Relationship Stickiness: Measurement and Applications to International Economics

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Definition

- Most trade models assume importers may switch across suppliers at no costs

- In practice, changing supplier might be costly
  - ⇒ Difficult: few suppliers, search frictions, specific investments or elaborate contracts
  - ⇒ Easy: products purchased on spot markets

- This characteristics encompasses several concepts including:
  - ⇒ *investment specificity* (eg. Feenstra & Hanson 2005)
  - ⇒ *relationship specificity* (eg. Nunn 2007)
  - ⇒ *input specificity* (eg. Barrot & Sauvagnat 2016)
  - ⇒ *lock-in effects* (eg. Antras & Staiger 2012)

⇒ In the paper, we use the term **relationship-stickiness**

Motivation

Stickiness of trade relationships is key for many (trade) analysis:

- Levchenko (Restud, 2007) & Nunn (QJE, 2007): comparative advantage
- Acemoglu et al. (JF, 2009): vertical integration
- Antras & Staiger (AER, 2012): trade policy
- Antras & Chor (ECTA, 2013): global value chains
- Barrot & Sauvagnat (QJE, 2016): propagation of shocks in networks

How to assess the nature of a transaction?

⇒ Extent to which product markets are organized

- Rauch (1999): Product differentiation
  - Products traded on organized exchanges, reference prices, differentiated
- Relationship specificity (Nunn 2007)
  - Builds on Rauch's (1999) measure of products' differentiation

  ⇒ RS proxied by the share of differentiated inputs used in the production process
- Other product-level measures have emerged:

  ⇒ quality ladder (Khandelwal 2010), share of wholesalers (Bernard et al. 2010), distance to final demand (Antras, Chor, Fally, Hillberry 2012), Suppliers' R&D expenses / number of patents issued (Barrot & Sauvagnat, 2016)

⇒ **We derive a new measure of relationship-stickiness for highly disaggregated traded products**

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A fresh look at relationship-stickiness

- Length of a firm-to-firm relationship, conditional on the seller's competitiveness, is informative about the "stickiness" of the relationship
- Dispersion across products is informative about product-level attributes that tend to lengthen firm-to-firm relationships $\Rightarrow$ **Ex-post** indicator of the "relationship-stickiness" of traded goods
- Ex-post nature of the measure implies we are agnostic about the specific source of stickiness:
  - $\Rightarrow$ Product attributes, e.g. relation-specific investments (Joskow, 1987, Nunn, 2007) or switching costs (Klemperer, 1995, MacKay, 2017)
  - $\Rightarrow$ Contractual habits, e.g. relational contracts under imperfect contractual enforcement and uncertainty about firms' reliability (Macchiavello & Moriaria, 2015)

What we do (1/2): Measurement

- Mean durations of buyer-seller relationships
  - ⇒ exploit firm-to-firm trade data (French exports to EU countries, 1995-2010)
  - ⇒ compute the duration of trade relationship, at the seller-buyer-product level
- Estimate of product-level relationship stickiness
  - ⇒ conceptual framework where buyers receive offers from sellers randomly
  - ⇒ stickiness affects the likelihood that a buyer keeps on interacting with the same seller, conditional on an offer
  - ⇒ length of relationships is a function of RS and supplier's competitiveness

What we do (2/2): Applications

We use our RS measure to analyze 5 aspects of international trade:

1. Gravity and the stickiness of traded goods
2. Institutional comparative advantage in the production of high-RS goods
3. Relationship stickiness and intrafirm trade
4. Trade-comovement correlation and the stickiness of relationships
5. Stickiness, uncertainty, and the formation of exporter-importer relationships

Literature

- **Measures of relationship specificity**
  - ⇒ Rauch (1999), Nunn (2007)
- **Duration of trade relationships**
  - ⇒ Besedes and Prusa (2006): higher hazard rate for homogeneous products
  - ⇒ Besedes (2008), Nitsch (2009), Békés and Muraközy (2012)
- **Firm-to-firm trade**
  - ⇒ French data: Kramarz, Martin, Mejean (2016), Lenoir, Martin, Mejean (2016)
  - ⇒ Other: Bernard et al. (2014), Carballo et al. (2013), Magerman et al. (2016)
  - ⇒ Dynamics of trade: Eaton, Eslava, Jinkins, Krizan, Tybout (2016)
- Literature specific to each application

Data

- French Customs data reporting the value of exports to EU countries per transaction from 1995 to 2010
- For each transaction we know the (French) seller, the 8-digit (CN) product, the EU buyer, the month and year
- Aggregate data by seller, buyer, product, month and year
- Concorde the CN8 data across years to avoid nomenclature-driven censoring
- Need to follow the history of buyers: drop buyers importing only once over the entire sample (44% of buyer$\times$product pairs but less than 2% of the value of trade)

Description

Table: French monthly exports, Jan. 1995- Dec. 2010

	# transac.	# sellers	# buyers	# buyer*prod.
EU27	154,428,971	130,190	2,167,639	21,178,660
BE	29,754,113	88,537	251,175	3,573,758
DE	28,584,738	73,073	446,571	3,487,822
ES	19,516,222	63,219	311,756	2,724,880
GB	14,946,580	57,949	198,787	1,929,178
IT	19,818,038	62,208	394,835	3,186,895
NL	8,779,221	52,138	124,019	1,109,881

Characteristics of trade relationships

- Choice of a seller-buyer matching structure guided by the data
  - $\Rightarrow$ at a given date, do we observe shipments from one seller-to-one buyer, one seller-to-many buyers, many sellers-to-many buyers etc ?
- Most sellers(-product) interact with more than one buyer within a month
  - 68% of sellers export each of their products to more that one buyer per month on average (conditional on exporting)
- Buyers tend to import a product from a single French seller
  - About 95% of the buyers import a 8-digit product, at a given date, from a single French seller

$\approx$ **many-to-one relationships** : reminiscent to on-the-job search models

- (unlike Bernard et al. 2017, we work i) at the product level, ii) at the monthly level)

Measuring the duration of seller-buyer trade relationships

- Challenges
  - Left and right censoring
  - Discontinuous relationships
  - Heterogeneity in the frequency of transactions
  - Single-transaction buyers (dropped)
- Focus: Mean duration (of continuous relationships)
- Alternatives:
  - Switching probability
  - Switching probability conditional on a positive trade flow

▸ Discussion alternatives

Large transactions last longer

Table: Duration, switching probabilities, and the size of trade flows

	(1)	(2)	(3)	(4)	(5)	(6)
	duration	duration	duration	Log of 1/P(switch)	1/P(switch | Trade)	duration
Mean exports (log)	0.050***	0.053***	0.059***	0.125***	0.047***	0.091***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	9,797,609	9,797,609	9,797,609	9,797,609	9,797,609	25,132,896
(Within) R^2	0.005	0.005	0.005	0.046	0.004	0.014
Fixed effects	Country	Product	Product× country	Product× country	Product× country	Product× buyer

Conceptual framework: switching

- A buyer purchases an input from a single supplier
- A buyer receives an offer with probability λ every period
- An offer is a quality-adjusted price P drawn from a distribution

$$H_P(p) = \mathbb{P}(P \leq p)$$

- If the current relationship is at price p:
  - $\Rightarrow$ A firm decides to switch whenever $P < \frac{p}{\gamma}$ where $\gamma > 1$
  - $\Rightarrow$ Occurs with probability $\lambda H_P(p/\gamma)$
- γ captures the cost of switching across suppliers

Conceptual framework: duration

Under these conditions, the expected length of a buyer-seller relationship, conditional on its price is given by:

$$\mathbb{E}[\mathcal{T}|p] = \sum_{k=1}^{+\infty} k(1 - \lambda H_P(p/\gamma))^{k-1} \lambda H_P(p/\gamma) = \frac{1}{\lambda H_P(p/\gamma)}$$

$\Rightarrow$ The duration of a relationship is just the inverse of the probability of switching

(this holds true in continuous time)

Toward an econometric model: Assumption 1

- We do not observed quality-adjusted prices - but we observe sales
- Assumption 1: Demand for imports is iso-elastic (price-elasticity σ)

  $\Rightarrow$ duration in terms of sales (r) rather than unobserved prices

$$\mathbb{E}[\mathcal{T}|r] = \frac{1}{\lambda(1 - H_R(r\gamma^{\sigma-1}))}$$

Toward an econometric model: Assumption 2

- We have to make assumptions regarding the distribution of prices
- Assumption 2: the distribution of prices is inverse-Pareto

$\Rightarrow$ transactions are distributed Pareto

$$H_R(r) = 1 - \left(\frac{r}{R_{min}}\right)^{-\frac{k}{\sigma-1}}$$

with R_{min} the scale parameter and k the shape parameter

Toward an econometric model: Assumptions 1 and 2

Assumptions (1) and (2) deliver a log-linear relationship btw the expected (conditional) duration and relationship stickiness :

$$\mathbb{E}[\mathcal{T}|r] = \eta \left(\frac{r}{R_{min}} \right)^{\frac{k}{\sigma - 1}}$$

$\Rightarrow$ $\eta \equiv \frac{\gamma^k}{\lambda}$ is our measure of relationship-stickiness

$\Rightarrow$ duration of a buyer-seller relationship is increasing in η

$\Rightarrow$ duration increases with the size of the transaction

Discussion

- Departure from the competitive framework: Bertrand-type competition
  - $\Rightarrow$ same switching probability as in the competitive model
  - $\Rightarrow$ but the distribution of transactions changes

- Departure from the Pareto distribution of productivity
  - $\Rightarrow$ focus on the log-normal case
  - $\Rightarrow$ in-progress

Method of moments

- Moments: average duration within transaction-size deciles

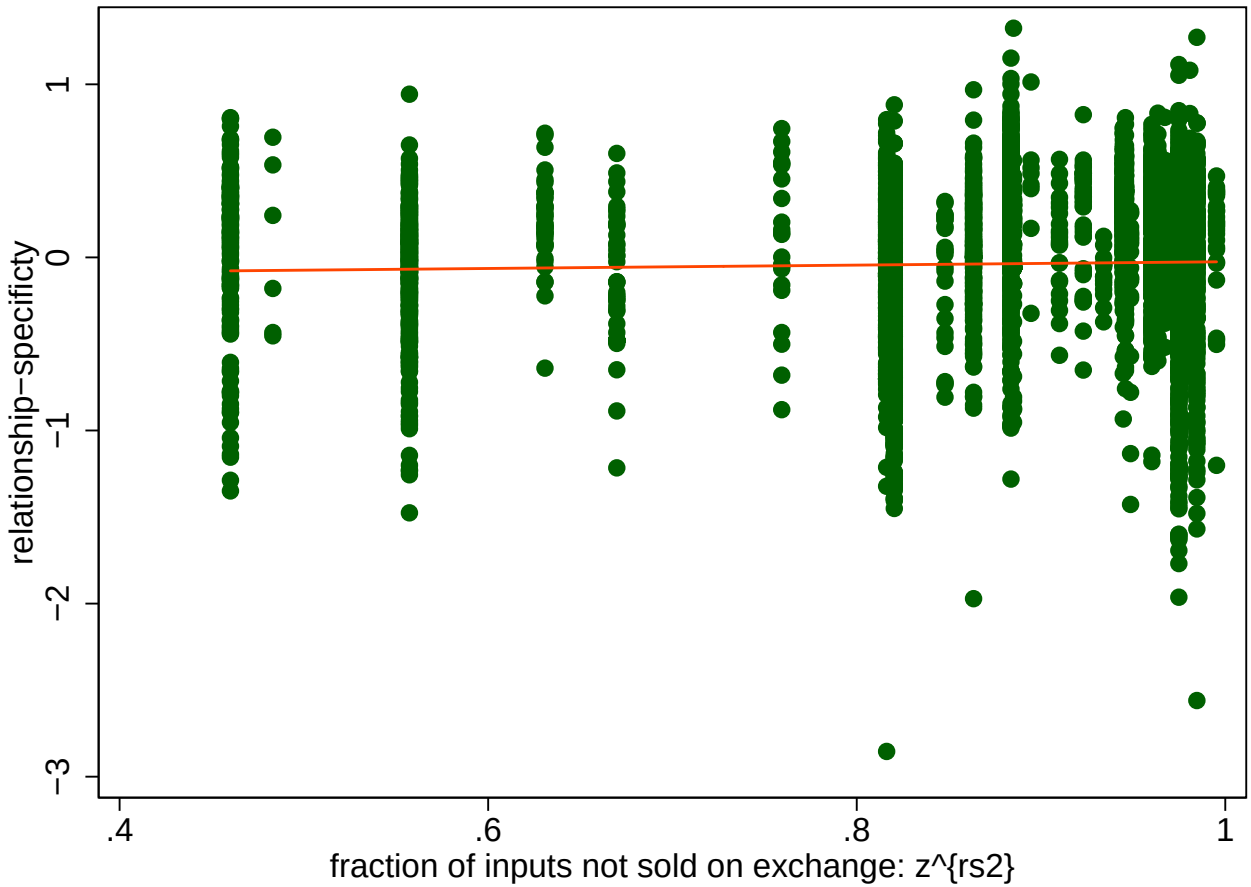
$$\int_d^{d+1} \mathcal{T}(r)_{zpd} f(r) dr = \frac{{\gamma_p}^{k_p}}{\lambda_p} log\left(\frac{10-d}{9-d}\right)$$

- $d = 0, 1, ..., 9$; $\frac{10-d}{9-d}$ increases with size
- Regress the log of averaged duration within a decile on
  - $\Rightarrow$ A function of the decile of the transaction
  - $\Rightarrow$ 4,000+ product fixed effects (to back out $log\eta \equiv k_p log(\eta_p) - log(\lambda_p)$)
  - $\Rightarrow$ country fixed effects (eg. heterog. in contract enforcement)
- The expected durations are measured with error (assumed iid)

Correlation with other measures

Measure	Corr(η,.)	OLS η
$\mathbf{1}_{differentiated}$ (Rauch)	.06***	.01
Share of not homogen. products (Nunn)	.07**	.09
Upstreamness (Antras et al.)	.14***	.16***
Elasticity of subs. (Imbs & Mejean)	-.11***	-.30***
Product complexity (Haussman & Hidalgo)	.25***	.10***
Observations		3,877
R^2	-	.11

Share of non-homog. products vs RS measure



Discussion

Tremendous dispersion in input specificity within 3-digit industries

Two examples:

1. Transport equipment
   - most specific sector in Nunn's classification
   - the sector includes bikes (likely not specific to the buyers)
   - ... but also drive-axles or saddles for motorcycles
2. Chemicals: raw products but also customized ones
   - Imerys Refractory Minerals Glomel is the world leader in Andalusite production [...]*Thanks to a customised range of products, Andalusite is also widely used in the technical ceramics and sand casting industries.*

Application 1/5: Gravity for relationship-specific goods

- Gravity equations in trade: empirical regularity with theoretical underpinnings (Head & Mayer 2014)
- Some products "defy" gravity (eg. luxury goods cf. Martin & Mayneris 2015)
- What about high-RS products?

$\Rightarrow$ Almost no guidance in the literature

- Atalay et al. (2017): firm boundaries are barriers to trade
- Head & Ries (2008): monitoring costs and distance

- Unit values increase with distance (Hummels and Skiba 2004)

Application 1/5: Results

	(1) Value	(2) UV	(3) Value	(4) UV	(5) Value	(6) UV
Distance (log)	-0.571***	0.467***	-0.699***	0.101***	-0.990***	0.087***
	(0.020)	(0.006)	(0.021)	(0.006)	(0.023)	(0.007)
RS	1.008***	-0.166***				
	(0.093)	(0.041)				
- × dist.	-0.151***	0.042***	-0.143***	0.020***	-0.113***	0.066***
	(0.012)	(0.005)	(0.012)	(0.004)	(0.010)	(0.005)
Upstreamness	1.008***	-0.166***				
	(0.041)	(0.043)				
- × dist.	0.010**	-0.084***	0.021***	0.028***	-0.012*	0.047***
	(0.005)	(0.000)	(0.005)	(0.002)	(0.007)	(0.002)
Fixed effects	country		country+sect		country×sect	
Observations	5,703,782				5,473,330	
R-squared	0.164	0.178	0.285	0.654	0.578	0.770

Clustered (country) standard errors in parentheses with *, **, *** denoting significance at the 10, 5 and 1% levels.

Application 2/5: Institutional comparative advantage

- Nunn (2007): *countries with good contract enforcement specialize in the production of goods for which relationship-specific investments are most important.*

- Baseline specification:

$$log(export_{ic}) = \alpha_i + \alpha_c + specif_i \times legal_c + \epsilon_{ic}$$

- Data: 4,339 hs6 sectors (i) - 122 countries (c)
- ($\neq$ Nunn, 182 sectors - 122 countries)

- Dep. variables: exports (log), Balassa index, $\mathbf{1}_{Balassa>1}$

- Control: Upstreamness (Costinot, Vogel & Wang, 2013: Specialization at various stages of production depends on country's probability of making mistakes)

Application 2/5: Results

	(1)	(2)	(3)	(4)	(5)
		log(exports)		Balassa Index	$\mathbf{1}_{Balassa>1}$
Rule of law					
× *RS*	0.349***		0.408***	0.286**	0.022***
	(0.053)		(0.053)	(0.120)	(0.006)
× Nunn specif.		0.811***	0.978***	0.316*	0.027*
		(0.100)	(0.117)	(0.168)	(0.015)
× Upstreamness			0.034	0.013	0.002
			(0.021)	(0.024)	(0.002)
Fixed effects			*country*(122) *and sector*(4,326)		
Observations	296,187	296,187	292,938	527,284	527,284
R-squared	0.605	0.606	0.610	0.012	0.139

Clustered (country) standard errors in parentheses with *, **, *** denoting significance at the 10, 5 and 1% levels.

Application 3/5: Intrafirm trade

- Theory: contracts and specific inputs (Antras 2003, Antras & Helpman 2004)

- Empiric: Bernard et al. (2010), Nunn & Trefler (2013), Corcos et al. (2010)

$\Rightarrow$ Product and country characteristics explain the share of intrafirm trade

$\Rightarrow$ What fraction of dispersion across products might be explained by our measure?

Application 3/5: Results

	(1)	(2)	(3)	(4)
	Share of intra-firm			
	exports		*imports*	
RS (η)	0.177***	0.180***	0.140***	0.138***
	(0.040)	(0.041)	(0.030)	(0.031)
Nunn		0.406***		0.199***
		(0.063)		(0.046)
Upstreamness		0.060***		0.015
		(0.016)		(0.011)
Elasticity (σ)		0.002		-0.005
		(0.006)		(0.004)
Observations	378	378	378	378
R-squared	0.058	0.166	0.071	0.119

Robust standard errors in parentheses with *, **, *** denoting significance at the 10, 5 and 1% levels.

Application 4/5: Trade and BCC

- Frankel & Rose (1998) di Giovanni & Levchenko (2010): Countries that trade more together comove more. Role of international IO linkages as a driver of comovements
- Hypothesis: Propagation of shocks in production networks should be especially strong for high input-specific goods (Barrot & Sauvagnat, 2016)
- Baseline specification (di Giovanni & Levchenko, 2010):

$$\rho_{kl}^{ij} = \alpha + \beta \ln Trade_{kl}^{ij} + \mathbf{u} + \varepsilon_{kl}^{ij}$$

  - ij a pair of countries, kl a pair of sectors, $\mathbf{u}$ a set of fixed effects
  - ρ_{kl}^{ij} the correlation between value added in sector k of country i and sector l of country j
  - $Trade_{kl}^{ij}$ a measure of the intensity of bilateral trade in both sectors:

$$Trade_{kl}^{ij} = \frac{1}{T} \sum_{t} \frac{X_{kt}^{ij} + X_{lt}^{ji}}{X_{kt}^{i} + X_{lt}^{j}}$$

Trade-BCC with relationship-specific trade

- Augmented specifications:
  1. $\rho_{kl}^{ij} = \alpha + \beta \ln Trade_{kl}^{ij} + \gamma RS_{kl}^{ij} + \beta^H RS_{kl}^{ij} \times \ln Trade_{kl}^{ij} + \mathbf{u} + \varepsilon_{kl}^{ij}$

     with RS_{kl}^{ij} a trade-weighted average of product-level RS indicators
  2. $\rho_{kl}^{ij} = \alpha + \beta^H TradeH_{kl}^{ij} + \beta^L TradeL_{kl}^{ij} + \mathbf{u} + \varepsilon_{kl}^{ij}$

     with $TradeH_{kl}^{ij}$ and $TradeL_{kl}^{ij}$ the two sub-components of $Trade_{kl}^{ij}$, respectively computed on above-the-median and below-the-median RS products
- Data: UNIDO + ComTrade

Results

	Dependent var: ρ_{kl}^{ij}				
	(1)	(2)	(3)	(4)	(5)
				alter.	
$log(Trade_{kl}^{ij})$	0.00150***	0.00147***	0.00148***	0.00108***	
	(0.000245)	(0.000246)	(0.000246)	(0.000221)	
RS_{kl}^{ij}				2.060***	
					(0.351)
$log(Trade_{kl}^{ij}) \times RS_{kl}^{ij}$			0.00212**	0.00150*	
			(0.000807)	0.000735)	
$TradeH_{kl}^{ij}$					2.060***
					(0.351)
$TradeL_{kl}^{ij}$					0.913***
					(0.208)
Observations	502,237	502,237	502,237	502,237	502,237
R_{tot}^2	0.29	0.29	0.29	0.29	0.29
$\alpha_i \times \alpha_j + \alpha_k \times \alpha_l$	yes	yes	yes	yes	yes

Robust t statistics in parentheses with *, **, *** denoting significance at the 10, 5 and 1% levels. α_i and α_j are the country fixed effects, α_k and α_l are the sector fixed effects

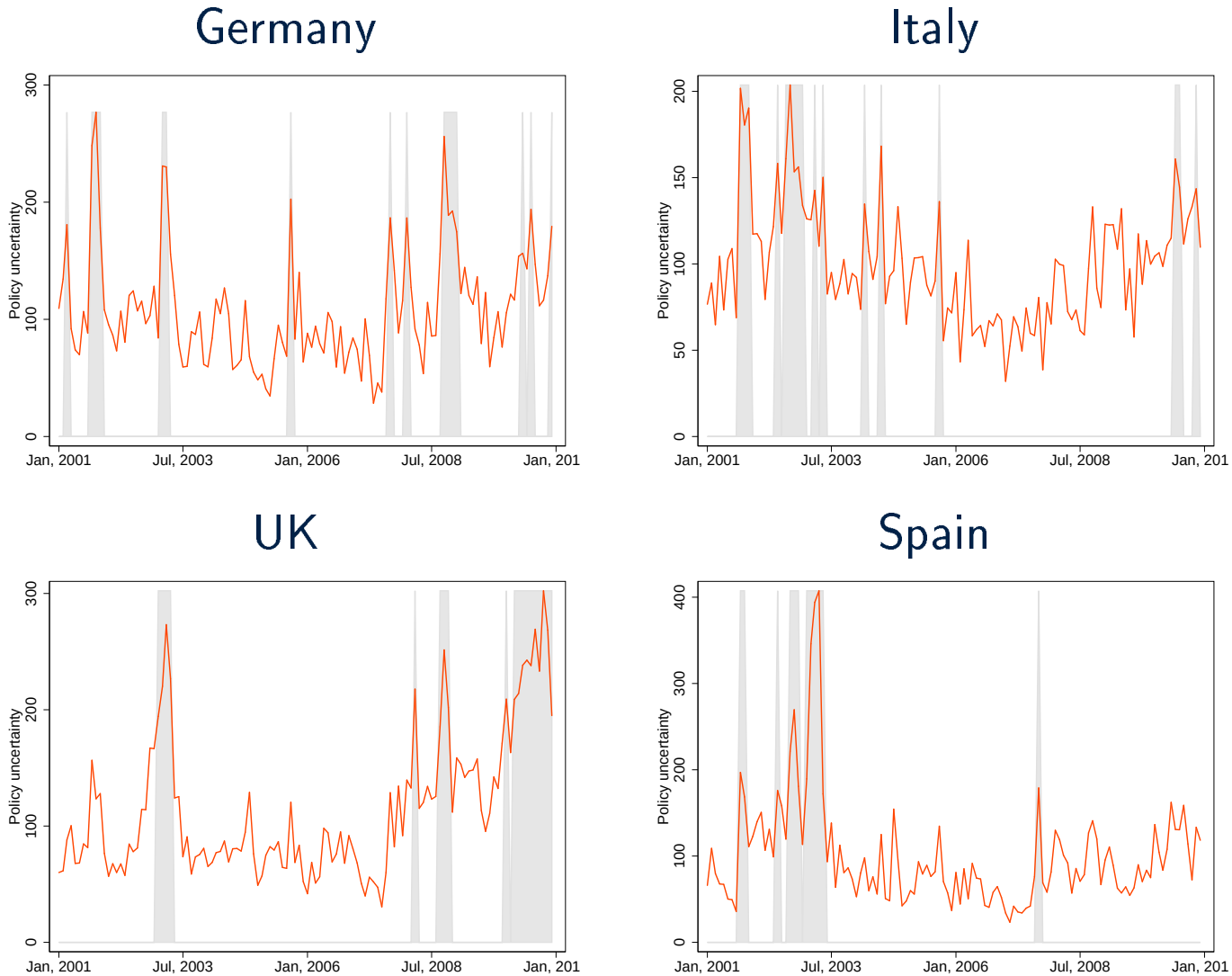
Uncertainty and the formation of trade relationships

- Bloom (2009) and subsequent lit.: Impact of policy uncertainty on the economic activity, through the decision to hire/invest/enter a market
  - $\Rightarrow$ Trade: Pierce & Schott'16, Handley & Limao'16, Novy & Taylor'14
- Hypothesis: Impact of uncertainty on the probability to form a new trade relationship, stronger for trade involving specific inputs
- Baseline specification:

$$\#newrelations_{pdt} = \alpha Uncertainty_{dt} + \beta RS_p + \gamma RS_p \times Uncert_{dt} + \epsilon_{pdt}$$

- Data:
  - Dep. Variable: new interaction btw a French seller and a foreign buyer
  - RHS variable: Policy uncertainty from Baker, Bloom & Davis (2016)
  - Poisson regression, with different sets of fixed effects (country trend, seasonality)

Policy uncertainty, 2000-2015 (Baker, Bloom, Davis 2016)



▸ More on cross-country correlations

Application 5/5: Results

	(1)	(2)	(3)	(4)	(5)
Dep. var:		*# new trade relationships*			
Uncertainty	-0.05***	-0.06***		-0.09***	
	(0.005)	(0.005)		(0.007)	
− × RS		-0.06***	-0.01***	-0.07***	-0.01***
		(0.010)	(0.002)	(0.014)	(0.003)
Fixed effects:					
Country	✓	✓		✓	
Product-month	✓	✓	✓	✓	✓
Country × Time			✓		✓
Method	*Poisson*	*Poisson*	*LPM*	*Poisson*	*LPM*
Threshold	*1 s.d.*	*1 s.d.*	*1 s.d.*	*1.64 s.d.*	*1.64 s.d.*
Obs.			*1,986,261*		

Conclusion

- New method to reveal relationship specificity using transaction data
- Easy to implement (and easy to improve)
- Easy to use : applied to 5 key issues in international trade
- RS dataset available to other researchers soon
- Discussion: strengths and limits of the RS measure

Differences across measures

	Mean duration	P(switch)	P(switch|trade>0)
S-S-S-S'-S'-S'	3 months	1/3	1/3
S-S-S-x-S'-S'	2.5 months	1/3	2/5
S-x-S-S'-x-S'	3 months	1/3	1/2
S-x-S-x-S'-S'	2.5 months	1/3	1/2

- All three measures are the same if buyers trade every month
- Duration and switching probability conditional on a positive trade flow are similar if vacancies only occur at the time of switching
- Duration and unconditional switching probability are similar if vacancies only take place within a firm-to-firm relationship
- The three measures differ in the other cases

$\Rightarrow$ In general, $1/P(switch|Trade) \leq Mean\ duration \leq 1/P(switch)$

Duration of French-EU buyers relationships

Table: Descriptive statistics on French- EU buyers relationships

	Mean	Median	P25	P75
Mean duration	24	13	3	34
P(switch)	0.115	0.053	0.024	0.125
P(switch|Trade)	0.355	0.333	0.143	0.500
Proba Recall	0.054	0.000	0.000	0.000
Frequency of transactions	0.358	0.246	0.120	0.500

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Correlation across measures

Table: Correlation of estimated RS measures

	Mean duration	$1/P(switch)$	$1/P(switch\|Trade)$
Mean duration	1.000		
$P(switch)^{-1}$	.828	1.000	
$P(switch\|Trade)^{-1}$	.793	.602	1.000
	Measures accounting for censoring		
$Duration_{cens}$	.922		
$P(switch)^{-1}_{cens}$		.883	
$P(switch\|Trade)^{-1}_{cens}$			.899

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Policy uncertainty, 2000-2015

Table: Correlation - uncertainty

	DE	IT	UK	ES
Germany	1,00			
Italy	0,52	1,00		
UK	0,67	0,55	1,00	
Spain	0,54	0,49	0,45	1,00

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