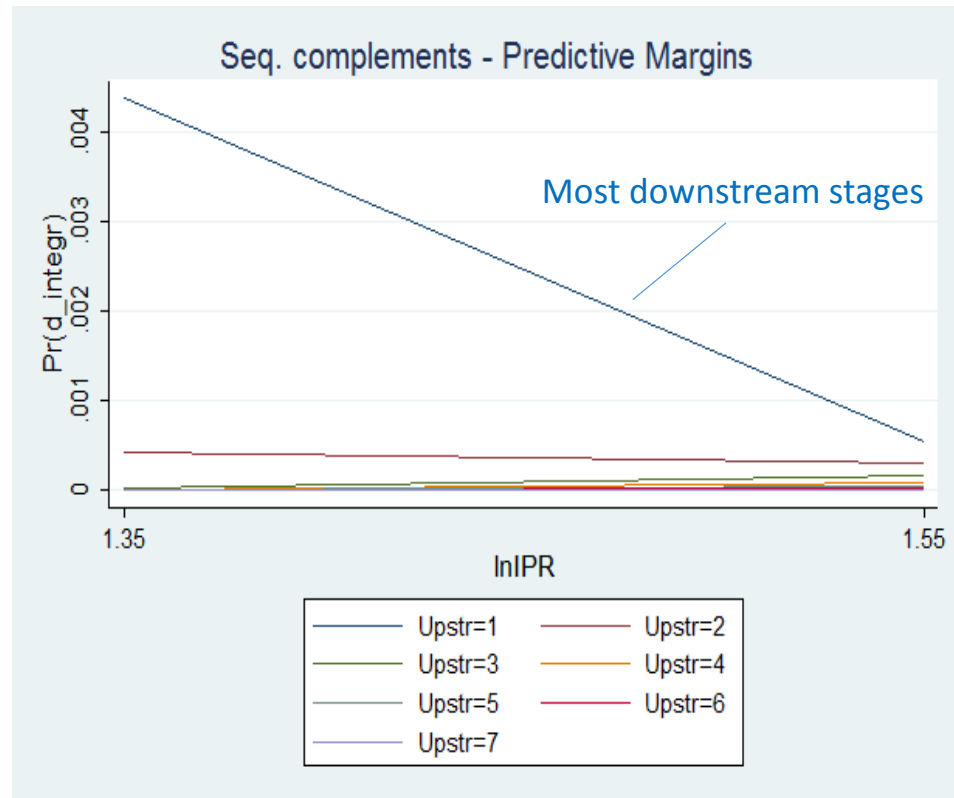
For **complements**, IPR enforcement decreases integration, effect weaker upstream (**more outsourcing downstream**)
 Effect not statistically significant effect for **substitutes**!

Results - Split sample specification

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	RE prob, ρ Comp	RE prob, ρ Subst	RE prob, ρ Comp	RE prob, ρ Subst	RE prob, ρ Comp	RE prob, ρ Subst	RE prob, ρ Comp	RE prob, ρ Subst
InIPR	-26.81*** (5.498)	-2.503 (5.975)	-22.36* (12.489)	-16.45 (17.889)				
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InIPR*Upstr	8.822** (3.430)	0.730 (2.647)	13.050*** (4.200)	0.786 (3.813)				
Rule_of_law					-0.703 (0.573)	-1.246** (0.603)	5.316*** (1.894)	-5.076*** (1.807)
Rule_of_law *Upstr					-0.248 (0.221)	0.016 (0.216)	-0.586*** (0.192)	0.039 (0.211)
Country dummies	no	no	yes	yes	no	no	yes	yes
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes
Industry dummies	yes	yes	yes	yes	yes	yes	yes	yes
Observations	308,518	390,751	246,902	312,789	340,984	444,657	277,561	362,193

When considering **rule of law** instead of IPR ... **opposite results, in line with plain property rights theory!**

Predictive Margins



Alternative measures of complements/substitutes

	(1) RE Probit α (ind) Comp	(2) RE Probit α (ind) Subst	(3) RE Probit $\rho \times \alpha$ (ind) Comp	(4) RE Probit $\rho \times \alpha$ (ind) Subst	(5) RE Probit $\rho - \alpha$ (elast.) Comp	(6) RE Probit $\rho - \alpha$ (elast.) Subst
lnIPR	-16.559*** (2.961)	-2.614 (5.760)	-15.179*** (2.952)	-1.376 (4.903)	-15.179*** (2.784)	-0.382 (6.632)
Upstr	-7.633*** (2.571)	0.560 (3.253)	-7.625*** (2.391)	0.096 (2.965)	-7.560*** (2.355)	-0.449 (3.832)
lnIPR*Upstr	4.761*** (1.734)	-1.169 (2.243)	4.765*** (1.609)	-0.929 (2.026)	4.757*** (1.591)	-0.232 (2.604)
Country dummies	no	no	no	no	no	no
Time dummies	yes	yes	yes	yes	yes	yes
Industry dummies	yes	yes	yes	yes	yes	yes
Observations	408,896	414,750	336,484	371,962	265,050	396,920

Further robustness checks

- ▶ Adding **country fixed effects** in the baseline model (split sample, RE probit) ... lower significance of the direct effect of IPR as expected, but interaction persists
- ▶ **Adding** partner-countries' **institutional variables** (likely correlated with IPR) from Worldwide Governance Indicators (2015) and GDP pc. + their interactions with upstreamness
- ▶ One-country model, many-countries world: subsample of firms with **increasing concentration of sourcing from one country**, results hold coefficient increasing with thresholds at 10% -20% -30%
- ▶ Other checks:
 - additional constraint of **positive intra-firm trade** by subsidiary to define integration: assure **vertical FDI**
 - subsample of **intermediate** or capital good import transactions
 - restricting to firms involved in outward FDI (removing firms that outsource all stages performed abroad)

Concluding remarks

We provide novel insights on how IPRs shape the **organization of GVCs**:

- ✓ Better institutions in form of higher **IPR protection encourage outsourcing** in the case of investment complementarity along the GVC (opposite to contract enforcement)
⇒ can be explained by introducing **imitation** in the framework of **property rights theory**.
 - ▶ **Lack of IPR protection** induces firms to opt for **integration**.
 - ▶ **Sound IPR regime** allows firms to use **outsourcing** to create supplier incentives.
- ✓ IPRs relevant for **sequential complements** and relatively **downstream** stages but less so for sequential substitutes.

Caveats:

- ✓ Not a model of prevention of IP dissipation, but of mitigation of its effect -- investment in IP protection can be endogenized (~ Alfaro et al., 2017)
- ✓ Not a model of location choice: locations of production activities are given
- ✓ No ex-post adjustment in the organization of the GVC after imitation happens