Border Processing, Trade Costs and New Trade Policy

Jeronimo Carballo
University of Colorado

Alejandro Graziano
University of Maryland

Georg Schaur
University of Tennessee

Christian Volpe Martincus
Inter-American
Development Bank

Geneva Trade and Development Workshop

May, 2018

Introduction

High border costs motivate new trade policy

- Borders impose costs on trade flows
  - Traditionally: tariffs, quotas and general border effects.
  - More recently: the processing of shipments

High border costs motivate new trade policy

- Borders impose costs on trade flows
  - Traditionally: tariffs, quotas and general border effects.
  - More recently: the processing of shipments
- Policy consequence: 2013 WTO Agreement on Trade Facilitation
  - Simplification, modernization, harmonization of trade processes

High border costs motivate new trade policy

- Borders impose costs on trade flows
  - Traditionally: tariffs, quotas and general border effects.
  - More recently: the processing of shipments
- Policy consequence: 2013 WTO Agreement on Trade Facilitation
  - Simplification, modernization, harmonization of trade processes
- Roberto Azevedo - Director-General of the WTO:
  - *"WTO Trade Facilitation Agreement has come into force! This is the biggest global trade deal of this century"*
  - *"The impact of the Trade Facilitation Agreement could be greater than the elimination of all existing tariffs around the world"*

High border costs motivate new trade policy

- Borders impose costs on trade flows
  - Traditionally: tariffs, quotas and general border effects.
  - More recently: the processing of shipments
- Policy consequence: 2013 WTO Agreement on Trade Facilitation
  - Simplification, modernization, harmonization of trade processes
- Roberto Azevedo - Director-General of the WTO:
  - *"WTO Trade Facilitation Agreement has come into force! This is the biggest global trade deal of this century"*
  - *"The impact of the Trade Facilitation Agreement could be greater than the elimination of all existing tariffs around the world"*
  - Hopes are high!

High border costs motivate new trade policy

- Borders impose costs on trade flows
  - Traditionally: tariffs, quotas and general border effects.
  - More recently: the processing of shipments
- Policy consequence: 2013 WTO Agreement on Trade Facilitation
  - Simplification, modernization, harmonization of trade processes
- Roberto Azevedo - Director-General of the WTO:
  - *"WTO Trade Facilitation Agreement has come into force! This is the biggest global trade deal of this century"*
  - *"The impact of the Trade Facilitation Agreement could be greater than the elimination of all existing tariffs around the world"*
  - Hopes are high!
- Don't know how firms manage these processes $\Rightarrow$ Don't know how this affects trade, trade theory, or, trade facilitation

High border costs motivate new trade policy

- Borders impose costs on trade flows
  - Traditionally: tariffs, quotas and general border effects.
  - More recently: the processing of shipments
- Policy consequence: 2013 WTO Agreement on Trade Facilitation
  - Simplification, modernization, harmonization of trade processes
- Roberto Azevedo - Director-General of the WTO:
  - *"WTO Trade Facilitation Agreement has come into force! This is the biggest global trade deal of this century"*
  - *"The impact of the Trade Facilitation Agreement could be greater than the elimination of all existing tariffs around the world"*
  - Hopes are high!
- Don't know how firms manage these processes $\Rightarrow$ Don't know how this affects trade, trade theory, or, trade facilitation
- **Goal:** Develop a systematic way to examine border processing that is comparable to existing literature, can be interpreted within trade models, useful to evaluate costs and policies.

Why is this challenging and interesting?

- No comprehensive existing datasets for trade processing costs $\Rightarrow$ *Room for empirical work*.

Why is this challenging and interesting?

- No comprehensive existing datasets for trade processing costs $\Rightarrow$ *Room for empirical work*.
- Firms optimize supply chains $\Rightarrow$ *Room for theory*.

Why is this challenging and interesting?

- No comprehensive existing datasets for trade processing costs $\Rightarrow$ *Room for empirical work*.
- Firms optimize supply chains $\Rightarrow$ *Room for theory*.
- Policies:
  - A stew of provisions to streamline document, information and shipment processing.
  - How can we measure this in a coherent way?

Why is this challenging and interesting?

- No comprehensive existing datasets for trade processing costs $\Rightarrow$ *Room for empirical work*.
- Firms optimize supply chains $\Rightarrow$ *Room for theory*.
- Policies:
  - A stew of provisions to streamline document, information and shipment processing.
  - How can we measure this in a coherent way?
- Tariffs are comparatively boring.
  - They are usually exogenously set, measurable, reported in datasets and firms take them as given...

Why is this challenging and interesting?

- No comprehensive existing datasets for trade processing costs $\Rightarrow$ *Room for empirical work*.
- Firms optimize supply chains $\Rightarrow$ *Room for theory*.
- Policies:
  - A stew of provisions to streamline document, information and shipment processing.
  - How can we measure this in a coherent way?
- Tariffs are comparatively boring.
  - They are usually exogenously set, measurable, reported in datasets and firms take them as given...
  - TPU and Economic Uncertainty: see Carballo, Handley and Limão (2018).

Why is this challenging and interesting?

- No comprehensive existing datasets for trade processing costs $\Rightarrow$ *Room for empirical work*.
- Firms optimize supply chains $\Rightarrow$ *Room for theory*.
- Policies:
  - A stew of provisions to streamline document, information and shipment processing.
  - How can we measure this in a coherent way?
- Tariffs are comparatively boring.
  - They are usually exogenously set, measurable, reported in datasets and firms take them as given...
  - TPU and Economic Uncertainty: see Carballo, Handley and Limão (2018).
- We have a major policy initiative that affects trade costs through a firm optimization mechanism
  - Don't know how trade processing affects trade
  - Hard to predict consequences of trade policy or policy effectiveness.

Our starting point

- Literature shows that slow supply chains are costly (Djankov et al., 2010; Hummels and Schaur, 2013; Carballo et al. 2014; Volpe Martincus et al., 2015; Fernandes et al., 2015; Evans and Harrigan, 2005; Harrigan 2010)
  - Lenghty processing procedures take longer and raise costs

Our starting point

- Literature shows that slow supply chains are costly (Djankov et al., 2010; Hummels and Schaur, 2013; Carballo et al. 2014; Volpe Martincus et al., 2015; Fernandes et al., 2015; Evans and Harrigan, 2005; Harrigan 2010)
  - Lenghty processing procedures take longer and raise costs
- How to measure time?
  - Enterprise Survey and Doing Business: Aggregate de facto versus de jure measures (Hallward-Driemeier and Prichett, 2015)
  - Total border time versus time in inspections, unloading, etc
  - Time to import versus time to export versus time in ocean transit (Djankov et al., 2010; Hummels and Schaur, 2013; Volpe Martincus et al., 2015; Fernandes et al., 2015)

Our starting point

- Literature shows that slow supply chains are costly (Djankov et al., 2010; Hummels and Schaur, 2013; Carballo et al. 2014; Volpe Martincus et al., 2015; Fernandes et al., 2015; Evans and Harrigan, 2005; Harrigan 2010)
  - Lenghty processing procedures take longer and raise costs
- How to measure time?
  - Enterprise Survey and Doing Business: Aggregate de facto versus de jure measures (Hallward-Driemeier and Prichett, 2015)
  - Total border time versus time in inspections, unloading, etc
  - Time to import versus time to export versus time in ocean transit (Djankov et al., 2010; Hummels and Schaur, 2013; Volpe Martincus et al., 2015; Fernandes et al., 2015)
- How to translate time to money?
  - What is the appropriate time cost function we have to estimate?
  - How does the interpretation change with different time measues?
  - Identification?

What we do in this paper

- **Empirical Facts** to characterize the border process.

What we do in this paper

- **Empirical Facts** to characterize the border process.
- **Theory:** Firms optimize supply chains taking into account delivery windows and random processing times.

What we do in this paper

- **Empirical Facts** to characterize the border process.
- **Theory:** Firms optimize supply chains taking into account delivery windows and random processing times.
    - Provide fundamental for time cost elasticities and sources for heterogeneity.

What we do in this paper

- **Empirical Facts** to characterize the border process.
- **Theory:** Firms optimize supply chains taking into account delivery windows and random processing times.
  - Provide fundamental for time cost elasticities and sources for heterogeneity.
  - Clarify measurement and identification problems.

What we do in this paper

- **Empirical Facts** to characterize the border process.
- **Theory:** Firms optimize supply chains taking into account delivery windows and random processing times.
  - Provide fundamental for time cost elasticities and sources for heterogeneity.
  - Clarify measurement and identification problems.
  - Provide a theory consistent time-cost function.

What we do in this paper

- **Empirical Facts** to characterize the border process.
- **Theory:** Firms optimize supply chains taking into account delivery windows and random processing times.
  - Provide fundamental for time cost elasticities and sources for heterogeneity.
  - Clarify measurement and identification problems.
  - Provide a theory consistent time-cost function.
  - Inform cost rankings based on different time meaures.

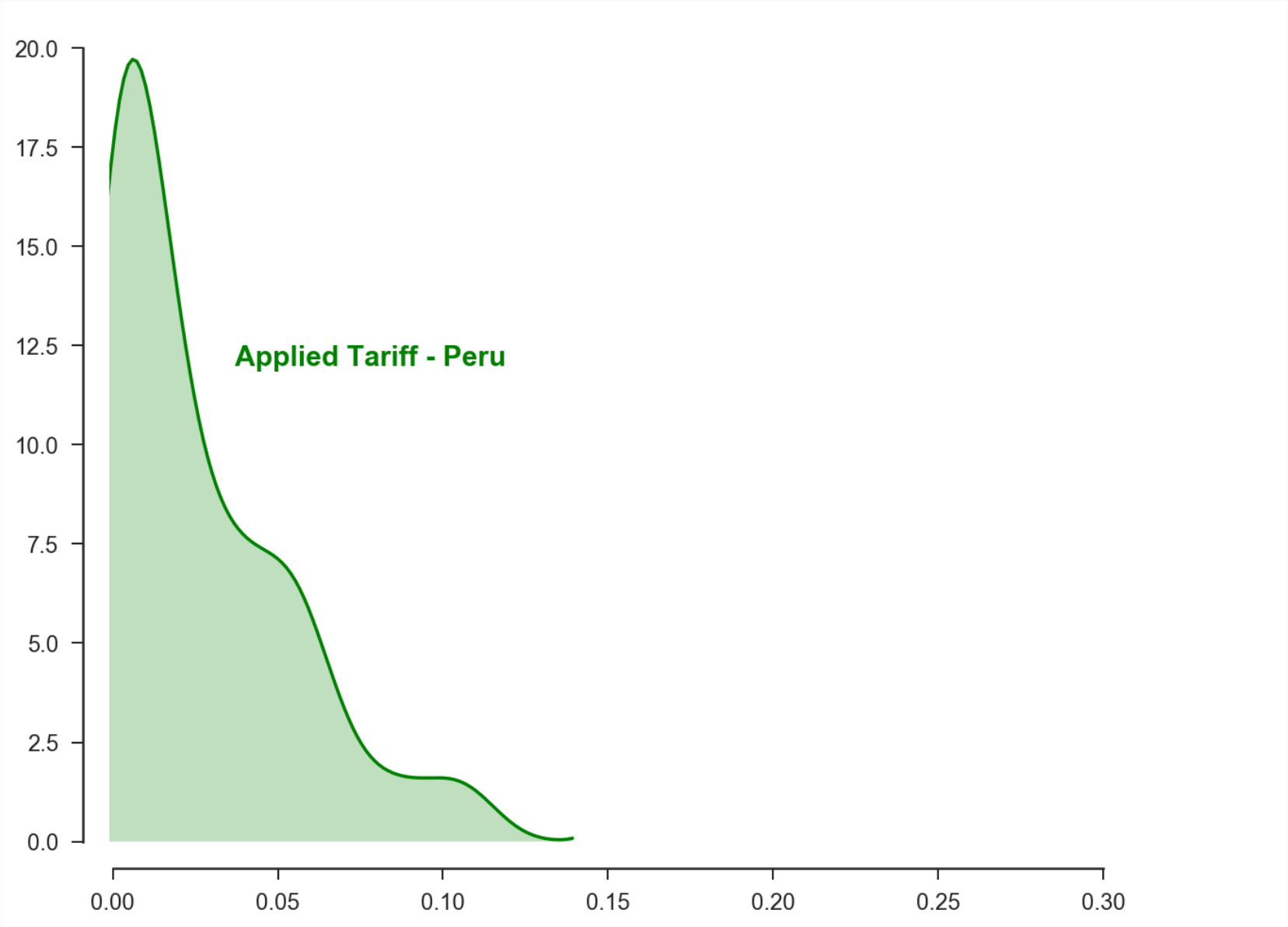
What we do in this paper

- **Empirical Facts** to characterize the border process.
- **Theory:** Firms optimize supply chains taking into account delivery windows and random processing times.
  - Provide fundamental for time cost elasticities and sources for heterogeneity.
  - Clarify measurement and identification problems.
  - Provide a theory consistent time-cost function.
  - Inform cost rankings based on different time meaures.
- **Empirics:** Detailed import data for Peru.
  - Merge detailed processing of shipments with firm level import data.
  - Estimate the costs elasticities employing fixed effect and IV techniques.

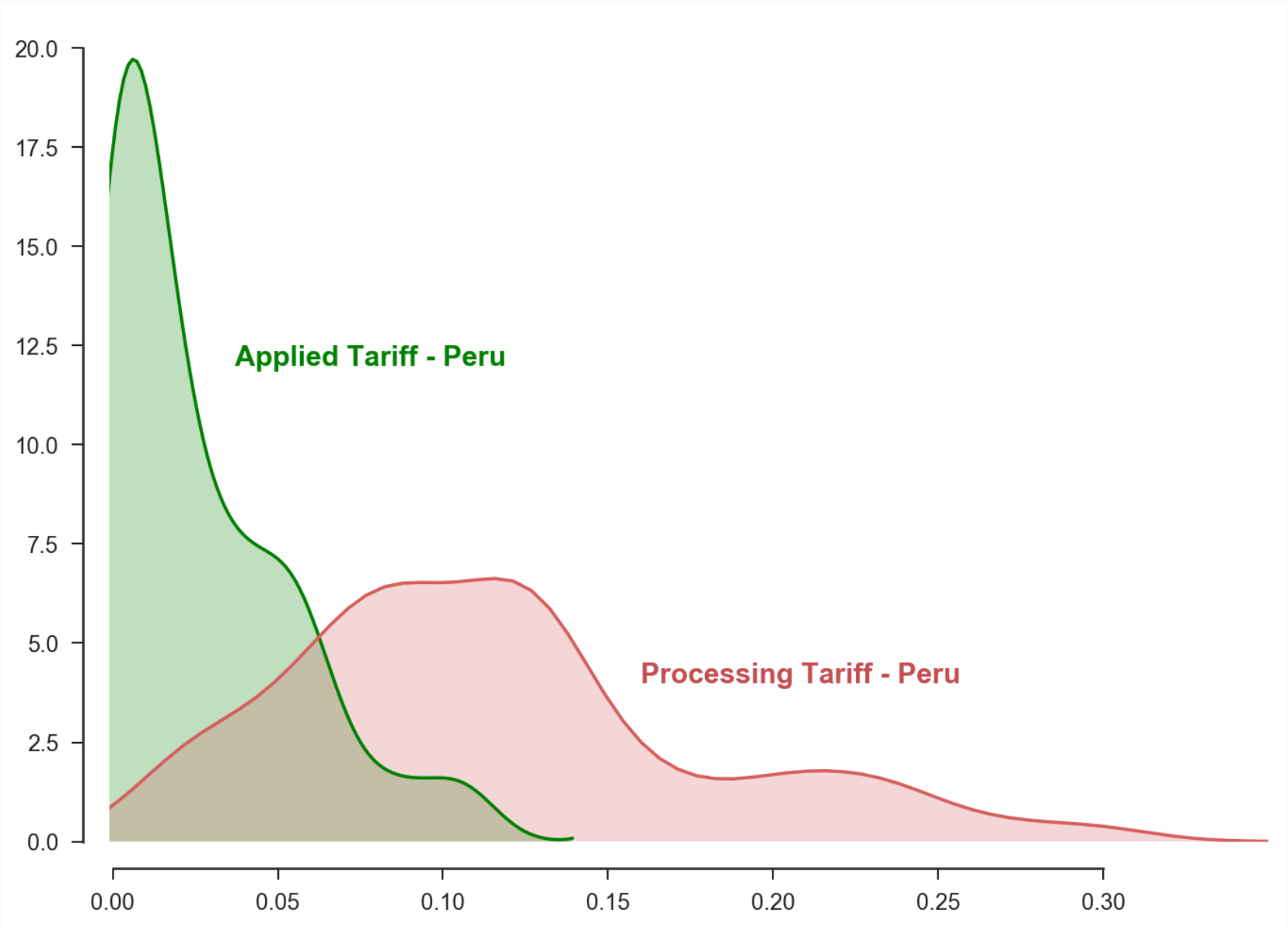
What we do in this paper

- **Empirical Facts** to characterize the border process.
- **Theory:** Firms optimize supply chains taking into account delivery windows and random processing times.
  - Provide fundamental for time cost elasticities and sources for heterogeneity.
  - Clarify measurement and identification problems.
  - Provide a theory consistent time-cost function.
  - Inform cost rankings based on different time meaures.
- **Empirics:** Detailed import data for Peru.
  - Merge detailed processing of shipments with firm level import data.
  - Estimate the costs elasticities employing fixed effect and IV techniques.
- **Policy:**
  - Estimate border processing tariff equivalent.
  - Provide a theory consistent processing cost measure to evaluate costs and measure peformance.
  - Quantify policy experiments.

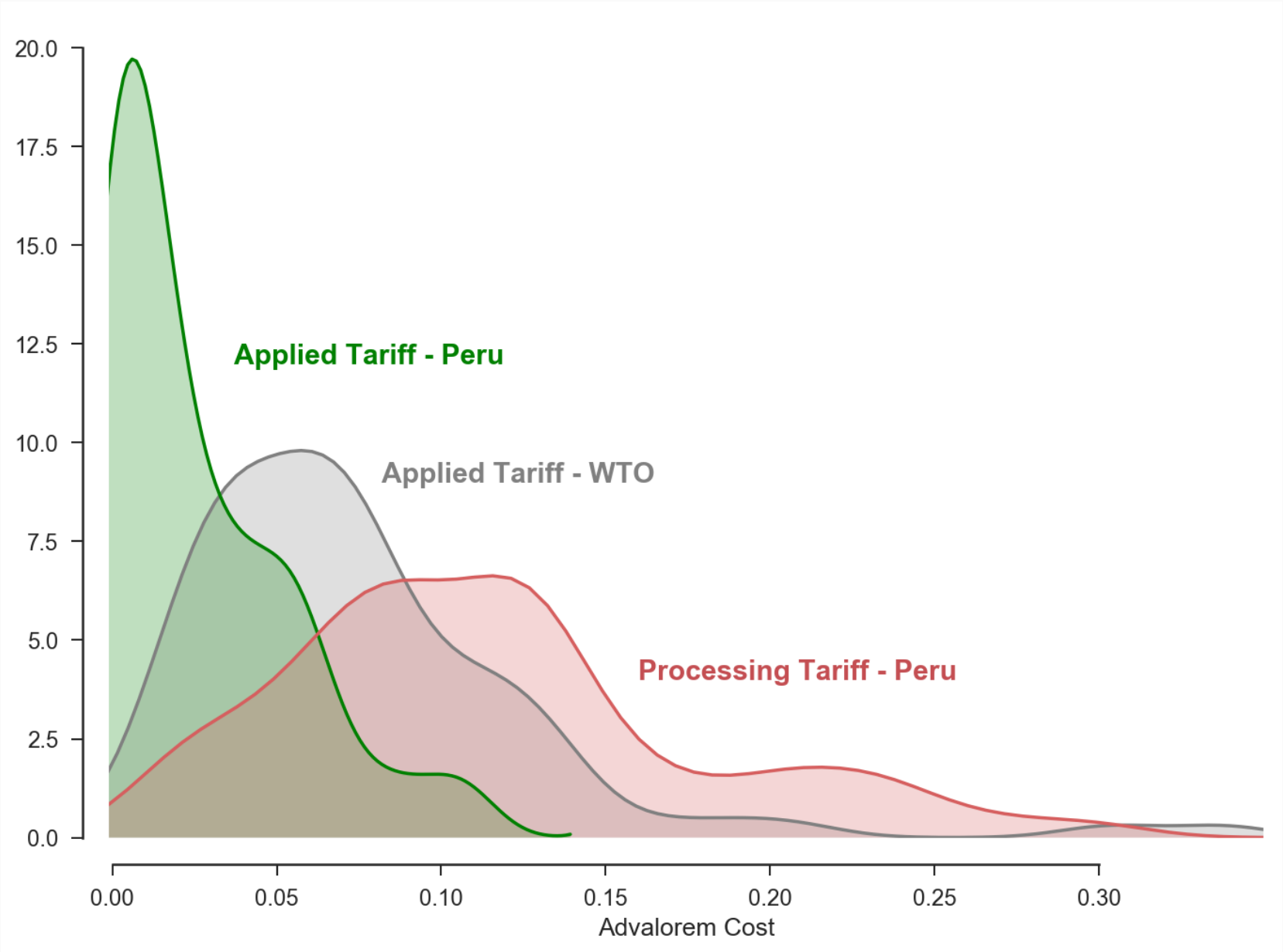
Preview: Tariffs and Processing Tariff



Preview: Tariffs and Processing Tariff



Preview: Tariffs and Processing Tariff



Related Literature

- A set of papers identify trade costs with respect to frictions related to crossing borders (McCallum, 1995; Helliwell, 1996; and Anderson and van Wincoop, 2003).

Related Literature

- A set of papers identify trade costs with respect to frictions related to crossing borders (McCallum, 1995; Helliwell, 1996; and Anderson and van Wincoop, 2003).
  - Instead of estimating a catch all border effect, we quantify the impact of detailed border procedures.

Related Literature

- A set of papers identify trade costs with respect to frictions related to crossing borders (McCallum, 1995; Helliwell, 1996; and Anderson and van Wincoop, 2003).
  - Instead of estimating a catch all border effect, we quantify the impact of detailed border procedures.
- A number of papers show that time is costly (Evans and Harrigan 2005; Freund et al., 2010; Hummels and Schaur 2013; and Volpe Martincus et al. 2015).
  - Our theory provides a structural foundation for time cost estimates and shows that their estimates don't apply to evaluate trade facilitation policy and that firm heterogeneity is important issue at the firm level.

Empirical Facts

Import Processing Data

- Detailed data taken from import declarations and load manifests at the transaction level data, 2007-2013.
- Source: Peru's National Tax Agency (SUNAT).
- For each shipment clearing through the sea-port of Callao we observe:
  1. Date when the ship arrived.
  2. Date the shipment (container) was unloaded.
  3. Date the customs import declaration was created and registered.
  4. The customs channel.
  5. Date the shipment was released by customs.
- Transaction Level: importing firm-by-export country-by-HS10 product-by-shipment

Fact 1- Processing Time and Storage Time

Stage	Channel	Mean	5th	50th	95th
Total Border	All	16.5	4.0	12.0	44.0
	Green	11.6	4.0	8.0	29.5
	Red	23.2	7.0	19.0	55.0
Storage	All	11.0	2.0	7.0	32.0
	Green	9.7	2.0	7.0	27.0
	Red	12.5	2.0	8.0	37.0
Port and Custom ("Processing")	All	6.4	1.0	4.0	19.0
	Green	3.8	1.0	2.0	6.0
	Red	12.1	4.0	9.0	26.0

- **Total Border**: duration from arrival to customs clearance.
- **Processing**: time spend in actual processing stages: Port and Custom.

Fact 1- Processing Time and Storage Time

Stage	Channel	Mean	5th	50th	95th
Total Border	All	16.5	4.0	12.0	44.0
	Green	11.6	4.0	8.0	29.5
	Red	23.2	7.0	19.0	55.0
Storage	All	11.0	2.0	7.0	32.0
	Green	9.7	2.0	7.0	27.0
	Red	12.5	2.0	8.0	37.0
Port and Custom	All	6.4	1.0	4.0	19.0
("Processing")	Green	3.8	1.0	2.0	6.0
	Red	12.1	4.0	9.0	26.0

- **Total Border**: duration from arrival to customs clearance.
- **Processing**: time spend in actual processing stages: Port and Custom.
- Firms face a **time distribution** where the storage and channels matter.

Fact 2- Exporters manage storage time

	Storage			
Port Time	-0.152***	-0.169***	-0.111***	-0.132***
	(0.011)	(0.013)	(0.011)	(0.012)
	Customs Time			
Storage Time	-0.001	-0.009	-0.005	-0.016
	(0.007)	(0.008)	(0.006)	(0.011)
Firm FE	Yes	No	Yes	No
Product-Origin FE	Yes	No	Yes	No
Firm-Product-Origin FE	No	Yes	No	Yes
Day FE	No	No	Yes	Yes

- Firms absorb longer unloading times with shorter storage times

Fact 2- Exporters manage storage time

	Storage			
Port Time	-0.152***	-0.169***	-0.111***	-0.132***
	(0.011)	(0.013)	(0.011)	(0.012)
	Customs Time			
Storage Time	-0.001	-0.009	-0.005	-0.016
	(0.007)	(0.008)	(0.006)	(0.011)
Firm FE	Yes	No	Yes	No
Product-Origin FE	Yes	No	Yes	No
Firm-Product-Origin FE	No	Yes	No	Yes
Day FE	No	No	Yes	Yes

- Firms absorb longer unloading times with shorter storage times
- Longer storage times have no effect on customs times

Fact 3- Firm Heterogeneity

Stage	Firm Type	Mean	5th	50th	95th
Total Border	New Importers	24.7	7.0	20.0	60.0
	Incumbent	15.2	4.0	11.0	40.0
Processing	New Importers	9.8	2.0	8.0	25.0
	Incumbent	5.8	1.5	4.0	17.0
Total Border	Non-Exporters	17.2	5.0	13.0	45.0
	Exporters	13.0	4.0	9.0	37.0
Processing	Non-Exporters	7.2	2.0	5.0	20.0
	Exporters	4.8	1.0	3.0	14.0

- Variation related to standard trade models hidden in aggregate data.

Fact 3- Firm Heterogeneity

Stage	Firm Type	Mean	5th	50th	95th
Total Border	New Importers	24.7	7.0	20.0	60.0
	Incumbent	15.2	4.0	11.0	40.0
Processing	New Importers	9.8	2.0	8.0	25.0
	Incumbent	5.8	1.5	4.0	17.0
Total Border	Non-Exporters	17.2	5.0	13.0	45.0
	Exporters	13.0	4.0	9.0	37.0
Processing	Non-Exporters	7.2	2.0	5.0	20.0
	Exporters	4.8	1.0	3.0	14.0

- Variation related to standard trade models hidden in aggregate data.
- Firms border management may be related to firm heterogeneity.

Fact 3- Firm Heterogeneity

Stage	Firm Type	Mean	5th	50th	95th
Total Border	New Importers	24.7	7.0	20.0	60.0
	Incumbent	15.2	4.0	11.0	40.0
Processing	New Importers	9.8	2.0	8.0	25.0
	Incumbent	5.8	1.5	4.0	17.0
Total Border	Non-Exporters	17.2	5.0	13.0	45.0
	Exporters	13.0	4.0	9.0	37.0
Processing	Non-Exporters	7.2	2.0	5.0	20.0
	Exporters	4.8	1.0	3.0	14.0

- Variation related to standard trade models hidden in aggregate data.
- Firms border management may be related to firm heterogeneity.
- Important to understand trade models.

Conclusions from empirical facts

- Total border times are a combination of storage times and processing times and *endogeneous* to the firms.

Conclusions from empirical facts

- Total border times are a combination of storage times and processing times and *endogeneous* to the firms.
- Processing times are determined by customs and port efficiency
  - Conditional on fixed effects, less likely to be endogenous
  - Easier to measure and monitor
  - Processing times are random: random allocation to customs inspection, document handling, port strikes, equipment failure, etc.

Conclusions from empirical facts

- Total border times are a combination of storage times and processing times and *endogeneous* to the firms.
- Processing times are determined by customs and port efficiency
  - Conditional on fixed effects, less likely to be endogenous
  - Easier to measure and monitor
  - Processing times are random: random allocation to customs inspection, document handling, port strikes, equipment failure, etc.
- Firms optimize
  - Longer processing times are correlated with lower buffer times
  - Have to interpret processing costs through firms' supply chain optimization

Theory

Model of expected time cost

- Firms choose the time they allow to clear the port, t_c
- Problem: Processing time (t_p) is random with $t_p \sim \frac{\varphi t_{min}^{\varphi}}{t_p^{\varphi+1}}$
  - If $t_p \leq t_c$ then firms stores the shipment withouth additional costs
  - If $t_p > t_c$ then late shipment faces late costs: $\left(\frac{t_p}{t_c}\right)^{\omega} rv$
- Trade off: increasing t_c...
  - Raises supply chain cost: $t_c^{\vartheta} v$ with $\vartheta > 0$
  - Lowers expected late delivery cost: $\int_{t_c}^{\infty} \left(\frac{t_p}{t_c}\right)^{\omega} rv \frac{\varphi t_{min}^{\varphi}}{t_p^{\varphi+1}} dt_p$
- Objective: Minimize $ETC = \int_{t_c}^{\infty} \left(\frac{t_p}{t_c}\right)^{\omega} rv \frac{\varphi t_{min}^{\varphi}}{t_p^{\varphi+1}} dt_p + t_c^{\vartheta} v$
- Solution: $t^* = t_{min}^{\frac{\varphi}{\varphi+\vartheta}} \times \left(\frac{r\varphi^2}{(\varphi-\omega)\vartheta}\right)^{\frac{1}{\varphi+\vartheta}}$
- Intuition: If running late is costly $\Rightarrow$ Firms schedule more buffer time

Expected Cost Function

- Substitue t^* into objective to obtain:

$$TC = \lambda(\varphi, \omega, r, \vartheta) \times t_{median}^{\frac{\vartheta\varphi}{\vartheta+\varphi}} \times v$$

- Implications:
  - Distribution matters to understand elasticity
  - Existing estimates do not directly apply
  - Multiple sources of heterogeneity across firms, industries, countries
  - Rankings based on time alone do not provide consistent cost rankings
- Rewrite to obtain: $TC = (t^*)^{\vartheta} \times v \times \frac{\vartheta+\varphi}{\varphi}$
  - Different elasticity: $\vartheta > \frac{\vartheta\varphi}{\vartheta+\varphi}$
- Empirical questions:
  - Can we estimate the cost parameters?
  - Are sources of heterogeneity important?
  - Does the measurement distinction matter?

Empirical Evidence

Empirical Approach

- First best: Observe contracted delivery times ⇒not available
- Substitute cost into CES import demand:

$$\begin{aligned} ln(v_{ihxy}^{fob}) =& \delta_{hy} + \delta_{iy} + (1+\gamma) ln(p_{hxy}^{fob}) + \gamma ln(\lambda_{ihx}) \\ &+ \gamma ln(\tau_{ihxy}) + \gamma\chi ln(\hat{t}_{med,ihxy}) + u_{ihxy} \end{aligned}$$

  - i : importer, h : product, x : origin, y : year, $\chi = \frac{\vartheta\varphi}{\vartheta+\varphi}$
  - p_{hxy}^{fob} and λ_{ihx} absorb with fixed effects
  - τ_{ihxy} absorbed with fixed effects and included in specification
- Acomodate single and multi product firms
- Plug in solution: $\hat{t}_{med,ihxy} = E(MedianTime) + \epsilon_{ihxy}$
- No substitution across ports and customs offices
- Source of endogeneity: shipment size, measurement, demand shocks ⇒IV
  - Port congestion: Line of ships before arrival

Data - Snapshot

Year	Import Value	#Importers	#Origins	#Products
2007	19,100	19,290	199	6,989
2008	27,900	22,542	205	6,230
2009	20,600	23,597	201	6,174
2010	28,200	25,592	203	6,233
2011	36,100	26,804	210	6,177
2012	40,200	28,799	211	6,302
2013	41,100	30,131	209	6,303
		Percentage Share Callao		
2007	72.3	64.0	86.4	92.4
2008	72.4	65.4	87.3	92.6
2009	73.8	65.7	93.0	93.0
2010	75.5	64.8	84.7	92.9
2011	76.7	65.8	84.8	93.2
2012	75.9	65.5	90.5	93.3
2013	74.7	65.6	88.5	93.2

	Processing Time			Total Time		
	OLS	IV1	IV2	OLS	IV1	IV2
Time	-0.049[a]	-0.236[a]	-0.234[a]	-0.057[a]	-0.556[a]	-0.551[a]
	(0.005)	(0.011)	(0.011)	(0.005)	(0.026)	(0.026)
Trade Costs			-1.541[a]			-1.540[a]
			(0.044)			(0.044)
IV1: Congestion		0.028[a]	0.028[a]		0.009[a]	0.009[a]
		(0.000)	(0.000)		(0.000)	(0.000)
IV2: Channel		0.651[a]	0.651[a]		0.281	0.281[a]
		(0.003)	(0.003)		(0.003)	(0.003)
F-Test		33,593	33,594		6,632	6,,633
		[0.000]	[0.000]		[0.000]	[0.000]
Hansen		0.562	0.570		0.949	0.934
		[0.453]	[0.450]		[0.330]	[0.334]
Firm-Y FE	Yes	Yes	Yes	Yes	Yes	Yes
Orig-Prod-Y FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	589,842	589,842	589,842	589,844	589,844	589,844

The Impact of Border Time on Firms' Imports

	Processing Time			Total Time		
	OLS	IV1	IV2	OLS	IV1	IV2
Time	-0.049[a]	-0.236[a]	-0.234[a]	-0.057[a]	-0.556[a]	-0.551[a]
	(0.005)	(0.011)	(0.011)	(0.005)	(0.026)	(0.026)
Trade Costs			-1.541[a]			-1.540[a]
			(0.044)			(0.044)

[a]significant at 1% - Clustered S.E. at Firm level

- OLS is subject to attenuation bias due to measurement error and high dimensional FE.

The Impact of Border Time on Firms' Imports

	Processing Time			Total Time		
	OLS	IV1	IV2	OLS	IV1	IV2
Time	-0.049[a]	-0.236[a]	-0.234[a]	-0.057[a]	-0.556[a]	-0.551[a]
	(0.005)	(0.011)	(0.011)	(0.005)	(0.026)	(0.026)
Trade Costs			-1.541[a]			-1.540[a]
			(0.044)			(0.044)

[a]significant at 1% - Clustered S.E. at Firm level

- OLS is subject to attenuation bias due to measurement error and high dimensional FE.
- Tariffs, freights and insurances charges are independent of processing times (as assumed in theory) and provide an estimate for ρ.

The Impact of Border Time on Firms' Imports

	Processing Time			Total Time		
	OLS	IV1	IV2	OLS	IV1	IV2
Time	-0.049[a]	-0.236[a]	-0.234[a]	-0.057[a]	-0.556[a]	-0.551[a]
	(0.005)	(0.011)	(0.011)	(0.005)	(0.026)	(0.026)
Trade Costs			-1.541[a]			-1.540[a]
			(0.044)			(0.044)

[a]significant at 1% - Clustered S.E. at Firm level

- Total time overestimates the processing elasticity as our model predicts. *Intuition:* storage time dampens the variation.

The Impact of Border Time on Firms' Imports

	Processing Time			Total Time		
	OLS	IV1	IV2	OLS	IV1	IV2
Time	-0.049[a]	-0.236[a]	-0.234[a]	-0.057[a]	-0.556[a]	-0.551[a]
	(0.005)	(0.011)	(0.011)	(0.005)	(0.026)	(0.026)
Trade Costs			-1.541[a]			-1.540[a]
			(0.044)			(0.044)

[a]significant at 1% - Clustered S.E. at Firm level

- Total time overestimates the processing elasticity as our model predicts. *Intuition:* storage time dampens the variation.
- High attenuation bias for OLS for total time. *Intuition:* firms can actively manage storage (additional endogeneity).

Results - Robustness Checks

- Different sets of FE:
  - Firm-Year
  - Origin-Product-Year
  - Firm-Product-Year, Origin-Product-Year
  - Firm–Origin-Year, Origin-Product-Year
  - Firm–Year, Origin-Product-Year, Firm-Product-Origin
  - Firm fixed effects
- Controling Sample for:
  - Shipments pre-processed (small share of shipment)
  - Products that requires permits to import
  - Light products
- IV:
  - Different windows for congestion: 2-10 days
  - Focusing only on physical inspection
- Clustering at different levels
- Alternative specification: specify prices and freight charges

Results - Quantification

- Elasticities are not enough to quantify border processing times:
  - It requires estimating $\lambda(\varphi, \vartheta, r, \omega)$: ugly function!
  - φ is estimated from the processing time distribution

    $\Rightarrow t_{median} =^{\varphi} \sqrt{2} \times t_{min}$
  - With χ and φ we can recover ϑ
- Lower bound on λ that depends only on φ, ϑ based on our model
  - We show that $\lambda > \underline{\lambda} = \frac{\frac{\vartheta+\varphi}{\varphi}}{2^{\frac{\vartheta}{\vartheta+\varphi}}}$
  - In the paper we have mutliple ways to compute lambda
- Bootstrapped estimates to evaluate significance.

Results - Lower Bound Quantification

	IV1	IV2
γ	2.977	1.541
χ	0.079[a]	0.152[a]
	(0.008)	(0.008)
φ	2.072[a]	2.072[a]
	(0.037)	(0.037)
ϑ	0.082[a]	0.164[a]
	(0.007)	(0.016)
$(\underline{\lambda} - 1)$	0.013[a]	0.026[a]
	(0.002)	(0.004)
(Time Cost-1)	0.167[a]	0.346[a]
	(0.015)	(0.036)

- At the average median processing time, border processing tariff between 17% and 35% where expected late costs are between 4.5% and 9.7%.

Results - Lower Bound Quantification

	IV1	IV2
γ	2.977	1.541
χ	0.079[a]	0.152[a]
	(0.008)	(0.008)
φ	2.072[a]	2.072[a]
	(0.037)	(0.037)
ϑ	0.082[a]	0.164[a]
	(0.007)	(0.016)
$(\underline{\lambda} - 1)$	0.013[a]	0.026[a]
	(0.002)	(0.004)
(Time Cost-1)	0.167[a]	0.346[a]
	(0.015)	(0.036)

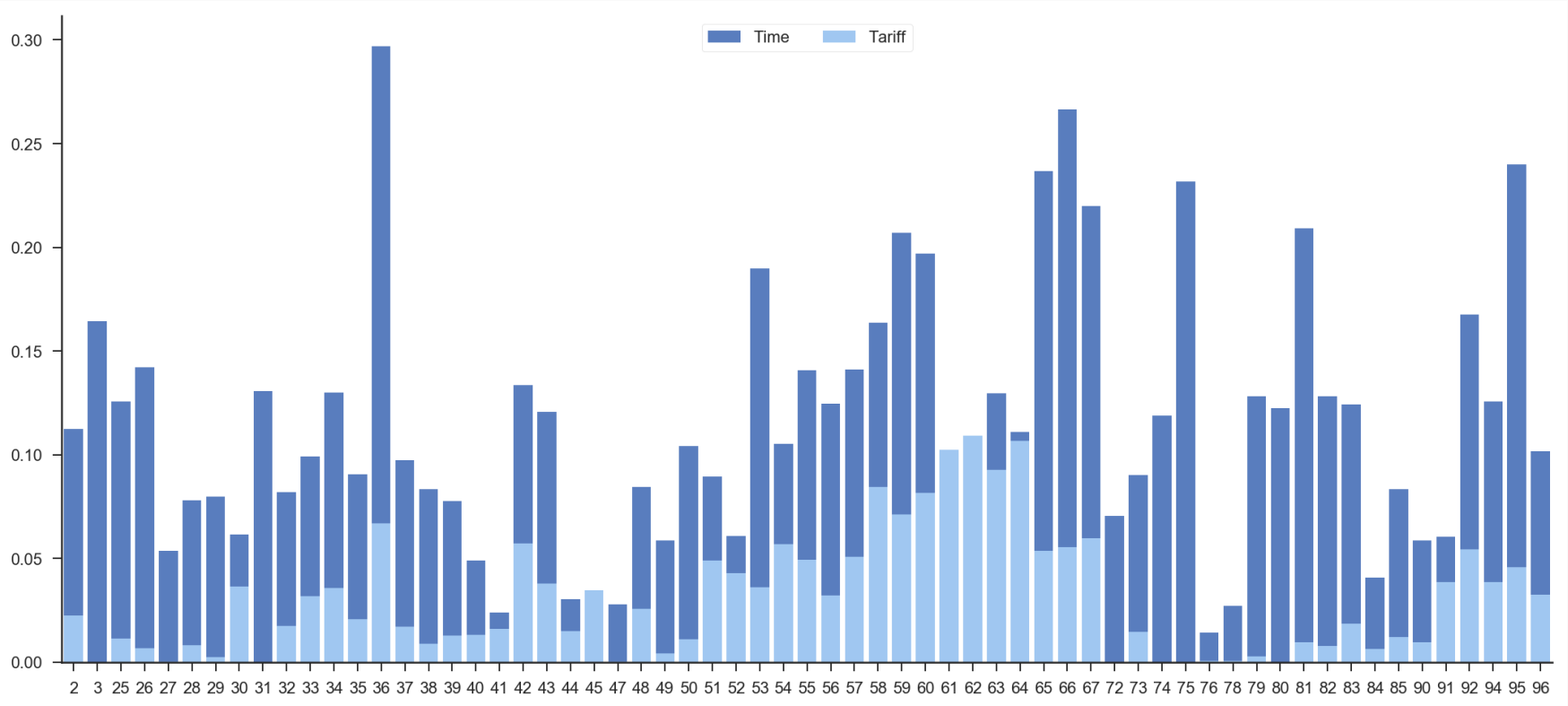
- Policy experiment: dropping physical inspection of documents reduces processing from 5 to 2 days and border processing tariff to 9% and 12%.

Results - Quantification: Firm Heterogeneity

- Trade costs are usually assumed homogeneous across firms.
  - This mutes policy consequences and conceals firms' optimal responses to trade barriers.
- Our results shows heterogeneity across firms.
  - Larger and Exporter Firms are more elastic to delays but compensate with investing in supply chain and reducing time.
  - New importers face greater costs.

	Size			**Export Experience**			**Import Experience**		
	SF	LF	Diff	NEF	EF	Diff	NIF	IF	Diff
Time	-0.204^a	-0.296^a	^{a}	-0.199^a	-0.268^a	^{a}	-0.422^a	-0.207^a	^{a}
γ	2.922	3.129		2.945	3.038		2.940	2.977	
χ	0.070^a	0.094^a	^{a}	0.068^a	0.088^a	^{a}	0.144^a	0.069^a	^{a}
φ	2.011^a	2.128^a		1.999^a	2.070^a		3.053^a	2.037^a	^{a}
ϑ	0.072	0.099	^{b}	0.070	0.092	^{b}	0.151	0.072	^{a}
$(\underline{\lambda} - 1)$	0.011^a	0.015^a	^{c}	0.011^a	0.014^a	^{c}	0.016^a	0.011^a	
Avg Time	6.531	3.771		6.961	3.846		11.868	5.374	
Time Cost	0.153^a	0.150^a		0.153^a	0.142^a		0.449^a	0.136^a	^{a}

Results - Quantification: HS2 Specific



Conclusion

Conclusion

- We focus on the role of border processing as a source of border costs.
- We model firm's optimal time management to meet delivery schedules when processing times are uncertain. We embed this into an import demand setting to develop an identification strategy.
- We estimate the model and structural parameters using highly detailed data from Peru.
- Our results show
  - Border processing imposes a trade cost greater than average applied WTO tariffs.

Conclusion

- Our results show
  - Processing tariffs are dispersed across products, and especially new trade relationship suffer from high border costs.
  - Aggregate measures of border-processing are difficult to interpret as cost ranking because they combine actual processing times with optimally chosen storage times. Even actual processing times systematically vary with firms and product characteristics. Second moments about the processing distribution would be useful to interpret elasticities.