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Economic Consequences of Cabotage Restrictions

The Effect of the Jones Act on Puerto Rico

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Abstract

This paper studies the consequences of a U.S. cabotage law for Puerto Rico (PR). Data on ship arrivals in PR show that the fleet of U.S. vessels that call there lacks capacity for carrying non-containerized freight. Empirical estimation using trade data shows that PR's imports of sea-shipped final products are biased against U.S. mainland sources. This bias is strongest for heavy products and products not typically shipped in containers. Among upstream products, a strong bias against imports of sea-shipped products applies to all sources. Estimated tariff-equivalent costs among final products imply static annual welfare losses of 1.1 percent of household consumption ($203 per person). The same tariff-equivalent cost estimates imply that the law raises the cost of investment in PR by 3.0 percent. The observed bias against sea-shipped inputs in PR's imports may result from long-run industry location decisions that have been influenced by the law's presence.

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Economic consequences of cabotage restrictions: The effect of the Jones Act on Puerto Rico

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1 Introduction

The *U.S. Merchant Marine Act of 1920* (the Jones Act) requires that maritime vessels moving goods from one U.S. port to another must be U.S.-built, U.S.-flagged, U.S.-owned and U.S.-crewed.[1] This protectionist policy raises the cost of intra-national maritime shipping in the U.S., and imposes a disproportionate burden on residents of U.S. islands. These effects of the policy are generally understood as a qualitative matter, but there are few quantitative estimates of the economic burden the policy puts on U.S. outlying areas. In this paper we estimate the economic effects of the Jones Act (JA) on Puerto Rico (PR).[2]

We begin by exploring data documenting ship movements in the Caribbean. Supplementary data from the same source reveal each ship's type, country of build, country of ownership and the flag under which it operates. We use these data to identify ships that call in Puerto Rican ports and satisfy JA regulations. We compare the characteristics of vessels that satisfy JA requirements with the broader fleet calling in PR, and with vessels calling elsewhere in the Caribbean. This exercise reveals a striking pattern; the JA fleet serving PR is dominated by container ships and barges. Other cargo vessels that appear regularly in the rest of the Caribbean are nearly absent from the U.S.-PR market. We hypothesize that the JA raises costs on all-seaborne shipping, but more so on physically heavy and/or bulky products that are difficult to containerize.

[1] Specifically, the Jones Act requires that every vessel serving any U.S. domestic route must be (1) at least 75% owned by U.S. citizens; (2) built in the U.S.; (3) crewed by U.S. citizens or permanent residents; and (4) registered in the U.S. At least 75% of the crew should be U.S. citizens, and all of its officers and engineers (Beason et al. (2015), cited in Olney (2020)). The U.S.-build requirement includes some infrequently used exceptions that happen to be relevant in the Puerto Rican setting.

[2] It is likely that the JA has similar effects on other U.S. islands and outlying areas, including Hawaii (HI) and Alaska (AK). The U.S. does not collect the detailed intra-national trade data for AK and HI that we use here. There is similar data available for other U.S. possessions, but these island economies are quite small, usually more distant from the U.S., and not subject to the same breadth of JA restrictions that apply to PR.

In what follows, our maintained hypothesis is that the JA is responsible for the unusual mix of vessels participating on U.S.-PR routes.[3] We describe the mechanisms here. The container ships and barges that carry the vast majority of U.S.-PR trade have business models that are reasonably well suited to back-and-forth shipping between the U.S. and PR. Container ships carry a diverse set of products, allowing voyage-specific economies of scale that - combined with rents from protection - can justify the high capital costs of purchasing U.S.-built vessels. Barges can carry an even more diverse mix of freight, but do so at a small scale that offers little advantage from also serving foreign ports. Barges' lower construction costs and flexibility justify the higher marginal costs associated with the low volumes they carry.

The tanker, bulk, liquid and general cargo vessels that are nearly absent from the U.S.-PR route typically carry non-containerized freight, making it difficult to achieve economies of scale (either within- or across-voyages) unless they also serve foreign ports. JA-compliant versions of such vessels would not be competitive in international waters, so the resulting lack of scale means that high-cost U.S.-built vessels are not purchased for use on low-value domestic routes.[4] The restricted supply of these vessel-types imposes a differential burden on routes involving PR,

[3]Later in the paper we argue that one likely long-run consequence of the JA is that it has shifted PR's industrial production away from industries that use sea-shipped imports as inputs. Our argument here is that in the short run, the composition of the JA fleet serving PR imposes disproportionate trade costs on imports of products that rely on the vessel types that are in short supply.

[4]Consider the case of bulk vessels. Brancaccio et al. (2020) explain that in international markets bulk vessels act as taxis do in urban transportation; after unloading in one destination they search nearby for a new cargo, which they deliver to a subsequent destination of the shipper's choice. A significant share of the operating costs of ships with this business model is the time they spend searching for a new cargo. In the JA context, the opportunity costs of search time for high-cost U.S.-built bulk ships would be high, even as the limited number of solely domestic routes on which they would be competitive would increase the length of their search times. JA operators respond to these circumstances by choosing not to purchase bulk vessels that would operate with a taxi-like business model. While the particular business models of tanker and general cargo vessels differ from bulk carriers', the economic consequences of the JA appear to be similar.

which is neither a large producer or consumer of the products that usually travel on such vessels.[5] The fleet composition effects we observe in PR are not directly relevant for products that are typically containerized, but we further hypothesize that JA protection gives domestically-owned suppliers of container shipping greater scope to link freight charges to the physical weight of the products they transport. One likely mechanism is that air shipping is the only viable alternative transport mode on this route, and the cost of air shipping is highly dependent on physical weight.

We motivate our empirical framework with an adapted version of Krugman and Venables (1996). Among final products, the model's predictions are those of a conventional gravity model of trade: PR buyers substitute away from U.S. mainland sources in products exposed to JA trade costs, buying instead from other sources. Among products that are upstream in production chains, the model allows a larger set of behavioral responses to trade costs. Conventional substitution responses are possible, but trade in upstream products may also be reduced through the "production location effects" proposed by Hillberry and Hummels (2002). High maritime trade costs with a key supplier mean that industries that would otherwise import sea-shipped upstream products for processing in PR do not locate there at all. The consequence may be reduced levels of *total* import demand among sea-shipped products, rather than mere substitution away from U.S. mainland sources.

We use a pooled product-level gravity model to study PR's relative import demand for product characteristics that affect their products' mode of transport and transport charges.[6] The characteristics we study are the products' a) vessel share

[5]JA-compliant tanker and bulk vessels are active in U.S. waters, but appear to operate primarily on high volume back-and-forth routes. A November 2023 review of U.S.-flagged vessels built after 2014 on `vesselfinder.com` identifies several oil/chemical tankers working in the Gulf of Mexico, and others linking the U.S. west coast either to Alaska or to Hawaii and then sometimes Guam. One large U.S.-flagged bulk carrier of recent vintage is active on the Great Lakes.

[6]We focus on imports because most of the vessel freight between the U.S. and PR travels in

of imports, b) weight-to-value ratio, and c) containerized-share of imported shipments. In order to avoid a potential bias generated by endogenous choices of transport mode, we calculate these characteristics in U.S. import data (net of flows from Canada and Mexico). Among final products, we find that PR's home bias towards imports coming from the U.S. mainland is smaller for products that are vessel-shipped, physically heavy, and not typically shipped in containers. Among upstream products, evidence of substitution away from U.S. sources is less apparent; instead the composition of PR's imports exhibits a strong bias against sea-shipped products in general. These effects are consistent with a hypothesis that the JA has shifted PR's industrial structure away from sectors that use sea-shipped imports as inputs, though other policies may also have contributed to this outcome.

Since we estimate trade distortions on a single trade route, our empirical methods are somewhat different than conventional approaches to estimating the gravity model of trade. As a robustness check we apply precisely the same methods to the imports of three comparison countries: the Dominican Republic (DOM), Jamaica (JAM) and the Bahamas (BHS). The patterns we uncover in PR do not appear in these other countries; giving credence to the view that the effects we observe for PR are due to the JA, rather than to other anomalies in U.S.-Caribbean trade.

In order to provide quantitative context for our estimates, we incorporate external estimates of product-level elasticities of substitution to infer tariff-equivalent JA trade costs among final products, and conduct a compensating variation (CV) calculation that removes JA tariff-equivalent costs in final demand. Our preferred specification produces a mean JA-tariff-equivalent of 30.6 percent among final products. The CV calculation suggests an annual welfare burden of the policy of $1.4 billion

the direction of PR. The container ships that work the route typically return to the mainland with less than full loads and, anecdotally, charge much lower rates. The dearth of self-propelled vessels available to carry non-containerized freight may also affect PR's exports to the U.S., but given PR's industrial mix it does not seem likely that this is quantitatively important (in a static sense, at least).

(in 2016 dollars). Focusing on household consumption alone, the estimates suggest a burden of 1.1 percent of expenditure, or \$203 per citizen per year. Applying the same approach to investment spending generates an estimate that the JA increases the cost of investment in PR by 3 percent.

Our estimates of missing trade among upstream products are more difficult to attribute directly to the JA, but are potentially much more important since they suggest dynamic effects of the JA. We find that PR's total imports of sea-shipped upstream products are approximately 77% lower than imports of otherwise equivalent air-shipped products. Similar calculations for DOM, JAM and BHS finds no bias against sea-shipped products in upstream import demand. Although the bias against sea-shipped upstream products in PR's import demand is suspiciously large, attributing these effects to the JA is difficult because the evidence of additional bias against U.S. mainland sources is weak. We therefore refrain from including the effects we observe among upstream products in our welfare estimates. If even a fraction of the effects we estimate are in fact due to the JA, the policy has imposed a large burden on PR's long-run development.

There is a relatively small academic literature on the JA. The paper closest to ours is Olney (2020), who shows evidence of substitution away from waterborne shipping among data on shipments arriving in U.S. coastal states. Our econometric exercise is similar, but with a few key differences. We focus on PR (an island) rather than coastal U.S. states, and use data on Puerto Rican imports rather than freight movements destined for U.S. mainland ports. Our focus on PR's trade means that only two modes of transport are relevant (air and sea), while Olney's data contain possibilities for easier substitution towards rail and road transport. We estimate a structural parameter, the tariff-equivalent cost of JA restrictions that can explain cross-product variation in estimated home bias that is attributable to the relevant product characteristics. These estimates reveal relatively higher tariff equivalents for products that are unusually heavy and/or not typically shipped in containers.[7]

Kellogg and Sweeney (2023) study the effects of the JA on U.S. regional markets for petroleum and related products. They show that transport cost differentials associated with the JA lead buyers on the U.S. East Coast to substitute toward foreign sources, even as U.S. suppliers in the Western Gulf Coast shift their sales towards exports and away from the U.S. East Coast. Although their analysis does not include PR, the behavior they document for petroleum products on the East Coast is similar to what we observe for all sea-shipped final products purchased in PR. The absence of JA-compliant tankers and liquid vessels in our port-of-call data is also consistent with their results.

Francois et al. (1996) use a computable general equilibrium (CGE) model of the entire U.S. to measure the equivalent variation of removing the JA for the U.S. economy as a whole. These authors calculate that the welfare cost of the JA to the U.S. economy was approximately $3 billion in 1989.[8] These CGE estimates would include a significant burden of the JA operating through higher prices for upstream inputs. We lack a credible, up-to-date input-output table for PR, which limits our ability to do economy-wide general equilibrium calculations. Furthermore, attribution among upstream products is difficult because firms can respond to JA trade costs by locating outside of PR entirely, which means that some industries to which hat calculus might otherwise be applied are altogether missing from the data.[9] Our CV calculations thus consider only distortions to purchases by final demand, and

[7] Our evidence that the composition of PR's upstream imports is biased against sea-shipped products from all sources is different than the substitution away from U.S.-sourced products that Olney estimates in his sample of all products. These are different samples, but the different results may also be due to PR's island status making industry location decisions there more sensitive to elevated costs of sea-shipping than they are in the collection of U.S. coastal states that Olney studies.

[8] Estimates using this methodology also appear in USITC (1991) along with subsequent versions of the USITC report. PR was not considered part of the U.S. economy in the CGE studies cited here.

[9] The endogenous supply of capital and labor flows also complicates GE counterfactual analysis. PR has seen quite large emigration flows over the last two decades, an outflow that may have been much smaller if a larger set of industries were viable in PR.

rely solely on an expenditure/cost function.[10]

There is also a consulting and/or policy literature on the JA.[11] The most relevant study for our paper is John Dunham & Associates (2019), which notes that the JA is likely to put an especially large burden on the movement of heavy goods. We build on this insight, estimating JA tariff equivalents that depend on physical weight. We also note the unusual composition of the JA fleet, and estimate a disproportionate burden on non-containerized freight.

The remainder of the paper is organized as follows. Section 2 briefly reviews the unusual features of the Puerto Rican economy, namely the dominance of the pharmaceutical sector. Section 3 describes the data. Section 4 compares the composition of the JA fleet to that serving Caribbean routes generally. Section 5 describes the theoretical framework and empirical estimation approach. In section 6 we report estimation results. Section 7 reports welfare losses from the distortions we estimate among final products. Section 8 concludes.

2 The pharmaceutical sector in PR

Manufacturing is a dominant sector in PR, accounting for 45.2 percent of gross output and 11.8 percent of employment.[12] Within PR's manufacturing sector, the *Pharmaceuticals and related manufacturing* sector accounts for 64.6 percent of the manufacturing sector's gross output in PR and 17.7 percent of its employment. While there appear to be no published data on the value added in PR by the sector itself, it accounts for 98.7 percent of PR's gross output in the larger Chemical Products sector, which accounts for 72 percent of PR's total value added in manu-

[10]Protectionist measures like the JA also generate rents for U.S. shipbuilders, owners and crews. Our calculations assume that these rents accrue to residents of the U.S. mainland, not to Puerto Ricans.

[11]Jimenez (2023) reviews this literature, including the Spanish language literature specific to PR.

[12]By comparison, in 2019 the manufacturing sector accounted for 15.8 percent of U.S. gross output and 8.5 percent of U.S. non-farm employment.

facturing.

The dominance of the pharmaceutical sector is likely due, in part, to the JA. Because sectors that rely on sea-shipped inputs are largely missing from PR's industrial mix, a sector that uses air transport for most inputs and outputs appears more dominant. But the pharmaceutical sector's dominance is also the result of other U.S. policies, notably the "Possession Tax Credit" (commonly known as Section 936). This policy gave favorable tax credits to firms with intangible assets (such as patents) locating activities in PR. While Section 936 was phased out by 2006, the dominance of the pharmaceutical sector in PR is clearly a legacy of the policy. Pharmaceuticals account for a large share of PR's trade (20.9 percent of imports and 74.0 percent of exports). We exclude trade in pharmaceutical products from our regressions to avoid attributing to the JA the lingering effects of Section 936. Our CV calculations assume JA tariff-equivalents of zero on everything purchased and sold by the pharmaceutical sector.

3 Data

We exploit three main sources of data. Comprehensive data on ship ports-of-call in the Caribbean illustrate the relative supplies of different types of vessels in Caribbean shipping markets. Data on PR's imports – from both foreign and U.S. mainland sources - are used in an empirical gravity model. Once we have estimated tariff-equivalent trade costs attributable to the JA, we match them to data on final expenditures from a Puerto Rican input-output table. In this section we describe these three data sets, as well as some ancillary data that we use in our estimation.

3.1 Port of call data

In order to better understand the relative and absolute supplies of different shipping services to PR, we purchased comprehensive data on freight vessels' ports of call in the Caribbean from LLI (2021).[13] The data offer comprehensive information on ports of call by freight hauling vessels in the Caribbean during the years 2004-2020. Each observation reports the previous five and subsequent five ports of call by the ship in question, as well as a unique vessel ID number. We also purchased from LLI data on characteristics of the 16,097 freight-hauling vessels in our database. The following information is available for nearly every vessel: the vessel identification number, vessel type, flag of registry, year and place of build, the vessel's owner, and its dead-weight tonnage (DWT). We combine the port of call data with the ship characteristics data to describe the supply of vessels that call in Caribbean or PR ports, as well as those that meet JA criteria,

The LLI data understate the volume of barge traffic between the U.S. and PR. We also use data from the National Ballast Information Clearinghouse (NBIC, 2024), which reports data that is similar to that of LLI, but only for U.S. ports. The NBIC data are publicly available, another advantage. We report port-of-call data from both series for 2019 because it is the most recent year of LLI data not affected by the COVID-19 pandemic.

3.2 Puerto Rican import data

Our empirical gravity model relies on data documenting flows of imports into PR. These data are provided by IEPR (2021) for 2010-2017. The data report monthly imports to PR disaggregated by HS10-digit product code, origin country (for foreign imports) and U.S. customs district (for U.S.-origin shipments).[14] The data report the value of imports (defined in FOB terms) and imported quantities (in kg.).[15]

[13] Taylor (2021) uses these data to study the impact of large vessels on the reproduction rates of Southern Right Killer Wales.

[14] The variables we use to control for export supply and the trade elasticities we include to generate structural trade cost estimates are only available at the HS6-digit level. As a result, we aggregate our trade data to the HS6 level.

[15] The data do not report port of destination in PR; for the purpose of calculating shipping distances we assume that all seaborne freight traffic goes through San Juan. Our port-of-call data show this to

The Puerto Rican import data are the source of the dependent variable in our pooled product-level gravity regressions. For independent variables, we calculate great circle distances from each country or U.S. customs district to the port of San Juan. For reasons that we describe later in the paper, we parameterize export supply in the shipments' origin rather than relying on fixed effects to sweep out heterogeneity in supplying regions' product-level export supplies. To do this we calculate each origin's total export supply of a given HS6 product in a given year, and include it as a control in the gravity regression estimated at the HS6 level of aggregation. The export supply measures are calculated using the CEPII (2022) data for non-U.S. origins and U.S. export data for U.S. origins.

Our analysis also exploits variation across products in characteristics that relate to demand for particular kinds of shipping and/or the freight rates that might be charged for transporting a given dollar value of that product. We use four product characteristics to predict reliance on particular kinds of shipping: a) the value share of a product's annual imports that moves by sea, b) the log weight-to-value ratio of imports in the commodity, c) the squared log weight-to-value ratio, and d) the value share of imports that are shipped in containers. We calculate all these measures with U.S. import data so that they are exogenous to the flows we observe involving PR.[16] We estimate the model separately over subdivisions of final and upstream products. Our primary tool for separating final and upstream goods is the upstreamness measure from Antràs et al. (2012), though we also use the United Nations' BEC classification to identify a sample of consumption goods for use in a robustness check.

be imperfect, but quite reasonable.

[16] We exclude imports from Canada and Mexico in these calculations so the U.S. data we use reflect the air-vs-sea choice that is available to shippers on PR routes. In this we follow Hummels and Schaur (2013) who use air and sea shipments to measure the value of time in the movement of U.S. import shipments. All U.S. export and import data files were taken from (U.S. Census Bureau, 2018). All dollar values are deflated by the U.S. consumer price index and expressed in 2019 dollars.

Our gravity regressions also include trade policy measures that enter as control variables: a) the U.S. statutory most favored nation (MFN) tariff rate taken from USITC (2018), and b) dummy variables indicating countries that are members of a preferential trade agreement (PTA) with the U.S. Finally, we include in the structural regressions product-level elasticities of substitution estimated by Fontagné et al. (2022).

3.3 Input-output relationships in PR

Calculation of the welfare costs of the JA requires information that is more comprehensive than what is available in the trade flow data. A critical element for such calculations is data on PR's purchases of its own output, activity that is not included in the trade data. We employ a Puerto Rican input-output (IO) table that separates expenditures on local output from expenditures on imports (including imports from U.S. sources). The IO table was produced by the Junta de Planificación de Puerto Rico for the years 2006-2007.[17] The table reports final demand expenditures (consumption, investment, etc.) for every 4-digit NAICS sector in the PR economy. The table also reports - for each purchasing NAICS code and final demand category - expenditures on local production and on imports, respectively. We match the trade data to the NAICS codes, and calculate U.S. and rest of world (ROW) shares of imports for each cell of the table, including purchases by final demand.

4 Fleet composition in the Caribbean

The LLI data on vessel characteristics contains information on vessels' place-of-build, flag-of-registry and ownership. We combine the vessel characteristics and the

[17] The Puerto Rican government has been under severe financial stress in recent decades, limiting its ability to produce economic statistics in a timely and credible manner. The 2006-2007 table was the most recent table available when we did the calculations. A 2011-2012 table has finally been produced, but it is imputed and contains an uncomfortably large number of negative values. We use the 2006-2007 figures (JPP, 2022). The dated nature of the IO table is a limitation.

port-of-call data to offer a sketch of freight shipping in the Caribbean. We compare the observed supply of JA-compliant shipping services to the characteristics of the overall freight hauling fleets calling in PR and the Caribbean. We use the NBIC (2024) data to verify our conclusions about the JA fleet and to provide a better representation of barge traffic on the U.S.-PR route.[18]

Panel A of Table 1 reports data for the Caribbean on three relevant measures of freight supply for six different types of freight-hauling maritime vessels. The statistics reported are the number of vessels calling, the number of port calls, and the DWT associated with vessels making port calls. These data illustrate the importance of self-propelled, non-containerized freight vessels in the overall Caribbean shipping market. Collectively, tankers, bulk, liquid and general cargo vessels account for 82 percent of the vessels calling in the Caribbean in 2019, 62 percent of the port calls and approximately 64 percent of the DWT. Container ships are an important part of Caribbean shipping, but collectively these other ship types arrive with greater frequency, and provide much more capacity.

Panel B of Table 1 reports the same statistics from the LLI data for vessels arriving in PR. The composition of freight vessel supply to PR is broadly similar to that of the Caribbean as a whole. Container ships and barges play a larger role (especially with respect to port calls), but the other vessel types collectively retain sizable shares of reported freight vessel traffic.

In order to distinguish JA-compliant ships from others serving PR, we use the LLI data to identify vessels that were U.S.-flagged and U.S.-owned.[19] Only 11

[18] The NBIC data do not report DWT, though this information is available for most vessels via public web sites like `https://www.vesselfinder.com`. Our data summary uses DWT data collected by Colin Grabow, who used a collection of public web sites to match DWT data to the names of JA vessels in the NBIC. We cross-validated this information with the NBIC and the sources of DWT data he provided. We thank Mr. Grabow for bringing the NBIC data to our attention, for providing the results of his DWT calculations, and for highlighting the rare examples of JA vessels granted exemptions from the U.S. build requirement.

[19] Because the law allows exceptions to the U.S.-build requirement, we focus on flag-of-registry

Table 1: Type of Vessels Serving the Caribbean (2019)

Type of Vessel	Number of vessels	%	Number of Calls	%	DWT (million)	%
Panel A. All vessels in the Caribbean						
Tanker	1,198	38.2%	8,602	26.5%	274.24*	35.7%
Bulk	678	21.6%	2,434	7.5%	102.01	13.3%
Container ships	541	17.3%	12,350	38.1%	278.80*	36.3%
General Cargo	468	14.9%	6,666	20.6%	50.88*	6.6%
Liquid vessels	236	7.5%	2,330	7.2%	61.12	8.0%
Barges	14	0.4%	51	0.2%	0.12*	0.0%
Total	3,135	100.0%	32,433	100.0%	767.16	100.0%
Panel B. All vessels serving Puerto Rico						
Tanker	189	52.6%	321	19.7%	14.35	36.3%
Container ships	50	13.9%	840	51.5%	14.91	37.7%
Bulk	48	13.4%	103	6.3%	5.12	13.0%
General Cargo	42	11.7%	288	17.6%	2.31*	5.8%
Liquid vessels	25	7.0%	71	4.4%	2.83	7.2%
Barges	5	1.4%	9	0.6%	0.03*	0.1%
Total	359	100.0%	1,632	100.0%	39.55	100.0%
Panel C. Jones Act vessels - LLI database						
Container ships	5†	45.5%	221	92.5%	6.15	92.3%
Barges	4†	36.4%	4	1.7%	0.03*	0.4%
General Cargo	1	9.1%	1	0.4%	0.00	0.0%
Bulk	1	9.1%	13	5.4%	0.48	7.3%
Total	11	100.0%	239	100.0%	6.66	100.0%
Panel D. Jones Act vessels - NBIC database						
Barges	8†	57.1%	124	37.9%	1.52*	21.0%
Container ships	5†	35.7%	192	58.7%	5.31	73.3%
Bulk	1	7.1%	11	3.4%	0.41	5.7%
Total	14	100.0%	327	100.0%	7.24	100.0%

Note: Number of vessels, port calls, and dead-weight tonnage (DWT) of freight vessels arriving in Caribbean and Puerto Rican ports in 2019, by type of vessel and inferred JA status. Panels A.-C. are constructed from ship arrival data in the Caribbean purchased from LLI (2021). Panel D. summarizes cargo ship arrival data in PR sourced from NBIC (2024). Vessels' JA status are identified as those that are U.S.-flagged and U.S.-owned. (Some vessels serving PR have been exempted from the JA's U.S.-build requirement.) The NBIC data better capture barge traffic on U.S.-PR routes, while the LLI data allow comparisons with the broader Caribbean.

* indicates an understatement of DWT in a category because data on one or more vessels lacked DWT information.

† indicates the presence of dual use JA vessels with "roll-on, roll-off" capacity for carrying vehicles.

vessels that called in PR in 2019 satisfied these conditions in the LLI data. (See Panel C. in Table 1). A comparison of Panel C with Panels A and B shows that the composition of freight supply that is available on U.S.-PR routes is quite different than it is in the broader Caribbean, or even among PR routes as a whole. With the exception of just two vessels, the LLI data indicate that the JA fleet serving PR in 2019 consisted entirely of container ships and barges. Container ships are responsible for the vast majority of port calls and available DWT. The tankers, bulk, liquid and general cargo vessels that play such a large role in PR and Caribbean shipping are almost absent from the JA fleet.

While the LLI data are useful for comparing shipping in the broader Caribbean, they miss a large volume of barge traffic serving U.S.-PR routes. We redo the same calculations using publicly available data from NBIC (2024), reporting the results in Panel D of Table 1. These data better track barge traffic, resulting in a much larger share of barge traffic in Panel D than in Panel C. Although there are differences between the LLI and NBIC data, the dearth of tankers, bulk, liquid and general cargo vessels is common across the two tables.[20] The near absence of such vessels serving the JA market motivates our subsequent exercises involving the gravity model of trade.

5 Theory

We motivate our empirical work with an adaptation of Krugman and Venables (1996). The model's prediction for trade in final products is conventional: buy-

and ownership. We screen first for U.S.-flagged ships, and then check by hand to verify that the firms that own U.S.-flagged ships are located in the U.S. The JA also requires domestic crewing. Our data lack comprehensive data on crews. We assume that the ships arriving in PR that meet observable JA requirements are also U.S.-crewed. This assumption only affects our initial summary statistics; it is irrelevant to our main results.

[20]It is also possible to use the NBIC data to compare JA vessels with the entire fleet serving PR. This comparison returns the same lessons. We omit NBIC data on all port calls to PR for reasons of space.

ers substitute away from varieties with high trade costs. Among upstream products, substitution of this kind occurs, but trade also responds to trade costs through a channel involving firm location choices.[21]

5.1 Model set-up

In this section we offer a brief description of the model. We focus on the explication necessary to generate a trade prediction equation and motivate the set of trade responses. One modification we make is to separate products k into two categories - final and upstream - rather than assuming that products serve both functions, as Krugman and Venables (1996) do.

Let the representative agent in PR have the following utility function:

$$U = \prod_{k \in F} \left[\sum_j n_j^k \left(\frac{q_j^k}{\tau_j^k} \right)^{\frac{\sigma^k - 1}{\sigma^k}} \right]^{\alpha^k \left(\frac{\sigma^k}{\sigma^k - 1} \right)}. \tag{1}$$

where F is the set of final products, n_j^k is the number of monopolistically competitive firms in region j sector k, q_j^k is the quantity each firm ships from j to PR, $\tau_j^k \geq 1$ is the iceberg trade cost associated with PR's purchases of product k from region j, σ^k is the elasticity of substitution between varieties of commodity k, and α^k the Cobb-Douglas share of product k in PR's utility.[22]

Maximizing (1) subject to PR's household income, Y, returns a conventional prediction for the value of bilateral imports in final commodity k, $M_j^k|_{k \in F}$:

$$(M_j^k / \tau_j^k)|_{k \in F} = n_j^k \times p_j^k \times q_j^k = n_j^k \left(\frac{p_j^k}{\widetilde{P}^k} \right)^{1-\sigma^k} (\tau_j^k)^{-\sigma^k} \alpha^k Y. \tag{2}$$

where p_j^k is the factory gate price of product k in region j, and $\widetilde{P}^k$ is the conventional

[21] Hillberry and Hummels (2002) argue that "production location effects" of this kind will produce an excess local intensity of trade flows where sequential production activities are co-located. Hillberry and Hummels (2008) find evidence for this prediction in U.S. freight movements.

[22] Many of the variables above would normally have a destination-region subscript. Since PR is the only destination in our exercises we suppress it.

Dixit-Stiglitz price index for good k in PR, defined as:

$$\widetilde{P}^k = \left(\sum_j n_j^k (p_j^k \tau_j^k)^{1-\sigma^k} \right)^{\frac{1}{1-\sigma^k}}. \tag{3}$$

Expenditures on final products k are a fixed share (α^k) of PR income, and therefore not endogenous to trade costs. Among final goods, the only behavioral response to τ_j^k is substitution across sources of k according to σ^k.[23]

Among upstream products, expenditure on product k is driven by the destination region's output mix, which is endogenous to trade costs. In the model, PR firms in sector s purchase a bundle of inputs A^s. The cost function for purchasing a unit of A^s follows:

$$c(A^s) = w^{\mu_L^s} \prod_{k \in K^s} (\widetilde{P}^k)^{\mu^{ks}} \tag{4}$$

where w is the price of the productive factor(s), μ_L^s is the associated cost share, K^s the set of upstream input products used in sector s production, $\widetilde{P}^k$ the conventional CES price index of k, and μ^{ks} the share of product k in sector s production. The μ's are assumed fixed (within sectors and across locations), with $\mu_L^s + \sum_{k \in s} \mu^{ks} = 1$.

Production follows an increasing returns to scale technology. Sector s uses the input bundle A^s to produce q^s according to:

$$A^s = a_0^s + a_1^s q^s. \tag{5}$$

where a_0^s and a_1^s are the fixed and marginal input requirements, respectively. The model differs from conventional theories that motivate the gravity model of trade because of scale economies and an associated entry condition.[24] Firms will not

[23]Our data are measured with origin (F.O.B.) prices. Following convention among estimators of σ^k, (Fontagné et al. (2022) or Hummels (1999), for example), we consider the trade response of import value in estimation to be $-\sigma^k$ rather than $1 - \sigma^k$, as it would be for imports valued in destination-region prices. For this reason we include the quantity of iceberg melt on the left-hand side of (2), and ignore the effects of τ_j^k on delivered quantities in estimation.

[24]The inequality that follows is taken from Balistreri and Rutherford (2013), who demonstrate mixed complementarity methods for computing monopolistic competition models of trade. Ques-

operate in PR ($n^s = 0$) if

$$a_0^s c(A^s) > \frac{p_s q_s}{\sigma^s}. \tag{6}$$

The relationships in (3), (4), and (6) demonstrate how trade costs on inputs can affect the industrial structure of a region. If a given location j (e.g. the U.S. mainland) hosts a large number of suppliers of upstream product k, and trade costs from location j are high, then $\widetilde{P}^k$ (in PR) will be high. If the products k with high trade costs have sufficiently large input shares in sector s, μ^{ks}, then $c(A^s)$ will be high, leading gross output in sector s ($X^s = n^s p^s q^s$) to be low, possibly even zero. PR can be an unsuitable location for sector s if it would otherwise purchase high-cost inputs from the U.S. Sector s varieties that might have been produced in PR are produced elsewhere, and products k used as inputs into s production are not imported into PR.[25] Like the conventional substitution effect, production location effects reduce trade, but they do so in different ways, and their effects might be expected to dominate those of substitution effects among upstream products. Hillberry and Hummels (2008)'s finding that intermediate input trade is a central reason for the extremely high distance sensitivity of freight shipments over short distances is important evidence in this regard.

The bilateral trade prediction for upstream products $(k \in V)$ takes the form:

$$\left(M_j^k/\tau_j^k\right)|_{k\in V} = n_j^k \times p_j^k \times q_j^k = n_j^k \left(\frac{p_j^k}{\widetilde{P}^k}\right)^{1-\sigma^k} (\tau_j^k)^{-\sigma^k} \sum_s \mu^{ks} X^s. \tag{7}$$

Variation in τ_j^k affects bilateral trade through substitution according to $-\sigma^k$, but

tions of minimum efficient scale are likely to be particularly important in small economies like PR's.

[25]One possible example of industry composition effects due to the JA is the absence of viable sugar cane growing and processing sectors on the island. Global agronomic data (https://gaez-services.fao.org/) shows that much of PR has high yield potential in the production of cane sugar if modern production technologies are used (e.g. the application of physically heavy fertilizers and the use of bulky capital goods). While the increasing returns to scale model proposed here may not apply directly to the sugar cane growing sector, it offers a reasonable treatment of sugar cane processing. Trade data from IEPR (2021) show that exports of processed sugar from PR are almost non-existent.

also through its effects on downstream sectors X^s via (6).

5.2 Modeling JA trade costs

We next turn to describing the form of the trade cost function. Following the literature on border effects, we consider τ_j^k to be a multiplicative form of trade costs that depends upon distance and international borders. Using an aggregate model, Anderson and Van Wincoop (2003) specify the trade cost function as follows:

$$\tau_j = dist_j^{\rho}(b)^{1-HOME_j} \tag{8}$$

where $dist_j$ is the distance from origin j to PR's main city and port, San Juan, ρ is the distance elasticity of trade costs, b is an estimable parameter equal to 1 plus τ_{HB}, the tariff-equivalent border cost associated with purchasing goods from outside the U.S., and $HOME_j$ is an indicator that the product originated on the U.S. mainland.

We amend (8) to include an effect of the JA on PR's imports from the U.S. We assume that the JA imposes an additional cost on U.S. mainland varieties, a cost that varies across products according to characteristics related to the manner in which the product is usually shipped. We specify another parameter like b,

$$JA^k = 1 + \tau_{JA}^k, \tag{9}$$

where JA^k is a vector of parameters to be estimated, and τ_{JA}^k a tariff-equivalent cost linked to the JA^k's. The product-specific trade cost function now appears as:

$$\tau_j^k = dist_j^{\rho}(b)^{1-HOME_j}(JA^k)^{HOME_j}. \tag{10}$$

Product-level variation in bilateral trade responses to $HOME_j$ parameterize JA^k.[26]

[26] Equation (10) is for purposes of illustration. When we move to the estimation model, we allow flexible effects of distance on trade costs.

5.2.1 Parameterizing JA^k

We parameterize JA trade costs as follows. All imports, regardless of transport mode, pay a common tariff equivalent border cost, which takes the form τ_{HB} and is estimated via the parameter b. Products that are shipped from the U.S. by sea also pay a penalty (relative to products shipped from the U.S. by air). This penalty takes the form τ^k_{JA} and is estimated by the parameter JA^k.[27]

A simple approach to parameterizing JA^k would be to assume a common JA trade cost that applies to all sea-shipped imports from the U.S. In a pooled product-level gravity model, the effects of the JA would be identified through the coefficient on the interaction of $HOME_j$ with an indicator that the goods moved by sea.[28] The coefficient on $HOME_j$ (without an interaction term) would measure home bias toward U.S. products among air-shipped goods. The interaction term would capture reduced home bias among sea-shipped goods.

The near absence of bulk ships, tankers and general cargo vessels on U.S.-PR routes is likely to cause important cross-product variation in the burden the JA imposes on sea-shipped goods from the U.S. We therefore generalize the method involving dummy variables described above. To capture the burden the JA imposes on maritime shipments of product k, we specify a vector of product-specific characteristics, $\overrightarrow{Z}^k$. The elements of $\overrightarrow{Z}^k$ include an explicit measure of the degree to which transport of product k depends on maritime shipping, but also other characteristics that affect the cost of shipping and/or reliance on non-containerized shipping. We represent the log of JA^k as the inner product of the product characteristics $\overrightarrow{Z}^k$ and a vector of characteristic weights $\overrightarrow{\gamma}$, multiplied by $HOME_j$:

$$ln(JA^k) = -\overrightarrow{\gamma}' \overrightarrow{Z}^k \times HOME_j. \tag{11}$$

[27] We do not rule out cross-product variation in τ_{HB}. Variation in this parameter need only be assumed to be orthogonal to variation in the product characteristics that we attribute to the JA.

[28] This is the approach that Olney (2020) takes.

In a reduced-form gravity model, the elements of $\overrightarrow{\gamma}$ are not fully identified. Trade responses to geographic frictions depend upon a trade elasticity. In our exercise this applies to $HOME_j$ itself as well to the responses to $ln(JA^k)$. Let β be the coefficient on $HOME_j$ without an interaction, and $\overrightarrow{\beta}$ the coefficients on the interactions of $\overrightarrow{Z}^k$ with $HOME_j$. The response of bilateral imports to $HOME_j$ is:

$$\frac{\partial lnM_{j,t}^k}{\partial HOME_j} = \beta - \overrightarrow{\beta}' \overrightarrow{Z}_t^k. \tag{12}$$

As is familiar from the existing gravity literature, $\beta = \sigma b$; b can be identified only through the choice of σ. Similarly, we interpret the parameters in $\overrightarrow{\beta}$ as the product of a trade elasticity and predicted JA trade costs, $\overrightarrow{\gamma}' \overrightarrow{Z}^k$.

5.3 Estimation

The key parameters of interest for what follows are the elements of $\overrightarrow{\beta}$ and their structural counterparts $\overrightarrow{\gamma}$. We specify four $\overrightarrow{Z}^k$ variables that measure product characteristics related to transportation. These are: 1) the value share of U.S. imports that travel by oceangoing vessel in year t, Vsh_t^k, 2) the log of the median (across years) of the weight-to-value ratio of product k in U.S. imports, $ln(WV^k)$, 3) the square of the logged weight-to-value ratio $(ln(WV^k))^2$, and 4) the share of the product's U.S. imports that were shipped in containers in a given year, $Ctnr_t^k$. We attribute to the JA the systematic variation in measured home bias that the pooled product-level gravity regression attributes to these characteristics. In subsequent regressions, we include estimates of σ^k itself in the regression, and interact it with variables associated with geographic or other trade frictions. We interpret the coefficients on the interactions of σ^k with geographic frictions as structural trade cost parameters. Specifically, the inclusion of σ^k's in the regression allows the b term and the elements of $\overrightarrow{\gamma}$ to be identified. We use these estimates to predict JA^k and infer τ_{JA}^k.

Prior to turning to the structural model, we first estimate a reduced form gravity regression linking cross-product variation in home bias to the characteristics of $\overrightarrow{Z}^k$. Our data/estimation strategy is somewhat unusual. Before moving to estimation we describe some of the challenges this particular setting imposes, and the way in which we manage them.

It is now conventional to estimate gravity regressions with vectors of fixed effects that sweep out important variation in the data. In a cross-sectional regression with multiple origins and destinations, origin-product fixed effects control for systematic variation in the supply of a product, while destination-product fixed effects control for variation in expenditure levels and geographic remoteness of the destination. In a time series context origin-product-year and destination-product-year fixed effects sweep out heterogeneous supplies and demands, and shocks to either.

We use data from a single destination, PR.[29] Including destination-product fixed effects in the regression would sweep out useful cross-product variation in the data. Instead we parameterize import demand. Since our identification strategy relies on interactions between product characteristics and $HOME_j$, the key threat to identification is if cross-product variation in the level of import demand is correlated with the product characteristics of interest, the $\overrightarrow{Z}^k$'s. We address this problem in a manner that is conventional in applied econometrics; we include the $\overrightarrow{Z}^k$'s themselves in the regression, along with their interactions. In this way we control for cross-product variation in the level of demand that might bias the coefficients on the interactions. The way in which the $\overrightarrow{Z}^k$'s affect total import demand becomes important when estimate in the sample of upstream products.

[29] In principle we could have included other destinations in the sample (especially other countries in the Caribbean), but since the U.S.-PR flow would be the only domestic U.S. flow this strategy would lead the $HOME_j$ coefficient to compare U.S.-PR flows to all U.S. flows to the Caribbean, rather than to ROW-PR flows alone. If the demand structure of PR were typical of the Caribbean, this might be preferable, but the effects of U.S. sovereignty are likely to have made the structure of PR's import demand different than those of other Caribbean states.

Rather than sweep out variation in export supply with product-origin-year fixed effects, we include in the regression explicit measures of export supply. We do this because of our interest in $HOME_j$, which would be co-linear with the usual full set of fixed effects. Instead, we fully parameterize export supply - using the total volume of exports of each product from each origin in each year - since these data are readily available in the trade data we have.[30] This approach allows us to estimate a coefficient on $HOME_j$ itself, not only on the associated interaction terms.

We do include year fixed effects in the regressions. These are useful as controls for aggregate shocks, but they also assist in moving between the general equilibrium theory and the constant elasticity of substitution import demand model we estimate. Fally (2015) shows that fixed effects in a PPML specification have a useful adding up property (in this context $\sum_k \widehat{M}_{j,t}^k|_{t=\bar{T}} = \sum_k M_{j,t}^k|_{t=\bar{T}}$, where $\bar{T}$ is a specific year). The implication in this case is that the other parameters of the regression model determine the share of each product-country combination in PR's annual import flows; they do not have independent effects on the level of trade.

5.3.1 Model specifications

Our reduced-form is a Poisson Pseudo Maximum Likelihood (PPML) model:

$$M_{j,t}^k = e^{[\delta\left(h^{-1}(X_{j,t}^k)\right)+f\left(dist_j,\overrightarrow{Z}_t^k,\rho\right)+\beta HOME_j+\overrightarrow{\omega}\overrightarrow{Z_t^k}+\overrightarrow{\beta}\overrightarrow{Z}_t^k HOME_j+\phi_t]} + \epsilon_{jt}^k \qquad (13)$$

where $h^{-1}\left(X_{j,t}^k\right)$ is the inverse hyperbolic sine of the value of total exports of commodity k in year t from each region j, δ the associated regression coefficient, $f(dist_j, \overrightarrow{Z}_t^k, \rho)$ is a flexible function of distance, product characteristics and parameters that controls for region j's distance to PR. $\overrightarrow{\omega}$ is a vector of estimated coefficients on the product characteristics themselves. β, $\overrightarrow{\beta}$ and $\overrightarrow{Z}_j^k$ are as de-

[30] In some instances, the PR data report trade flows arriving from an origin, even though our corresponding data shows no exports of that product from that origin in that year. In these cases we add the PR trade flow to total exports, and include a dummy variable indicating that we made this transformation.

scribed above. ϕ_t are the year fixed effects. In some specifications we also include the log of one plus the U.S. MFN tariff, and a vector of dummy variables indicating that a country has a preferential trade agreements with the U.S. The coefficient on the MFN tariff provides an internal estimate of σ^k, under a restrictive assumption that σ^k has a common value across products.

The reduced form model is useful for illustrating the cross-product variation in home bias. For measuring welfare we need to infer structural trade costs. As discussed, the regression coefficients in (13) conflate the effects of trade costs and trade responses. Our solution to this problem is to include in the estimation external estimates of σ^k from Fontagné et al. (2022), treating them as data for the purpose of identification. σ^k enters into the regression alone. We also interact it with distance and $HOME_j$, and with the interactions of these variables with $\overrightarrow{Z}_t^k$. According to the structural model, the coefficients on the interaction terms can be used to infer the trade costs that each friction imposes on each product k. Our new specification is as follows:

$$M_{j,t}^k = e^{[\delta\left(h^{-1}(X_{j,t}^k)\right)+f\left(dist_j,\sigma^k,\overrightarrow{Z}_t^k,\rho\right)+\gamma\sigma^k HOME_j+\overrightarrow{\omega}\overrightarrow{Z_t^k}+\varepsilon\sigma^k+\overrightarrow{\gamma}\overrightarrow{Z}_t^k\sigma^k HOME_j+\phi_t]} + \epsilon_{jt}^k \tag{14}$$

where σ^k is taken from Fontagné et al. (2022), and ε is an estimate of the conditional correlation between σ^k and $M_{j,t}^k$. The key difference between (14) and (13) is that we have interacted σ^k with all of the geographic frictions, so that we can give a structural interpretation to the coefficient estimates. The coefficients of interest, γ and $\overrightarrow{\gamma}$ are structural equivalents to β and $\overrightarrow{\beta}$ (with $\gamma = -\frac{\beta}{\sigma^k}$ and $\overrightarrow{\gamma} = -\frac{\overrightarrow{\beta}}{\sigma^k}$). The γ term becomes lnb in equation (10), and $\overrightarrow{\gamma} \times \overrightarrow{Z}_t^k \times HOME_j$ produces a predicted distribution of $\tau_{JA,t}^k$. These estimates are not quite complete, because they are relative, rather than absolute measures of JA trade costs. We describe our process for turning relative into absolute values once our $\overrightarrow{\gamma}$ estimates are in hand.

6 Results

We report regression results from a divided sample: one with final products and one with the remaining upstream products. We use the upstreamness measure of Antràs et al. (2012) to divide products into 'final' and 'upstream' goods. Specifically, we define as final goods all products that belong to an HS6 with an upstreamness index of 1.3 or less. The set of remaining products we label 'upstream.'[31]

6.1 Reduced form estimates: Final goods

We report the reduced form model estimates for final goods in Table 2. All specifications include supply variables defined as above. All specifications also include both logged distance and the square of logged distance.[32] We focus on the coefficients on $HOME_j$ and its interactions with $\overrightarrow{Z}^k$.

Column 1 contains results from a simple specification focusing on the estimation of home bias. The $HOME_j$ coefficient is 2.22; this is a (cross-product) average estimate of the trade response, after controlling for variation in regional supplies and for distance. A product with this response of trade to $HOME_j$ has imports from the U.S. that are approximately $e^{2.22} = 9.21$ times larger than from ROW.

Column 2 includes the $\overrightarrow{Z}$ variables that we interact with $HOME_j$ in subsequent regressions. These estimates tell us whether the product characteristics help predict cross-product variation in the level of commodity k imports. Since we

[31]We chose the 1.3 threshold by inspection prior to estimation. Several sectors just below the 1.3 threshold produce items that are clearly household consumption (wine, apparel, frozen food). Some sectors produce consumption items above the 1.3 threshold (books, cutlery), but even near the threshold most sectors' outputs less obviously serve final demand (e.g. analytical laboratory instruments, support for oil and gas operations). Another way to interpret the threshold is that it requires at least 70 percent of purchases to come from final demand.

[32]We include the second order term to allow non-constant effects of distance on trade. The U.S. is much closer to PR than are other developed countries with a similar export mix, so we allow the effects of distance to taper - if the data suggest it - to reduce the chance that the assumption of a constant elasticity of distance biases the $HOME_j$ dummy coefficient. In subsequent specifications we also allow the effects of distance to vary across products as well as over distance.

Table 2: Reduced Form Estimates for Final Goods

			$M_{j,t}^k$		
VARIABLES	(1)	(2)	(3)	(4)	(5)
$\ln(dist_j)$	-1.593*	-2.206**	-2.873***	-5.415***	-4.599***
	(0.818)	(0.873)	(0.863)	(1.060)	(1.130)
$HOME_j$	2.220***	2.203***	1.688***	2.425***	1.739***
	(0.0639)	(0.0583)	(0.484)	(0.602)	(0.602)
Vsh_t^k		0.658***	2.304***	-10.50***	-11.21***
		(0.207)	(0.310)	(1.950)	(1.855)
$\ln(WV^k)$		0.392***	0.823***	1.112***	0.975***
		(0.0626)	(0.101)	(0.343)	(0.365)
$(\ln(WV^k))^2$		0.0134***	0.0121	-0.138***	-0.156***
		(0.00470)	(0.0280)	(0.0502)	(0.0520)
$Ctnr_t^k$		-1.060***	-1.935***	-0.171	1.165
		(0.138)	(0.237)	(1.960)	(2.012)
$Vsh_t^k \times HOME_j$			-1.679***	-2.193***	-1.538***
			(0.455)	(0.507)	(0.498)
$\ln(WV^k) \times HOME_j$			-0.674***	-0.718***	-0.617***
			(0.133)	(0.113)	(0.114)
$(\ln(WV^k))^2 \times HOME_j$			-0.0144	-0.0380***	-0.0260**
			(0.0283)	(0.0109)	(0.0115)
$Ctnr_t^k \times HOME_j$			1.190***	1.019***	0.722***
			(0.345)	(0.221)	(0.216)
$(\ln(dist_j))^2$	0.0136	0.0535	0.0956	0.151**	0.0964
	(0.0576)	(0.0609)	(0.0602)	(0.0671)	(0.0741)
$IHST(\widetilde{X}_{j,t}^k)$	0.679***	0.641***	0.643***	0.647***	0.651***
	(0.0308)	(0.0248)	(0.0249)	(0.0259)	(0.0263)
Observations	1,075,452	1,075,452	1,075,452	1,075,452	1,070,496
Year FE	YES	YES	YES	YES	YES
Flexible distance controls	NO	NO	NO	YES	YES
U.S. trade policy controls	NO	NO	NO	NO	YES
Pseudo R2	0.494	0.512	0.518	0.521	0.524

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over the sample of HS6 products with values of the upstreamness index ≤ 1.3. The LHS variable in all models is $M_{j,t}^k$, the value of product k imports to PR from origin j in year t. All models are estimated using the PPML estimator on PR's import data pooled across years, HS6 digit products and places of origin, with year fixed effects included in the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation. Pharmaceutical products are excluded from the estimation.

have controlled for variation in export supply, we interpret these as capturing cross-commodity variation with respect to the Z^k parameters in the level of PR's import demand. All coefficients are statistically significant; they jointly indicate that PR's total imports of a final product are relatively larger if the product is typically a) shipped by sea, b) heavier, and c) not containerized. Since these are final goods, we take these findings as indicative of the way in which consumers' taste parameters α^k are associated with the Z^k variables. The $HOME_j$ coefficient in column 2 is basically unchanged from its value in column 1.

Column 3 includes interactions of $HOME_j$ with the Z^k's. All the interaction coefficients are of the hypothesized sign, and all but the interaction of $HOME_j$ with $(\ln(WV^k))^2$ are statistically significant. Products typically shipped by sea have lower estimated home bias, which is consistent with the JA causing substitution away from U.S. sources of sea-shipped final products. Home bias is also smaller in heavier products, and in products that are not typically shipped in containers. These results are consistent with our hypothesis that the JA puts an even larger burden on products typically shipped on vessels other than container ships. The hypothesized results are maintained in column 4, where we allow the effects of distance to vary across products. Column 5 shows that the results are robust to the inclusion of trade policy variables, including the U.S. MFN tariff on product k and a vector of preferential trade agreement (PTA) dummies.[33]

6.2 Structural estimates: Final products

We now turn to the structural estimates. The theory implies that trade responses to geographic frictions can be decomposed into the product of a trade cost and $-\sigma^k$. In order to quantify JA trade costs, we incorporate external estimates of σ^k everywhere that a trade friction appears in the econometric model. Our preferred estimates use

[33]The (unreported) MFN tariff coefficient can be interpreted as an estimate of σ^k that is common across products, with $\sigma = 2.785$.

$\widehat{\sigma}^k$'s from Fontagné et al. (2022), and appear in Table 3.

The column 1 results offer a simple example of our method. Pre-multiplying $HOME_j$ by σ^k prior to estimation allows the associated regression coefficient to be interpreted as a measure of structural trade costs. Accounting for functional form, the estimate implies a tariff-equivalent trade cost of $\widehat{\tau}_{HB} = 0.267$. In other words, the estimate implies that the commonalities that PR shares with the U.S. mainland (common legal system, currency, etc.) is equivalent to a tariff of 26.7 percent on foreign imports.[34] This estimate is biased downward because it ignores the counteracting effects of the JA on sea-shipped imports.

When we add $\overrightarrow{Z}^k$ to the regression in Column 2, $\widehat{\gamma}$ is largely unchanged. The estimate grows slightly in column 3, where we include the interactions of $HOME_j$ with $\overrightarrow{Z}^k$. The inclusion of interaction terms in the regression means that $\widehat{\gamma}$ no longer captures a cross-product average trade cost, it now represents an estimated trade cost for a product with particular characteristics. In this case, $\widehat{\gamma}$ measures an implied tariff equivalent of home bias for a product that is always air-shipped, is not typically containerized, and has a weight-to-value ratio of 1 (i.e. $\ln(WV^k) = 0$). This estimate of $\widehat{\gamma}$ is somewhat larger than those in Columns 1 and 2.

The coefficients on the interaction terms are of greatest interest. They retain the same intuitive sign pattern as in the reduced form regression. The coefficient estimate on $\sigma^k \times Vsh_y^k \times HOME_j$ implies that shipping the same product exclusively by vessel rather than exclusively by air implies an increase in $\widehat{t}_{JA}^k$ of $e^{0.206}$. Heavier products have larger implied $\widehat{\tau}_{JA}^k$'s, while containerized shipments face substantially lower tariff-equivalent JA costs. The magnitudes of the estimates suggest that containerization largely offsets the additional costs of sea shipping when a product's weight-to-value ratio is low.

[34] As a point of reference, Anderson and van Wincoop (2004) estimate that the U.S.-Canada border imposes a tariff-equivalent border cost of 47 percent.

Table 3: Structural Estimates for Final Goods

VARIABLES	(1)	(2)	$M^k_{j,t}$ (3)	(4)	(5)
σ^k	-0.0722	0.115	0.215	0.587	0.225
	(0.352)	(0.359)	(0.388)	(0.407)	(0.473)
$\sigma^k \times \ln(dist_j)$	0.133	0.0670	0.0221	-0.0829	0.0332
	(0.106)	(0.109)	(0.118)	(0.132)	(0.152)
$\sigma^k \times HOME_j$	0.237***	0.230***	0.261***	0.452***	0.370***
	(0.0112)	(0.00863)	(0.0363)	(0.129)	(0.127)
Vsh^k_t		1.119***	3.282***	2.354***	2.319***
		(0.237)	(0.329)	(0.607)	(0.607)
$\ln(WV^k)$		0.482***	0.676***	0.101	0.0658
		(0.0563)	(0.0598)	(0.207)	(0.209)
$(\ln(WV^k))^2$		0.0237***	0.0538***	0.0275	0.0245
		(0.00441)	(0.00640)	(0.0219)	(0.0220)
$Ctnr^k_t$		-1.724***	-2.813***	-1.168***	-1.041***
		(0.158)	(0.190)	(0.350)	(0.358)
$\sigma^k \times Vsh^k_t \times HOME_j$			-0.206***	-0.590***	-0.528***
			(0.0304)	(0.125)	(0.122)
$\sigma^k \times \ln(WV^k) \times HOME_j$			-0.0537***	-0.111***	-0.106***
			(0.00910)	(0.0248)	(0.0245)
$\sigma^k \times (\ln(WV^k))^2 \times HOME_j$			-0.00522***	-0.00403	-0.00407
			(0.000695)	(0.00518)	(0.00467)
$\sigma^k \times Ctnr^k_t \times HOME_j$			0.162***	0.301***	0.281***
			(0.0300)	(0.0460)	(0.0496)
$\sigma^k \times (\ln(dist_j))^2$	-0.0188**	-0.0140*	-0.0107	-0.00416	-0.0116
	(0.00804)	(0.00813)	(0.00872)	(0.00902)	(0.0105)
$IHST(\widetilde{X}^k_{j,t})$	0.677***	0.612***	0.606***	0.614***	0.616***
	(0.0333)	(0.0239)	(0.0232)	(0.0238)	(0.0242)
Observations	1,075,452	1,075,452	1,075,452	1,075,452	1,070,496
Year FE	YES	YES	YES	YES	YES
Flexible distance controls	NO	NO	NO	YES	YES
U.S. trade policy controls	NO	NO	NO	NO	YES
Pseudo R2	0.451	0.479	0.489	0.497	0.499

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over the sample of HS6 products with values of the upstreamness index $<= 1.3$. The LHS variable on all models is $M^k_{j,t}$, the total value of PR's product k imports of product k from place of origin j in year t. All models are estimated using the PPML estimator on PR's import data pooled across observations at the year, HS6 digit product, and place-of-origin level, with year fixed effects included in the estimation model. σ^k estimates from Fontagné et al. (2022) are interacted with geographic frictions, and enter separately in the regression. IHST denotes the Inverse Hyperbolic Sine Transformation. Pharmaceutical products are excluded from the estimation.

Columns 4 and 5 allow for further flexibility in the response of trade to distance, and control for U.S. trade policy. The magnitudes of the coefficients of interest change, but the sign patterns remain robust. Since column 5 has the fullest set of controls, we use these results as our primary structural estimates of the distortions caused by the JA. Note that the inclusion of both flexible distance effects and the effects of explicit trade policies raises $\widehat{\tau}_{HB}$'s. The coefficients on the interaction terms also grew in magnitude, relative to column 3.

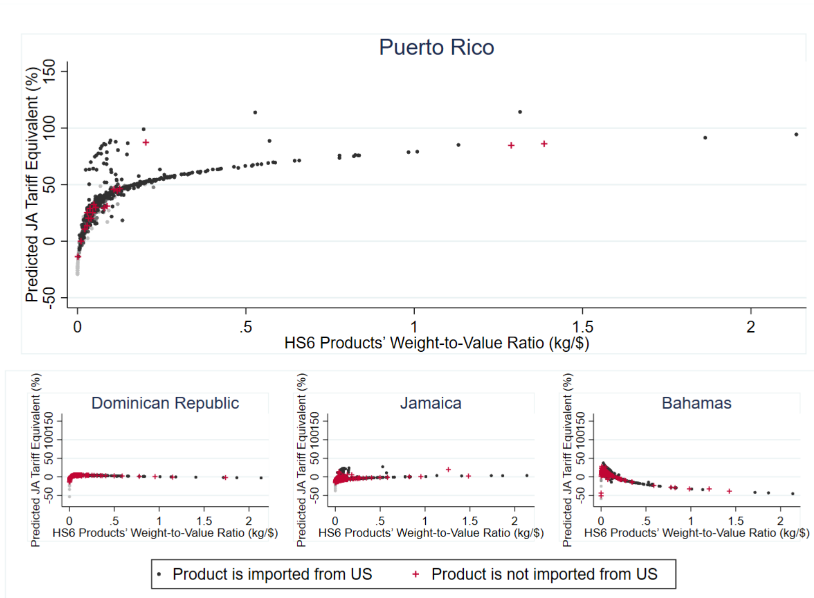
To illustrate the joint implications of the coefficients we calculate $\widehat{\tau}^{k}_{JA}$'s. The coefficient estimates themselves are only directly informative about relative trade costs; predictions for absolute tariff-equivalents require a set of parameters that we associate with $\tau^{k}_{JA,t} = 0$. Our reference product is air-shipped, not containerized and has the median weight to value ratio for air-shipped products: $\widetilde{WV} = 0.0247653$ kg/\$.[35] We predict τ^{k}_{JA} with:

$$\widehat{\tau}^{k}_{JA} = e^{-\left[\gamma_{Vsh} Vsh^{k}_{t} + \gamma_{WV}\left(ln(WV^{k}) - ln(\widetilde{WV})\right) + \gamma_{WV2}\left((ln(WV))^{2} - (ln(\widetilde{WV}))^{2}\right) + \gamma_{Ctnr} Ctnr^{k}_{t}\right]} - 1 \tag{15}$$

We calculate the values of $\widehat{\tau}^{k}_{JA}$ using estimates from columns 3-5 of Table 3. Predictions from column 5 are our preferred estimates. We show the distribution of fitted values in the top portion of Figure 1, which plots the 2016 values of $\widehat{\tau}^{k}_{JA}$ against each product's weight-to-value ratio. As the figure shows, product weight plays an important role in our estimates. As weight-to-value rises, the implied tariff equivalent rises, but at a decreasing rate. The heaviest products, relative to value, in the consumption sample are types of water (*Non-mineral or aerated waters*, and *Mineral or aerated waters*); both products have predicted JA tariff-equivalents of nearly 100 percent.

[35]Products that fit these criteria and have weight-to-value ratios in the neighborhood of this value are (1) men's suits (made of synthetic fibers, wool or fine animal hair); (2) women's suits (made of artificial fibers) and (3) toasters.

Figure 1: Estimated Jones Act tariff equivalents against weight-to-value ratios



Note: Estimates of predicted HS6 product-level JA tariff-equivalents for 2016. All estimates are predicted by applying equation 15 and multiplying by 100. Predicted JA tariff-equivalents rely on parameter estimates from Column 5 of Tables 3, A1, A2, A3 and σ^k estimates from Fontagné et al. (2022). Shading of dots on imported products from U.S. indicates the vessel share of every product in imports. Lighter dots mean a lower share of sea-shipment.

The products with the highest tariff-equivalents have somewhat lower weight-to-value ratios, but have product characteristics that lead them to be less frequently shipped in containers, raising their predicted JA-tariff equivalents. These products are *Cereal grains of barley* (with a tariff-equivalent of 114.3 percent), *Frozen orange juice* (113.8 percent) and *Fire fighting vehicles* (99.0 percent). Nineteen products are not imported at all from the U.S.; the $\widehat{\tau}^k_{JA}$'s for these products are marked in with '+' signs in red. The figure also reveals a large number of products with negative $\widehat{\tau}^k_{JA}$'s. Most of these are light-weight air-shipped products; to illustrate this point we shade data-points in proportion to their dependence on vessel-shipping in U.S.-PR shipments. Light shaded dots are products shipped primarily by air.

Since our empirical strategy focuses on a single trade route, and because we therefore employ a strategy that is a bit unusual, we check to see how the method behaves in other Caribbean markets. We apply the same techniques to data from three Caribbean island nations - DOM, JAM, and BHS - and calculate implied $\widehat{\tau}^k_{JA}$'s for those countries' imports from the U.S.[36] If our estimating strategy were to falsely attribute some unusual feature of exports from the Southeastern U.S. to the JA, we would expect to see the same pattern of $\widehat{\tau}^k_{JA}$'s for at least one of these countries. As the bottom of Figure 1 shows, none of the three countries' imports exhibit the same pattern we observe in PR. Relative to PR, the predicted distribution of implied $\widehat{\tau}^k_{JA}$'s is compressed for all three countries. In DOM, PR's nearest neighbor, the distribution of predicted JA tariff-equivalents is tightly compressed around zero, except for some air-shipped products with large negative $\widehat{\tau}^k_{JA}$'s. The estimates for JAM are somewhat noisier, with no significant tendency for $\widehat{\tau}^k_{JA}$'s to rise with weight. The BHS estimates are noisier still, but the distribution remains compressed relative to PR, and the relationship of $\widehat{\tau}^k_{JA}$'s to weight is negative rather than positive. These estimates all support the argument that the shipping characteristics' effects on PR's imports reflect consequences of the JA rather than some artifact of our procedures.

Our estimates of $\widehat{\tau}^k_{JA,t}$ return values for all final products, including those that typically travel by air. Since the reference air-shipped product is at the median of the weight-to-value ratio for air-shipped products, our procedures predict positive values of $\widehat{\tau}^k_{JA,t}$ for roughly half of the products that arrive in PR by air. To avoid attributing positive JA trade costs to air-shipped goods, we multiply $\widehat{\tau}^k_{JA,t}$ by the product's share of PR's import value arriving from the U.S. by sea: $\overline{\tau}^k_{JA,t} = \widehat{\tau}^k_{JA,t} \times Vshr^k_{JA,t}$, where $Vshr^k_{JA,t}$ is the value share of PR's product k imports arriving from the U.S. in an oceangoing vessel in year t.[37] The values of $\overline{\tau}^k_{JA,t}$ that

[36] We report tables with the associated coefficients for each country in Appendix A.

[37] Recall that the $Vshr^k_t$ used in the regressions comes from U.S. imports, not U.S.-PR flows. We include the subscript JA here to indicate that we are using U.S.-PR flows in this adjustment.

follow from this adjustment are our estimated JA trade costs going forward.[38] For these calculations we also assign zero values to the small number of sea-shipped products with fitted values of $\widehat{\tau}^{k}_{JA,t}$ below zero.[39]

Table 4 reports summary statistics for the distribution of estimates of $\overline{\tau}^{k}_{JA}$ for the year 2016. The first three rows contain estimates predicted from columns 3-5 in Table 3. Our preferred estimates come from Column 5, which include flexibly defined distance terms and U.S. trade policy controls. In these estimates - labelled "All Controls" in Table 4 - the simple average tariff-equivalent estimate of the JA is 30.6 percent, while the trade weighted average is 53.6 percent. 87 percent of final products have a positive JA tariff-equivalent trade cost.

The second row of Table 4 shows 2016 estimates of $\overline{\tau}^{k}_{JA}$'s using the same methods, but calculated from Column 4 of Table 3 estimates, the regression that excludes trade policy controls. In these estimates, the simple average value of $\overline{\tau}^{k}_{JA,2016}$ is 35.5 percent. The third row uses estimates from column 3, where the effects of distance are assumed common across products. This specification produces lower values of $\overline{\tau}^{k}_{JA,2016}$, with a simple average of 6.4 percent. The estimated effects of sea shipping are smaller when the effects of distance are constrained to be the same across products, and containerization is estimated to do more to offset other sources of JA costs. We prefer the estimates in row 1 of Table 4 because they contain the largest set of control variables.

We undertake a number of exercises to check the robustness of our results.

[38] The application of $Vshr^{k}_{JA,t}$ to the predicted trade costs is an effort to be conservative in our estimates. We focus our efforts on quantifying the implicit distortion that causes PR importers to substitute towards rest of the world (ROW) products and away from U.S. products. It is likely that the JA also causes U.S. products to be shipped to PR by air rather than by waterborne transport. Arguably this distortion is evident in the positive JA tariff equivalents that we zero out because shipments - in fact - travel by air rather than by sea. While this is plausible, assigning positive JA tariff equivalents to shipments that travel by air risks overstating the economic burden of the JA. We choose to be more conservative and treat goods travelling to PR by air as entirely unaffected by the JA.

[39] These are containerized products with extremely low weight-to-value ratios.

Table 4: Summary Statistics of Estimated Jones Act Tariff Equivalent - 2016

Control of PR's Imports DA	# Obs.	Simple Average	Trade Weighted Average	Median	Maximum
		Table 3 estimates			
FE: YEAR - All controls	609	30.6%	53.6%	29.5%	114.3%
FE: YEAR - No τ + No FTA's	609	35.5%	61.9%	34.8%	130.8%
FE: YEAR - No τ + No FTA's + No Dist $\times \overrightarrow{Z}$	609	6.4%	14.2%	5.4%	32.2%
		Robustness			
FE: YEAR - All controls - BEC	1,099	11.3%	11.2%	14.0%	24.0%
FE: YEAR $\times$ product (HS6) - All controls	609	11.8%	25.2%	7.4%	80.7%
FE: YEAR $\times$ sector (HS2) - All controls	609	33.2%	57.2%	32.1%	128.5%
FE: YEAR - All controls + Soderbery σ	609	310.0%	555.3%	335.8%	917.9%
FE: YEAR - All controls + Common σ	609	49.2%	76.0%	43.6%	226.7%

Note: These statistics are calculated as the product of the predicted JA-tariff equivalent for 2016 and the vessel share of 2016 U.S.-PR shipments in the corresponding product. Estimates are reported for numerous specifications of the structural regression (in equation (14)). All estimates rely on the σ estimates of Fontagné et al. (2022), except the row labeled "Soderbery σ" (which uses $\widehat{\sigma}^k$ from Soderbery (2015)) and the "common σ" case (which uses the MFN tariff coefficient associated with Column 5 of Table 2). The UN BEC classification has more observations because it defines a broader set of products.

Rather than report all of the regression estimates, we focus our reporting on the distributions of $\overline{\tau}^k_{JA}$ linked to each regression. These values are reported in the bottom half of Table 4. All of the results in Table 4 apply to estimates from a set of structural regressions among a sample of final goods. We provide a fuller discussion of our estimates and inferences in Appendix B. The general lessons are that a) the qualitative predictions of our hypothesis are robust among final goods, especially with respect to interactions involving products' vessel share and container share of shipments, b) the econometric specification matters for the estimated sizes of $\overline{\tau}^k_{JA}$, and c) the values of σ^k imposed in the regression are even more important for predictions of $\overline{\tau}^k_{JA}$ than the set of controls entering the specification.

6.3 Results for upstream products

We next turn to results for the set of upstream products. We report the structural estimates in Table 5. The associated reduced form estimates appear in Table C1 of Appendix C.

Among upstream products, our primary focus is on the coefficients associated with the $\overrightarrow{Z}$ variables themselves. These estimates capture the degree to which the product characteristics explain cross-commodity variation in the level of PR's total import demand. These variables first appear in column 2, where all of their coefficients are negative and statistically significant. The results imply that PR's imports of upstream products (from all sources) are relatively lower amongst products that are typically sea-shipped, physically heavy and containerized. As we add interactions with $HOME_j$, flexible distance related costs, and trade policy controls, the only $\overrightarrow{Z}$ coefficient that remains robust is that on Vsh_t^k, which takes a large negative value in all specifications. The quantitative implication of the coefficient estimate in Column 5 is that PR's imports of sea-shipped products are 77% lower than otherwise equivalent air-shipped products. Although the coefficients on the other $\overrightarrow{Z}$ variables change in both magnitude and levels of statistical significance across the columns, the large negative Vsh_t^k coefficient in all specifications means that implied reduction in sea-shipped goods is robust to whatever combination of Z coefficients we use for these calculations.

The very large implied reductions in imports of sea-shipped products from all sources means that there is not much room for even further reductions in imports of such products from the U.S. mainland. When we turn to the coefficients on the interactions with $HOME_j$, the coefficient estimates are much smaller in magnitude, and often statistically insignificant. Looking specifically at the column 5 results, for example, the additional substitution away from vessel-shipped products in U.S.

Table 5: Structural Estimates for Upstream Goods

			$M_{j,t}^k$		
VARIABLES	(1)	(2)	(3)	(4)	(5)
σ^k	0.308***	0.274**	0.276**	0.333***	-0.358
	(0.116)	(0.113)	(0.114)	(0.108)	(0.344)
$\sigma^k \times \ln(dist_j)$	-0.0492	-0.0401	-0.0411	-0.0618**	0.121
	(0.0320)	(0.0310)	(0.0311)	(0.0296)	(0.0883)
$\sigma^k \times HOME_j$	0.0102**	0.00547	-0.0307***	-0.00123	-0.00819
	(0.00447)	(0.00426)	(0.00907)	(0.0157)	(0.0147)
Vsh_t^k		-1.583***	-1.685***	-1.854***	-1.476***
		(0.258)	(0.290)	(0.368)	(0.348)
$\ln(WV^k)$		-0.270***	-0.240***	0.240**	0.127
		(0.0544)	(0.0601)	(0.117)	(0.105)
$(\ln(WV^k))^2$		-0.0520***	-0.0524***	0.00176	-0.00332
		(0.00798)	(0.00878)	(0.0155)	(0.0149)
$Ctnr_t^k$		-0.298***	-0.460***	0.0481	0.111
		(0.106)	(0.111)	(0.133)	(0.150)
$\sigma^k \times Vsh_t^k \times HOME_j$			-0.00824	-0.0197**	-0.0272***
			(0.00945)	(0.00934)	(0.00877)
$\sigma^k \times \ln(WV^k) \times HOME_j$			-0.00663***	0.00990	0.00285
			(0.00225)	(0.00887)	(0.00764)
$\sigma^k \times (\ln(WV^k))^2 \times HOME_j$			-0.000220	0.00144	0.000719
			(0.000279)	(0.00101)	(0.000815)
$\sigma^k \times Ctnr_t^k \times HOME_j$			0.0585***	0.0929***	0.114***
			(0.00759)	(0.0165)	(0.0187)
$\sigma^k \times (\ln(dist_j))^2$	0.00167	0.00111	0.00118	0.00217	-0.00950*
	(0.00213)	(0.00207)	(0.00207)	(0.00195)	(0.00563)
$IHST(\widetilde{X}_{j,t}^k)$	0.789***	0.802***	0.801***	0.800***	0.825***
	(0.0258)	(0.0321)	(0.0322)	(0.0306)	(0.0340)
Observations	5,892,852	5,892,852	5,892,852	5,892,852	5,892,852
Year FE	YES	YES	YES	YES	YES
Flexible distance controls	NO	NO	NO	YES	YES
U.S. trade policy controls	NO	NO	NO	NO	YES
Pseudo R2	0.420	0.443	0.446	0.453	0.500

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The LHS variable on all models is $M_{j,t}^k$, the total value imported in Puerto Rico from place of origin j of product k in year t. All models are estimated using the PPML estimator on Puerto Rico's import data pooled across observations at the year, HS6 digit product, and place-of-origin level, with year fixed effects included in the estimation model. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation.

imports is small, and its quantitative effects more than completely offset for containerized products. This pattern is also stable across the columns in the structural estimates. The reduced form estimates tell the same story (although in that case an estimated bias towards heavy and containerized products from the U.S. more than offsets the bias against sea-shipped U.S. goods). In every specification the large negative sign on $Vshr_t^k$ alone is robustly large and negative. One interpretation is that among upstream products, production location effects dominate substitution effects, reducing imports of sea-shipped products from all sources, not only the U.S.

We do not see the same patterns emerge in our comparison countries (results of the structural regressions for these countries appear in appendix tables C2 - C4, and their reduced form counterparts in C5 - C7). Judging by the $\overrightarrow{Z}$ coefficients reported in column 5 of each table, the bias in all three countries is *towards* sea-shipped and physically heavy products (an effect that is only partially offset among containerized products in JAM and BHS). Differential effects on imports from the U.S. (i.e. substitution effects) are muted in all three cases, as expected. If anything, it seems that that these countries exhibit a small bias in favor of heavy products from the U.S. In BHS, an apparent bias against U.S. sea-shipped goods nearly disappears if the goods are physically heavy or containerized.[40]

7 Welfare loss calculations

Although the dearth of sea-shipped imports of upstream products to PR suggests potentially important consequence of the JA, it is difficult to attribute these effects

[40]The coefficients in the BHS regressions are quite large and volatile in the sample of upstream products, though the patterns we observe appear to be stable in relative - if not absolute - magnitudes across the specifications. Noisy estimates for BHS are perhaps understandable, considering that it is unique among the countries in being an archipelago (presumably generating bias towards sea-shipped imports) and largely a service economy (limiting the need for upstream imports). These features lead us to believe that BHS is least-suited for this particular comparison exercise. The results nonetheless support our argument that PR's bias against sea-shipped products in upstream imports is unusual in the Caribbean.

directly to the policy alone. Section 936 offers another plausible explanation. We therefore leave effects on upstream imports aside, turning our attention back to the evidence of sizable substitution effects among final products. We conduct a welfare analysis that focuses on measuring the losses from JA distortions in PR's final demand. Our objective is to quantify the degree to which the JA requires higher levels of spending to obtain the same level of utility (for consumers) or output (producers). Our tool for this analysis is Compensating Variation (CV). Under the assumption that the rents that accrue to suppliers of JA shipping are received by agents on the U.S. mainland, CV is an appropriate measure of PR's (static) welfare loss.

Consider an expenditure function $E(P, U)$ that reflects the minimized cost of purchasing an optimal consumption basket in PR.[41] The expenditure function is the product of a specific numerical level of utility $\overline{U}$, and the true cost of living index $P_t = \prod_l (\widetilde{P}_t^l)^{\alpha_l}$, where l indicates a NAICS sector that is an aggregate of the set of products $k \in l$.[42] Abstracting away from the possibility that changes in trade costs might change the number of varieties that PR purchases from the U.S. mainland, for counterfactual analysis we define the price sub-index in sector l as:

$$\widetilde{P}_t^l = \left[\sum_j \theta_{j,t}^l (1 + \tilde{\tau}_{j,t}^l)^{1-\sigma^l} \right]^{\frac{1}{1-\sigma^l}} \tag{16}$$

where $\theta_{j,t}^l$ acts an Armington distribution weight, σ^l and $\tilde{\tau}_{j,t}^l$ are the trade-weighted average elasticities and trade costs in sector l, respectively. Regions j in this analysis are PR, U.S. and ROW.

It is straightforward to calibrate this expenditure function with data from PR's IO table. Let $S_{j,t}^l$ be region $j's$ observed share of Puerto Rican purchases of sector l.

[41] For final demand categories other than private consumption, we replace expenditure with cost and utility with output and conduct the same calculations.

[42] Our data on PR's purchases of its own output (and value added) do not allow us to calculate welfare at the same level of disaggregation as the structural regressions, so we aggregate τ_{JA}^k's and σ^k's using trade weights and replace superscript k with l.

The presence of JA trade costs (in the case of the U.S. mainland), and tariffs (in the case of ROW) means that the data shares of purchases from those sources are larger than the distribution weights. The distribution weights can be uncovered by dividing the trade shares by the trade costs associated with an origin and product $\theta^l_{j,t} = \frac{S^l_{j,t}}{(1+\tilde{\tau}^l_{j,t})^{1-\sigma^l}}$. The data required for this transformation - the values of $\tilde{\tau}^l_{j,t}$ and σ^l - are also applied where necessary in $\widetilde{P}^l_t$, and thus P_t. Since purchases of PR output face no trade costs, $\theta^l_{PR} = S^l_{PR}$. The α^l parameters are the observed share of sectors l in expenditure in the IO table, whereas the initial values of $E(P,U)^0$ are the total expenditures observed in the table, and inflated by GDP growth to 2016.[43]

Our calculation of CV is accomplished as follows. Let $\overline{U}_t$ be the numerical value of utility associated with the initial price index P^0_t and observed expenditures $E(P^0_t, \overline{U}_t)^0$. In counterfactual analysis we remove $\tilde{\tau}^l_{j,t}$ in (16) on imports from the U.S. mainland, assuming no change in ROW or Puerto Rican domestic prices.[44] Given new values of the price index P^1_t, we calculate an updated value of the expenditure function $E(P^1_t, \overline{U}_t)^1$. The CV of the price change is calculated as

$$CV = E(P^0_t, \overline{U}_t)^0 - E(P^1_t, \overline{U}_t)^1 \tag{17}$$

We do this calculation for JA tariff-equivalent trade costs on U.S. imports, and U.S. tariffs on ROW imports. We also conduct the exercise for sub-components of final demand (Consumption, Investment, Government spending, etc.).

[43] We use trade shares and inferred trade costs from 2016. We inflate the older input-output data to produce estimates in 2016 dollars. Puerto Rican nominal GDP grew by a factor of 1.195 between 2006 and 2016.

[44] The assumption of perfectly elastic supply to the Puerto Rican market is reasonable for U.S. and ROW imports. Our calculations implicitly assume no change in the prices of Puerto Rican goods. Puerto Rican domestic prices might also be expected to fall with JA removal, since domestic suppliers would face greater competition from imports (and have access to cheaper imported inputs). Falling domestic prices would raise our estimate of CV. But these additional welfare gains would be partially offset by reduced incomes from reduced domestic sale revenue (absent any additional income gains arising through comparative advantage). We take the assumption of no net change in Puerto Rican prices as a reasonable approximation that facilitates transparent calculations.

Using this method and $\overline{\tau}^{l}_{JA}$'s that depend on 2016 estimates of $\widehat{\tau}^{k}_{JA}$, we calculate that final expenditure in Puerto Rico would be \$1.4 billion (about 0.8 percent) lower in 2016 without the JA. Table 6 decomposes this value into burdens on particular types of final expenditure; consumption spending would be \$692 million (about 1.1 percent) lower per year, or \$203 per citizen annually. The highest burden is on investment, which could be maintained at existing levels with 3 percent lower expenditures if the JA were removed. This implicit tax on investment implies that the policy imposes dynamic losses on PR that are likely much more consequential than our static CV estimates.

Table 6: Compensating Variation, Jones Act Removal, 2016

	Share in Final Demand	Total CV (millions of \$U.S.)	Per Capita (\$U.S.)	% Change vs No JA
Final Demand	100.0%	1,398	410	0.8%
Consumption	36.7%	692	203	1.1%
Exports	46.0%	291	85	0.4%
Investment	8.2%	403	118	3.0%
Local Government	6.6%	0	0	0.0%
Municipal Government	1.6%	0	0	0.0%
Federal Government	0.9%	0	0	0.0%

Note: CV estimates are calculated using NAICS code level weighted averages of the estimated JA-tariff equivalents. All figures are in 2016 dollars; per capita estimates use PR's population in 2016. All calculations assume zero tariff equivalents for NAICS codes 3251, 3254 and 3390, the pharmaceutical sector.

Using the same approach, but considering the removal of 2016 U.S. MFN tariffs for all goods arriving from ROW partners that are not members of a preferential trade agreement with the U.S., we calculate the CV of removing such tariffs to be U.S.\$150 million (about 0.1 percent of expenditures).[45] MFN tariffs on Puerto Rican households' imports of non-PTA partner goods costs them approximately \$94 million, or \$28 per person per year. The implication is that the JA costs Puerto

[45]The tariffs we remove are trade-weighted averages of 2016 MFN tariffs imposed on non-U.S. PTA partners, assuming a value of zero for PTA partners.

Rican households approximately 7.3 times as much as MFN tariffs.

8 Conclusion

We study the consequences for PR of the JA, a U.S. law that requires vessels carrying waterborne freight to be U.S.-built, -owned, -flagged and -crewed. Data on port arrivals show a dearth of tanker, bulk, liquid and general cargo vessels in the JA fleet serving PR. We develop a theory that allows the effects of the law to have different consequences for trade among final and upstream products.

Among final products, we find reduced bias toward U.S. sources among products that are sea-shipped, heavy and/or difficult to transport in containers. Among upstream products, there is a large bias against sea-shipped products from all sources. The latter finding is consistent with JA having shifted the structure of PR's production away from processing sea-shipped inputs over the long run, although other policies may have contributed to the outcome.

Since our evidence of the effects of the JA is strongest among final products, we focus our calculation of welfare costs there. Structural estimates of JA trade costs imply simple average tariff equivalents of 30.6 percent. In a simple calculation we estimate that tariff equivalent trade costs of this magnitude imply a burden of the policy on Puerto Rican households that is equivalent to 1.1 percent of expenditure, or about $203 per person annually. Our work also points in the direction of much larger dynamic losses from the JA. These include an estimated 3 percent increase in the cost of private investment, along with suggestive evidence that the Puerto Rican industrial structure has evolved to limit its use of sea-shipped imported inputs.

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Appendixes

A Gravity estimates - Final products

Table A1: Structural Estimates for Final Goods - Dominican Republic

	$M_{j,t}^k$				
VARIABLES	(1)	(2)	(3)	(4)	(5)
σ^k	3.677***	3.974***	4.002***	4.054***	4.493***
	(0.224)	(0.239)	(0.248)	(0.223)	(0.224)
$\sigma^k \times \ln(dist_j)$	-0.830***	-0.911***	-0.920***	-0.910***	-1.037***
	(0.0572)	(0.0630)	(0.0654)	(0.0604)	(0.0606)
$\sigma^k \times HOME_j$	0.110***	0.116***	0.131***	0.170***	0.188***
	(0.0116)	(0.0123)	(0.0372)	(0.0364)	(0.0368)
Vsh_t^k		-0.447***	-0.0836	3.346***	3.071***
		(0.169)	(0.184)	(0.488)	(0.489)
$\ln(WV^k)$		0.339***	0.376***	0.827***	0.844***
		(0.0420)	(0.0426)	(0.126)	(0.130)
$(\ln(WV^k))^2$		0.0146***	0.0228***	0.169***	0.167***
		(0.00313)	(0.00338)	(0.0195)	(0.0199)
$Ctnr_t^k$		-0.753***	-0.829***	-1.584***	-1.550***
		(0.150)	(0.145)	(0.349)	(0.354)
$\sigma^k \times Vsh_t^k \times HOME_j$			-0.0516**	-0.0196	-0.0194
			(0.0261)	(0.0277)	(0.0264)
$\sigma^k \times \ln(WV^k) \times HOME_j$			-0.0139	0.0395**	0.0382**
			(0.00851)	(0.0156)	(0.0164)
$\sigma^k \times (\ln(WV^k))^2 \times HOME_j$			-0.00170***	0.00836***	0.00842***
			(0.000612)	(0.00255)	(0.00263)
$\sigma^k \times Ctnr_t^k \times HOME_j$			0.0195	-0.0253	-0.0120
			(0.0182)	(0.0257)	(0.0257)
$\sigma^k \times Vsh_t^k \times \ln(dist_j)$				-0.0336***	-0.0308***
				(0.00497)	(0.00504)
$\sigma^k \times \ln(WV^k) \times \ln(dist_j)$				-0.00960***	-0.0102***
				(0.00274)	(0.00284)
$\sigma^k \times (\ln(WV^k))^2 \times \ln(dist_j)$				-0.00254***	-0.00257***
				(0.000466)	(0.000479)
$\sigma^k \times Ctnr_t^k \times \ln(dist_j)$				0.0126***	0.0113***
				(0.00436)	(0.00436)
$\sigma^k \times \ln(1 + tar_{j,t}^k)$					0.0769**
					(0.0392)
$\sigma^k \times (\ln(dist_j))^2$	0.0454***	0.0505***	0.0511***	0.0516***	0.0599***
	(0.00360)	(0.00402)	(0.00418)	(0.00387)	(0.00387)
$IHST(\widetilde{X}_{j,t}^k)$	0.877***	0.864***	0.862***	0.838***	0.860***
	(0.0121)	(0.00868)	(0.00853)	(0.0108)	(0.0113)
Constant	-4.435***	-2.425***	-2.597***	-4.826***	-5.127***
	(0.217)	(0.287)	(0.331)	(0.551)	(0.557)
Observations	1,322,178	1,322,178	1,322,178	1,322,178	1,309,781
Year FE	YES	YES	YES	YES	YES
PTA Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.638	0.643	0.644	0.665	0.676

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over the sample of HS6 products with values of the upstreamness index $<=$ 1.3. The LHS variable on all models is $M_{j,t}^k$, the total value imported in Dominican Republic from place of origin j of product k in year t. All models are estimated using the PPML estimator on Dominican Republic's import data pooled across observations at the year, HS6 digit product, and place-of-origin level, with year fixed effects included in the estimation model. σ^k estimates from Fontagné et al. (2022) are interacted with geographic frictions, and enter separately in the regression itself. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation. Model (5) is estimated using fewer observations due to missing trade tariff data.

Table A2: Structural Estimates for Final Goods - Jamaica

			$M^k_{j,t}$		
VARIABLES	(1)	(2)	(3)	(4)	(5)
σ^k	3.265***	4.136***	4.319***	4.504***	4.503***
	(0.318)	(0.368)	(0.379)	(0.375)	(0.361)
$\sigma^k \times \ln(dist_j)$	-0.761***	-0.994***	-1.047***	-1.061***	-1.062***
	(0.0811)	(0.0957)	(0.0990)	(0.0965)	(0.0937)
$\sigma^k \times HOME_j$	0.0564***	0.0752***	-0.00336	-0.0407	-0.0398
	(0.0118)	(0.0134)	(0.0318)	(0.0340)	(0.0361)
Vsh^k_t		0.125	0.588**	2.071***	2.005***
		(0.200)	(0.247)	(0.407)	(0.524)
$\ln(WV^k)$		0.726***	0.791***	0.772***	0.763***
		(0.0517)	(0.0566)	(0.118)	(0.119)
$(\ln(WV^k))^2$		0.0335***	0.0377***	0.120***	0.119***
		(0.00351)	(0.00416)	(0.0150)	(0.0156)
$Ctnr^k_t$		-1.316***	-1.802***	-0.831***	-0.800**
		(0.164)	(0.168)	(0.276)	(0.319)
$\sigma^k \times Vsh^k_t \times HOME_j$			-0.175***	-0.148***	-0.148***
			(0.0295)	(0.0283)	(0.0288)
$\sigma^k \times \ln(WV^k) \times HOME_j$			-0.0456***	-0.0377***	-0.0379***
			(0.00765)	(0.0122)	(0.0130)
$\sigma^k \times (\ln(WV^k))^2 \times HOME_j$			-0.00289***	0.00126	0.00123
			(0.000544)	(0.00158)	(0.00160)
$\sigma^k \times Ctnr^k_t \times HOME_j$			0.279***	0.298***	0.298***
			(0.0272)	(0.0291)	(0.0294)
$\sigma^k \times Vsh^k_t \times \ln(dist_j)$				-0.0148***	-0.0142***
				(0.00389)	(0.00482)
$\sigma^k \times \ln(WV^k) \times \ln(dist_j)$				-4.99e-06	2.85e-05
				(0.00248)	(0.00250)
$\sigma^k \times (\ln(WV^k))^2 \times \ln(dist_j)$				-0.00124***	-0.00123***
				(0.000325)	(0.000330)
$\sigma^k \times Ctnr^k_t \times \ln(dist_j)$				-0.0123***	-0.0126***
				(0.00330)	(0.00375)
$\sigma^k \times \ln(1 + tar^k_{j,t})$					0.0102
					(0.0502)
$\sigma^k \times (\ln(dist_j))^2$	0.0438***	0.0585***	0.0618***	0.0642***	0.0643***
	(0.00509)	(0.00606)	(0.00627)	(0.00612)	(0.00595)
$IHST(\widetilde{X}^k_{j,t})$	0.845***	0.824***	0.825***	0.827***	0.828***
	(0.0272)	(0.0222)	(0.0216)	(0.0237)	(0.0228)
Constant	-5.465***	-2.525***	-2.338***	-4.937***	-4.946***
	(0.542)	(0.406)	(0.404)	(0.527)	(0.507)
Observations	1,015,104	1,015,104	1,015,104	1,015,104	1,010,412
Year FE	YES	YES	YES	YES	YES
PTA Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.566	0.592	0.604	0.610	0.610

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over the sample of HS6 products with values of the upstreamness index $<= 1.3$. The LHS variable on all models is $M^k_{j,t}$, the total value imported in Jamaica from place of origin j of product k in year t. All models are estimated using the PPML estimator on Jamaica's import data pooled across observations at the year, HS6 digit product, and place-of-origin level, with year fixed effects included in the estimation model. σ^k estimates from Fontagné et al. (2022) are interacted with geographic frictions, and enter separately in the regression itself. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation. Model (5) is estimated using fewer observations due to missing trade tariff data.

Table A3: Structural Estimates for Final Goods - Bahamas

	$M_{j,t}^k$				
VARIABLES	(1)	(2)	(3)	(4)	(5)
σ^k	2.320***	2.463***	2.587***	2.500***	2.468***
	(0.218)	(0.251)	(0.269)	(0.280)	(0.280)
$\sigma^k \times \ln(dist_j)$	-0.557***	-0.633***	-0.669***	-0.784***	-0.779***
	(0.0692)	(0.0793)	(0.0856)	(0.0975)	(0.0974)
$\sigma^k \times HOME_j$	-0.0630***	-0.0298	0.759***	0.805***	0.796***
	(0.0212)	(0.0294)	(0.0920)	(0.111)	(0.114)
Vsh_t^k		5.688***	6.709***	5.284***	5.110***
		(0.555)	(0.500)	(1.452)	(1.398)
$\ln(WV^k)$		-1.509***	-1.949***	2.628***	2.578***
		(0.221)	(0.216)	(0.267)	(0.268)
$(\ln(WV^k))^2$		-0.0887***	-0.117***	0.419***	0.414***
		(0.0154)	(0.0179)	(0.0459)	(0.0454)
$Ctnr_t^k$		-0.553***	-0.703***	-0.162	-0.0337
		(0.188)	(0.198)	(0.364)	(0.368)
$\sigma^k \times Vsh_t^k \times HOME_j$			-0.427***	-0.348***	-0.331***
			(0.0404)	(0.0425)	(0.0440)
$\sigma^k \times \ln(WV^k) \times HOME_j$			0.186***	0.254***	0.256***
			(0.0226)	(0.0373)	(0.0390)
$\sigma^k \times (\ln(WV^k))^2 \times HOME_j$			0.0118***	0.0230***	0.0234***
			(0.00158)	(0.00439)	(0.00457)
$\sigma^k \times Ctnr_t^k \times HOME_j$			0.0605*	0.113***	0.0982***
			(0.0310)	(0.0305)	(0.0336)
$\sigma^k \times Vsh_t^k \times \ln(dist_j)$				0.0101	0.0120
				(0.0114)	(0.0108)
$\sigma^k \times \ln(WV^k) \times \ln(dist_j)$				-0.0736***	-0.0734***
				(0.00979)	(0.00971)
$\sigma^k \times (\ln(WV^k))^2 \times \ln(dist_j)$				-0.00931***	-0.00928***
				(0.00158)	(0.00157)
$\sigma^k \times Ctnr_t^k \times \ln(dist_j)$				-0.00150	-0.00360
				(0.00417)	(0.00465)
$\sigma^k \times \ln(1 + tar_{j,t}^k)$					0.0763
					(0.0655)
$\sigma^k \times (\ln(dist_j))^2$	0.0343***	0.0409***	0.0432***	0.0416***	0.0412***
	(0.00494)	(0.00572)	(0.00616)	(0.00617)	(0.00619)
$IHST(\widetilde{X}_{j,t}^k)$	0.996***	0.942***	0.947***	1.029***	1.028***
	(0.0411)	(0.0543)	(0.0549)	(0.0641)	(0.0644)
Constant	-8.988***	-16.08***	-17.96***	-10.28***	-10.30***
	(0.871)	(1.943)	(1.910)	(2.047)	(2.011)
Observations	667,403	667,403	667,403	667,403	663,355
Year FE	YES	YES	YES	YES	YES
Pseudo R2	0.547	0.603	0.616	0.643	0.644

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over the sample of HS6 products with values of the upstreamness index $<= 1.3$. The LHS variable on all models is $M_{j,t}^k$, the total value imported in Bahamas from place of origin j of product k in year t. All models are estimated using the PPML estimator on Bahamas's import data pooled across observations at the year, HS6 digit product, and place-of-origin level, with year fixed effects included in the estimation model. σ^k estimates from Fontagné et al. (2022) are interacted with geographic frictions, and enter separately in the regression itself. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation. Model (5) is estimated using fewer observations due to missing trade tariff data. Model (5) is also estimated without PTA dummy variables because the Bahamas have no PTA's in place.

B Robustness exercises - Final products

In this appendix we check the robustness of our results for the final goods sample. In our first exercise we estimate over a different sample, using the United Nations' BEC classification rather than the upstreamness index to identify final products. We estimate the same empirical model separately for samples of products that the UN categorizes as Consumption products. We report structural estimates for this sample in Appendix Table B4. In this sample, we find the same sign patterns as in the estimates for final goods in Tables 2 and 3, although the coefficients on the interaction of $HOME_j$ with the logged weight to value terms become statistically insignificant in columns 4 and 5. Both reduced form and structural estimates have the predicted sign pattern on the $\overrightarrow{Z}^k \times HOME_j$ interactions for all specifications involving Consumption goods.

The lower coefficients on the $\sigma^k \times \overrightarrow{Z}^k \times HOME_j$ term in the BEC Consumption sample imply lower estimates of tariff equivalent trade costs. The simple average estimate of $\overline{\tau}^k_{JA}$ is 11.3 percent, the trade weighted average 11.2 percent, and the median 14.0 percent.[46] Looking again at the estimates in Table B4 one notes that the sample size is much larger than in the relevant counterpart, Table 3. The BEC sample contains products that are further upstream than the set of final goods in Table 3. In this larger sample, the effects of the $\overrightarrow{Z}^k$ variables on predicted home bias are much weaker, which generates the compressed distribution of $\overline{\tau}^k_{JA}$ in Table 4. We note that the BEC has been criticized for not keeping up with technological changes; consumption goods are now sometimes classified as intermediates and intermediates as final goods.[47] We therefore focus our remaining attention on the sample defined by products' position in the upstreamness index.

[46]These lower tariff equivalents apply to a greater share of Puerto Rican imports, offsetting the effects of the lower tariff equivalents on our CV calculations.

[47]See Sturgeon and Memedovic (2011) for a discussion of this issue.

Returning to the original sample, we estimate a range of different econometric specifications to check robustness. So far, we have controlled for time-varying shocks by assuming they simply affect import demand in the aggregate; the main specification includes year fixed effects. We also estimate the model with year-product fixed effects, which allow for time-varying effects on import demand at the product level. This specification produces coefficient estimates on the interaction terms we study, even though the fixed effects mean that the coefficients on the $\overrightarrow{Z}^k$'s alone are not reported because they are collinear with the fixed effects. In both the reduced form and the structural regressions, the sign pattern for the interaction terms is the same as in earlier specifications, though the magnitudes are different. We generate the distribution of imputed $\overline{\tau}^k_{JA}$'s from the specification with flexible distances and trade policy variables. These are reported in row 5 of Table 4, which shows a simple average $\overline{\tau}^k_{JA}$ of 11.8 percent and a weighted average of 25.2 percent.

The somewhat lower estimates in this particular robustness check raise the question of which estimates are to be preferred. Normally, one might prefer an estimate from a specification with product-destination fixed effects, which would control for cross-product variation in α^k and $\widetilde{P}^k$ if the sample also included PR-PR flows. There are two features of these data that lead us to prefer a specification that allows the $\overrightarrow{\omega}\overrightarrow{Z}$ terms to parameterize import demand. First, we lack detailed data on trade flows within PR. The structural parameters α^k and $\widetilde{P}^k$ are shifters of *total* demand for the product k in PR, rather than shifters of *import* demand. The potential bias arising from this distinction would likely not be especially important if the data for each product contained imports from both U.S. and ROW sources. There are, however, many products for which imports arrive from either the U.S. or the ROW, but not from both regions. Consider the case of imports arriving only from U.S. sources. Suppose a product with relatively high unobserved trade costs from ROW sees imports arrive only from the U.S. If JA trade costs cause substitution towards domestic Puerto Rican sources, one will see relatively low values of total imports in this product. A product-destination fixed effect will interpret this outcome as the result of relatively low import demand for that product, rather than a result of high JA trade costs in the presence of higher levels of import demand. The $\overrightarrow{\omega}\overrightarrow{Z}$ terms in the preferred specification are, effectively, a model of PR's product-level import demands. They may or may not predict the level of import demand especially well (though the ω estimates on $Vshr_t^k$ and $Cntr_t^k$ are always highly significant). The relevant point is that the inclusion of the $\overrightarrow{Z}$ variables independently in the regression should produce an estimate of fitted import demand that will not bias downward estimates of JA trade costs in cases where those costs are idiosyncratically high.

Next we check robustness to our choice of Fontagné et al. (2022) as the source of structural estimates of σ^k. Soderbery (2015) produces a set of σ^k estimates for the U.S. using a version of the Feenstra (1994) estimator. We estimate a set of structural regressions akin to those in Table 3, except that the σ^k estimates we include in the regression are Soderbery's, not Fontagné *et al.*'s. The sign pattern in the structural estimates is once again robust, but the magnitudes of the coefficients of interest imply much larger $\hat{\tau}_{JA}^k$'s. This appears to be a mechanical result that comes from the fact that the Soderbery (2015) estimates of σ^k are generally lower than the estimates in Fontagné et al. (2022).[48] The predicted values of $\overline{\tau}_{JA}^k$'s implied by the Soderbery (2015) estimates are reported in Table 4. They are an order of magnitude larger than those implied by the Fontagné et al. (2022) estimates, with a simple average tariff equivalent of 310%. These are arguably implausible as *ad valorem*

[48] We speculate that the reason for this result is that the Feenstra (1994) estimator used by Soderbery (2015) is more reliant on time series variation than are the estimates in Fontagné et al. (2022), which exploit cross-sectional variation in a manner similar to Hummels (1999). Since short-run estimates are likely to be smaller than long-run responses - see Erkel-Rousse and Mirza (2002) - this would explain the discrepancy between the two sets of estimates. The JA is more than a century old, so long-run responses to trade costs are preferable.

estimates of bilateral trade costs, since they imply that the additional transport costs due to the JA account for 3/4 of the delivered price for the good (at the mean of the distribution).[49]

We also consider the implications of using the implied estimate of σ that is the coefficient estimate on the U.S. tariff variable in column 5 of Table 2. That interpretation of the estimate implies that all commodities share the same elasticity of substitution. Since the estimate of $\sigma = 2.785$ is rather low, the implied values of $\overrightarrow{\gamma}$ are rather high, especially for the products most affected by the JA.[50] The mean estimate in this case is a 49.2 percent tariff equivalent. The maximum values are much higher than in the benchmark estimates that use heterogeneous σ^k's. The very high maximum values in the common-σ case likely arise because the products most affected by the JA are also commodities with high elasticities of substitution (e.g. types of water). In this instance, applying an average value of σ to all products biases upward the $\overline{\tau}^k_{JA}$ estimates for highly substitutable products.

[49] Another problem with the Soderbery (2015) estimates for our purposes is that there are many commodities without an estimate of σ^k. In these cases we are still able to estimate implied values of $\widehat{\tau}^k_{JA}$, by calculating the implied values predicted by the estimated $\overrightarrow{\gamma}$ coefficients and the product characteristics associated with those commodities. We have relatively low levels of confidence in these estimates, however, given the absence of σ^k.

[50] These estimates of $\overrightarrow{\gamma}$ are calculated by dividing the reduced form coefficients $\overrightarrow{\beta}$ (from Table 2) by the estimated value of σ, the coefficient on the MFN tariff in Table 2.

Table B4: Structural Estimates for BEC Consumption Goods

			$M^k_{j,t}$		
VARIABLES	(1)	(2)	(3)	(4)	(5)
σ^k	-2.020***	-1.847***	-1.713***	-1.618***	-1.386***
	(0.258)	(0.276)	(0.258)	(0.286)	(0.309)
$\sigma^k \times \ln(dist_j)$	0.683***	0.642***	0.599***	0.563***	0.508***
	(0.0702)	(0.0748)	(0.0705)	(0.0775)	(0.0842)
$\sigma^k \times HOME_j$	0.232***	0.236***	0.263***	0.328***	0.351***
	(0.00916)	(0.00912)	(0.0209)	(0.0641)	(0.0558)
Vsh^k_t		-1.929***	1.241***	5.205***	5.405***
		(0.391)	(0.378)	(1.217)	(1.162)
$\ln(WV^k)$		0.231***	0.413***	0.446***	0.308**
		(0.0328)	(0.0501)	(0.120)	(0.126)
$(\ln(WV^k))^2$		0.0182***	0.0283*	-0.00973	-0.0180
		(0.00433)	(0.0149)	(0.0293)	(0.0295)
$Ctnr^k_t$		1.916***	-0.125	-4.570***	-4.401***
		(0.330)	(0.250)	(0.970)	(0.949)
$\sigma^k \times Vsh^k_t \times HOME_j$			-0.434***	-0.200*	-0.209*
			(0.0706)	(0.115)	(0.113)
$\sigma^k \times \ln(WV^k) \times HOME_j$			-0.0407***	-0.0315**	-0.00749
			(0.00580)	(0.0123)	(0.0136)
$\sigma^k \times (\ln(WV^k))^2 \times HOME_j$			-0.00346***	-0.00692***	-0.00452***
			(0.000982)	(0.00105)	(0.00109)
$\sigma^k \times Ctnr^k_t \times HOME_j$			0.357***	0.0770	0.0483
			(0.0642)	(0.0952)	(0.100)
$\sigma^k \times Vsh^k_t \times \ln(dist_j)$				-0.0955***	-0.0946***
				(0.0309)	(0.0287)
$\sigma^k \times \ln(WV^k) \times \ln(dist_j)$				-0.00255	-0.00389
				(0.00246)	(0.00261)
$\sigma^k \times (\ln(WV^k))^2 \times \ln(dist_j)$				0.000630**	0.000435
				(0.000313)	(0.000316)
$\sigma^k \times Ctnr^k_t \times \ln(dist_j)$				0.106***	0.106***
				(0.0254)	(0.0245)
$\sigma^k \times \ln(1 + tar^k_{j,t})$					-1.390***
					(0.165)
$\sigma^k \times \ln(dist_j))^2$	-0.0568***	-0.0544***	-0.0515***	-0.0504***	-0.0467***
	(0.00474)	(0.00502)	(0.00477)	(0.00519)	(0.00565)
$IHST(\widetilde{X}^k_{j,t})$	0.489***	0.493***	0.485***	0.485***	0.476***
	(0.0115)	(0.0114)	(0.0107)	(0.0105)	(0.0103)
Constant	4.613***	4.923***	4.405***	4.981***	4.544***
	(0.219)	(0.205)	(0.331)	(0.533)	(0.459)
Observations	1,727,103	1,727,103	1,727,103	1,727,103	1,719,144
Year FE	YES	YES	YES	YES	YES
U.S. PTA Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.395	0.400	0.408	0.411	0.418

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over a sample of goods defined by the UN BEC "Consumption" classification. The LHS variable on all models is $M^k_{j,t}$, the total value imported in Puerto Rico from place of origin j of product k in year t. All models are estimated using the PPML estimator on Puerto Rico's import data pooled across observations at the year, HS6 digit product, and place-of-origin level, with year fixed effects included in the estimation model. σ^k estimates from Fontagné et al. (2022) are interacted with geographic frictions, and enter separately in the regression itself. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation.

C Gravity estimates - Upstream products

Table C1: Reduced Form Estimates for Upstream Goods - Puerto Rico

			$M^k_{j,t}$		
VARIABLES	(1)	(2)	(3)	(4)	(5)
$\ln(dist_j)$	-4.047***	-2.995**	-2.649**	-2.668**	4.583***
	(1.087)	(1.201)	(1.257)	(1.224)	(1.582)
$HOME_j$	0.921***	0.774***	-0.0209	-0.0641	-1.237***
	(0.127)	(0.144)	(0.397)	(0.397)	(0.416)
Vsh^k_t		-1.282***	-0.989***	-4.546**	-13.28***
		(0.312)	(0.368)	(1.899)	(2.348)
$\ln(WV^k)$		-0.216***	-0.399***	2.334***	2.897***
		(0.0399)	(0.0692)	(0.368)	(0.484)
$(\ln(WV^k))^2$		-0.0476***	-0.0719***	0.270***	0.288***
		(0.00645)	(0.0101)	(0.0350)	(0.0440)
$Ctnr^k_t$		-0.465***	-1.737***	8.865***	12.21***
		(0.105)	(0.128)	(1.344)	(1.286)
$Vsh^k_t \times HOME_j$			-1.211***	-0.987**	-0.318
			(0.377)	(0.389)	(0.408)
$\ln(WV^k) \times HOME_j$			0.338***	0.183***	0.146**
			(0.0694)	(0.0582)	(0.0669)
$(\ln(WV^k))^2) \times HOME_j$			0.0531***	0.0361***	0.0369***
			(0.00917)	(0.00836)	(0.00913)
$Ctnr^k_t \times HOME_j$			3.598***	2.798***	2.854***
			(0.225)	(0.206)	(0.221)
$Vsh^k_t \times ln(dist_j)$				0.422**	1.426***
				(0.208)	(0.259)
$\ln(WV^k) \times ln(dist_j)$				-0.326***	-0.394***
				(0.0463)	(0.0604)
$(\ln(WV^k))^2) \times ln(dist_j)$				-0.0412***	-0.0440***
				(0.00511)	(0.00618)
$Ctnr^k_t \times ln(dist_j)$				-1.235***	-1.658***
				(0.164)	(0.156)
$\ln(1 + tar^k_{j,t})$					10.46***
					(0.569)
$(\ln(dist_j))^2$	0.198***	0.132*	0.112	0.101	-0.420***
	(0.0704)	(0.0775)	(0.0809)	(0.0794)	(0.106)
$IHST(\widetilde{X}^k_{j,t})$	0.864***	0.872***	0.868***	0.877***	0.902***
	(0.0237)	(0.0307)	(0.0311)	(0.0302)	(0.0353)
Constant	16.19***	13.02***	11.87**	12.55***	-11.39*
	(4.165)	(4.594)	(4.816)	(4.717)	(6.109)
Observations	6,174,735	6,174,735	6,174,735	6,174,735	6,174,735
Year FE	YES	YES	YES	YES	YES
U.S. PTA Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.486	0.503	0.514	0.520	0.563

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over the sample of HS6 products with values of the upstreamness index > 1.3. The LHS variable in all models is the $M^k_{j,t}$, the total value imported in Puerto Rico i from place of origin j of product k in year t. All models are estimated using the PPML estimator on Puerto Rico's import data pooled across years, HS6 digit products and places of origin, with year fixed effects included in the estimation. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation.

Table C2: Structural Estimates for Upstream Goods - Dominican Republic

VARIABLES	(1)	(2)	$M^k_{j,t}$ (3)	(4)	(5)
σ^k	-0.891***	-0.699***	-0.698***	-0.696***	-0.320
	(0.201)	(0.197)	(0.191)	(0.200)	(0.218)
$\sigma^k \times \ln(dist_j)$	0.311***	0.260***	0.261***	0.259***	0.158***
	(0.0508)	(0.0496)	(0.0485)	(0.0510)	(0.0553)
$\sigma^k \times HOME_j$	0.0294***	0.0366***	0.0377***	0.0453***	0.0557***
	(0.00315)	(0.00334)	(0.00464)	(0.00785)	(0.00896)
Vsh^k_t		0.611***	0.611***	0.440***	0.333**
		(0.136)	(0.149)	(0.154)	(0.155)
$\ln(WV^k)$		0.165***	0.156***	0.174***	0.241***
		(0.0249)	(0.0272)	(0.0381)	(0.0398)
$(\ln(WV^k))^2$		-0.00969*	-0.00288	-0.00713	0.00164
		(0.00519)	(0.00595)	(0.00873)	(0.00848)
$Ctnr^k_t$		-0.301***	-0.299***	-0.226	-0.190
		(0.103)	(0.105)	(0.147)	(0.154)
$\sigma^k \times Vsh^k_t \times HOME_j$			0.00177	-0.00778	-0.00823
			(0.00482)	(0.00987)	(0.0111)
$\sigma^k \times \ln(WV^k) \times HOME_j$			0.00276***	0.00430**	0.00643***
			(0.001000)	(0.00212)	(0.00240)
$\sigma^k \times (\ln(WV^k))^2 \times HOME_j$			-0.000570**	-0.000621*	-0.000348
			(0.000226)	(0.000356)	(0.000361)
$\sigma^k \times Ctnr^k_t \times HOME_j$			-0.000464	0.00613	0.00907
			(0.00583)	(0.00936)	(0.00971)
$\sigma^k \times Vsh^k_t \times \ln(dist_j)$				0.00168	0.00191
				(0.00132)	(0.00149)
$\sigma^k \times \ln(WV^k) \times \ln(dist_j)$				-0.000253	-0.000709**
				(0.000304)	(0.000346)
$\sigma^k \times (\ln(WV^k))^2 \times \ln(dist_j)$				2.87e-05	-2.73e-05
				(5.93e-05)	(6.16e-05)
$\sigma^k \times Ctnr^k_t \times \ln(dist_j)$				-0.00107	-0.00138
				(0.00126)	(0.00136)
$\sigma^k \times \ln(1 + tar^k_{j,t})$					0.0376
					(0.0255)
$\sigma^k \times (\ln(dist_j))^2$	-0.0253***	-0.0221***	-0.0222***	-0.0222***	-0.0157***
	(0.00317)	(0.00308)	(0.00304)	(0.00323)	(0.00348)
$IHST(\widetilde{X}^k_{j,t})$	0.876***	0.843***	0.843***	0.844***	0.856***
	(0.0152)	(0.0103)	(0.0103)	(0.0103)	(0.0105)
Constant	-3.928***	-3.195***	-3.215***	-3.075***	-3.209***
	(0.284)	(0.213)	(0.212)	(0.215)	(0.219)
Observations	7,585,952	7,585,952	7,585,952	7,585,952	7,449,838
Year FE	YES	YES	YES	YES	YES
PTA Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.600	0.616	0.617	0.617	0.623

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over the sample of HS6 products with values of the upstreamness index > 1.3. The LHS variable on all models is $M^k_{j,t}$, the total value imported in Dominican Republic i from place of origin j of product k in year t. All models are estimated using the PPML estimator on Dominican Republic's import data pooled across observations at the year, HS6 digit product, and place-of-origin level, with year fixed effects included in the estimation model. σ^k estimates from Fontagné et al. (2022) are interacted with geographic frictions, and enter separately in the regression itself. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation. Model (5) is estimated using fewer observations due to missing trade tariff data.

Table C3: Structural Estimates for Upstream Goods - Jamaica

			$M^k_{j,t}$		
VARIABLES	(1)	(2)	(3)	(4)	(5)
σ^k	-1.223***	-0.677***	-0.609***	-0.599**	-0.639***
	(0.232)	(0.213)	(0.215)	(0.243)	(0.242)
$\sigma^k \times \ln(dist_j)$	0.426***	0.272***	0.256***	0.261***	0.268***
	(0.0667)	(0.0587)	(0.0591)	(0.0658)	(0.0647)
$\sigma^k \times HOME_j$	-0.00501	0.0149**	0.0321***	0.0150	0.0188
	(0.00427)	(0.00618)	(0.00958)	(0.0136)	(0.0141)
Vsh^k_t		1.452***	1.534***	1.790***	1.730***
		(0.169)	(0.182)	(0.261)	(0.262)
$\ln(WV^k)$		0.257***	0.214***	0.370***	0.410***
		(0.0353)	(0.0401)	(0.0640)	(0.0639)
$(\ln(WV^k))^2$		0.00333	-0.00791	0.0214	0.0260
		(0.0108)	(0.0134)	(0.0231)	(0.0230)
$Ctnr^k_t$		-0.922***	-0.989***	-1.182***	-1.193***
		(0.135)	(0.138)	(0.208)	(0.209)
$\sigma^k \times Vsh^k_t \times HOME_j$			-0.0254***	-0.00358	-0.00658
			(0.00864)	(0.0185)	(0.0182)
$\sigma^k \times \ln(WV^k) \times HOME_j$			0.00749***	0.0145***	0.0150***
			(0.00222)	(0.00462)	(0.00485)
$\sigma^k \times (\ln(WV^k))^2 \times HOME_j$			0.00130***	0.00171	0.00162
			(0.000448)	(0.00140)	(0.00139)
$\sigma^k \times Ctnr^k_t \times HOME_j$			0.0166*	-0.00186	0.00206
			(0.00886)	(0.0166)	(0.0162)
$\sigma^k \times Vsh^k_t \times \ln(dist_j)$				-0.00384	-0.00332
				(0.00278)	(0.00279)
$\sigma^k \times \ln(WV^k) \times \ln(dist_j)$				-0.00165**	-0.00197**
				(0.000751)	(0.000781)
$\sigma^k \times (\ln(WV^k))^2 \times \ln(dist_j)$				-0.000165	-0.000183
				(0.000273)	(0.000272)
$\sigma^k \times Ctnr^k_t \times \ln(dist_j)$				0.00376	0.00340
				(0.00229)	(0.00230)
$\sigma^k \times \ln(1 + tar^k_{j,t})$					0.0736***
					(0.0268)
$\sigma^k \times (\ln(dist_j))^2$	-0.0347***	-0.0246***	-0.0236***	-0.0241***	-0.0246***
	(0.00481)	(0.00406)	(0.00407)	(0.00443)	(0.00430)
$IHST(\widetilde{X}^k_{j,t})$	0.969***	0.856***	0.856***	0.856***	0.862***
	(0.0388)	(0.0211)	(0.0209)	(0.0203)	(0.0202)
Constant	-6.563***	-4.446***	-4.494***	-4.581***	-4.646***
	(0.702)	(0.390)	(0.391)	(0.414)	(0.405)
Observations	5,068,176	5,068,176	5,068,176	5,068,176	5,031,660
Year FE	YES	YES	YES	YES	YES
PTA Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.581	0.612	0.612	0.616	0.620

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over the sample of HS6 products with values of the upstreamness index > 1.3. The LHS variable on all models is $M^k_{j,t}$, the total value imported in Jamaica i from place of origin j of product k in year t. All models are estimated using the PPML estimator on Jamaica's import data pooled across observations at the year, HS6 digit product, and place-of-origin level, with year fixed effects included in the estimation model. σ^k estimates from Fontagné et al. (2022) are interacted with geographic frictions, and enter separately in the regression itself. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation. Model (5) is estimated using fewer observations due to missing trade tariff data.

Table C4: Structural Estimates for Upstream Goods - Bahamas

			$M_{j,t}^k$		
VARIABLES	(1)	(2)	(3)	(4)	(5)
σ^k	0.146	0.0873	0.0562	-0.0174	0.143
	(0.143)	(0.129)	(0.134)	(0.119)	(0.125)
$\sigma^k \times \ln(dist_j)$	-0.0144	-0.0113	-0.00338	0.00155	-0.0275
	(0.0521)	(0.0483)	(0.0495)	(0.0446)	(0.0448)
$\sigma^k \times HOME_j$	0.0402*	0.0636**	0.181***	0.247***	0.231***
	(0.0234)	(0.0280)	(0.0341)	(0.0444)	(0.0430)
Vsh_t^k		6.798***	7.438***	6.109***	6.010***
		(0.880)	(0.871)	(0.832)	(0.852)
$\ln(WV^k)$		-1.077***	-1.167***	0.00318	0.321**
		(0.170)	(0.161)	(0.124)	(0.142)
$(\ln(WV^k))^2$		-0.0756***	-0.0644***	0.0780***	0.136***
		(0.0187)	(0.0159)	(0.0291)	(0.0328)
$Ctnr_t^k$		-4.365***	-4.682***	-3.241***	-2.925***
		(0.215)	(0.221)	(0.284)	(0.318)
$\sigma^k \times Vsh_t^k \times HOME_j$			-0.115***	-0.144***	-0.140***
			(0.0133)	(0.0261)	(0.0257)
$\sigma^k \times \ln(WV^k) \times HOME_j$			0.0275***	0.0894***	0.0884***
			(0.00286)	(0.0114)	(0.0135)
$\sigma^k \times (\ln(WV^k))^2 \times HOME_j$			-0.000678	0.00714***	0.00729**
			(0.000711)	(0.00232)	(0.00286)
$\sigma^k \times Ctnr_t^k \times HOME_j$			0.0603***	0.125***	0.158***
			(0.00719)	(0.0222)	(0.0259)
$\sigma^k \times Vsh_t^k \times \ln(dist_j)$				0.00802**	0.00577**
				(0.00315)	(0.00282)
$\sigma^k \times \ln(WV^k) \times \ln(dist_j)$				-0.0144***	-0.0190***
				(0.00227)	(0.00291)
$\sigma^k \times (\ln(WV^k))^2 \times \ln(dist_j)$				-0.00179***	-0.00267***
				(0.000443)	(0.000605)
$\sigma^k \times Ctnr_t^k \times \ln(dist_j)$				-0.0139***	-0.0178***
				(0.00454)	(0.00535)
$\sigma^k \times \ln(1 + tar_{j,t}^k)$					-0.179***
					(0.0253)
$\sigma^k \times (\ln(dist_j))^2$	-0.00111	-0.00120	-0.00194	-0.00328	-0.00147
	(0.00413)	(0.00386)	(0.00392)	(0.00345)	(0.00340)
$IHST(\widetilde{X}_{j,t}^k)$	1.139***	0.955***	0.963***	1.002***	0.963***
	(0.0328)	(0.0374)	(0.0375)	(0.0374)	(0.0360)
Constant	-10.54***	-11.31***	-11.97***	-11.12***	-10.18***
	(0.633)	(1.521)	(1.517)	(1.315)	(1.236)
Observations	2,660,650	2,660,650	2,660,650	2,660,650	2,629,262
Year FE	YES	YES	YES	YES	YES
Pseudo R2	0.511	0.600	0.612	0.632	0.640

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over the sample of HS6 products with values of the upstreamness index > 1.3. The LHS variable on all models is $M_{j,t}^k$, the total value imported in Bahamas i from place of origin j of product k in year t. All models are estimated using the PPML estimator on Bahamas's import data pooled across observations at the year, HS6 digit product, and place-of-origin level, with year fixed effects included in the estimation model. σ^k estimates from Fontagné et al. (2022) are interacted with geographic frictions, and enter separately in the regression itself. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation. Model (5) is estimated using fewer observations due to missing trade tariff data. Model (5) is also estimated without PTA dummy variables because the Bahamas has no PTAs in place.

Table C5: Reduced Form Estimates for Upstream Goods - Dominican Republic

			$M_{j,t}^k$		
VARIABLES	(1)	(2)	(3)	(4)	(5)
$\ln(dist_j)$	-6.878***	-7.317***	-7.394***	-7.631***	-8.676***
	(0.333)	(0.360)	(0.340)	(0.347)	(0.365)
$HOME_j$	0.412***	0.595***	1.431***	1.273***	0.631***
	(0.0650)	(0.0667)	(0.177)	(0.177)	(0.187)
Vsh_t^k		-0.0985	0.0277	-1.500	-5.822***
		(0.133)	(0.167)	(1.063)	(1.062)
$\ln(WV^k)$		0.0586**	-0.0867***	0.228	0.528***
		(0.0241)	(0.0303)	(0.207)	(0.193)
$(\ln(WV^k))^2$		-0.0316***	-0.0387***	-0.112***	-0.0624
		(0.00429)	(0.00553)	(0.0379)	(0.0384)
$Ctnr_t^k$		0.0927	0.231*	-0.482	1.851***
		(0.104)	(0.119)	(0.766)	(0.660)
$Vsh_t^k \times HOME_j$			-0.234	-0.0598	0.945***
			(0.240)	(0.244)	(0.247)
$\ln(WV^k) \times HOME_j$			0.325***	0.305***	0.238***
			(0.0456)	(0.0478)	(0.0488)
$(\ln(WV^k))^2 \times HOME_j$			0.0149*	0.0230***	0.0192**
			(0.00798)	(0.00844)	(0.00913)
$Ctnr_t^k \times HOME_j$			-0.531***	-0.555***	-0.788***
			(0.186)	(0.192)	(0.192)
$Vsh_t^k \times \ln(dist_j)$				0.176	0.672***
				(0.126)	(0.128)
$\ln(WV^k) \times \ln(dist_j)$				-0.0378	-0.0690***
				(0.0240)	(0.0228)
$(\ln(WV^k))^2 \times \ln(dist_j)$				0.00836*	0.00288
				(0.00434)	(0.00475)
$Ctnr_t^k \times \ln(dist_j)$				0.0918	-0.170**
				(0.0886)	(0.0785)
$\ln(1 + tar_{i,t}^k)$					0.778***
					(0.213)
$(\ln(dist_j))^2$	0.315***	0.345***	0.345***	0.343***	0.394***
	(0.0210)	(0.0224)	(0.0211)	(0.0215)	(0.0231)
$IHST(\widetilde{X}_{j,t}^k)$	0.893***	0.898***	0.904***	0.900***	0.906***
	(0.0104)	(0.0104)	(0.00951)	(0.00977)	(0.00885)
Constant	30.42***	32.13***	32.32***	34.55***	39.49***
	(1.327)	(1.397)	(1.322)	(1.477)	(1.535)
Observations	8,056,785	8,056,785	8,056,785	8,056,785	7,697,019
Year FE	YES	YES	YES	YES	YES
PTA Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.668	0.680	0.684	0.685	0.669

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over the sample of HS6 products with values of the upstreamness index $>$ 1.3. The LHS variable in all models is the $M_{j,t}^k$, the total value imported in Dominican Republic i from place of origin j of product k in year t. All models are estimated using the PPML estimator on Dominican Republic's import data pooled across years, HS6 digit products and places of origin, with year fixed effects included in the estimation. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation. Model (5) is estimated using fewer observations due to missing trade tariff data.

Table C6: Reduced Form Estimates for Upstream Goods - Jamaica

			$M_{j,t}^k$		
VARIABLES	(1)	(2)	(3)	(4)	(5)
$\ln(dist_j)$	-2.896***	-3.978***	-4.282***	-4.321***	-8.919***
	(0.772)	(0.848)	(0.895)	(0.924)	(0.567)
$HOME_j$	-0.338***	0.0133	1.807***	1.750***	-0.0994
	(0.122)	(0.123)	(0.244)	(0.236)	(0.222)
Vsh_t^k		0.357*	1.050***	3.868***	-1.335
		(0.186)	(0.224)	(1.180)	(1.294)
$\ln(WV^k)$		0.110***	-0.113**	-0.778***	-0.267
		(0.0389)	(0.0516)	(0.272)	(0.280)
$(\ln(WV^k))^2$		-0.0375***	-0.0662***	-0.308***	-0.245***
		(0.00765)	(0.0125)	(0.0670)	(0.0800)
$Ctnr_t^k$		-0.637***	-0.625***	-6.009***	-4.056***
		(0.153)	(0.212)	(0.803)	(1.071)
$Vsh_t^k \times HOME_j$			-1.631***	-1.604***	0.673**
			(0.365)	(0.359)	(0.334)
$\ln(WV^k) \times HOME_j$			0.538***	0.543***	0.439***
			(0.0681)	(0.0668)	(0.0671)
$(\ln(WV^k))^2 \times HOME_j$			0.0615***	0.0758***	0.0989***
			(0.0153)	(0.0137)	(0.0171)
$Ctnr_t^k \times HOME_j$			-0.180	-0.0219	-0.417
			(0.317)	(0.317)	(0.315)
$Vsh_t^k \times \ln(dist_j)$				-0.370**	0.213
				(0.145)	(0.162)
$\ln(WV^k) \times \ln(dist_j)$				0.0854***	0.0294
				(0.0324)	(0.0343)
$(\ln(WV^k))^2 \times \ln(dist_j)$				0.0299***	0.0216**
				(0.00792)	(0.0100)
$Ctnr_t^k \times \ln(dist_j)$				0.683***	0.485***
				(0.0889)	(0.127)
$\ln(1 + tar_{i,t}^k)$					0.868***
					(0.295)
$(\ln(dist_j))^2$	0.0575	0.131**	0.147***	0.149***	0.403***
	(0.0499)	(0.0540)	(0.0566)	(0.0573)	(0.0340)
$IHST(\widetilde{X}_{j,t}^k)$	0.962***	0.895***	0.899***	0.896***	0.916***
	(0.0201)	(0.0147)	(0.0156)	(0.0151)	(0.0173)
Constant	12.86***	18.36***	18.98***	19.31***	39.39***
	(3.067)	(3.205)	(3.386)	(3.639)	(2.436)
Observations	5,388,048	5,388,048	5,388,048	5,388,048	5,132,436
Year FE	YES	YES	YES	YES	YES
PTA Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.649	0.670	0.675	0.678	0.674

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over the sample of HS6 products with values of the upstreamness index > 1.3. The LHS variable in all models is the $M_{j,t}^k$, the total value imported in Jamaica i from place of origin j of product k in year t. All models are estimated using the PPML estimator on Jamaica's import data pooled across years, HS6 digit products and places of origin, with year fixed effects included in the estimation. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation. Model (5) is estimated using fewer observations due to missing trade tariff data.

Table C7: Reduced Form Estimates for Upstream Goods - Bahamas

			$M^k_{j,t}$		
VARIABLES	(1)	(2)	(3)	(4)	(5)
$\ln(dist_j)$	-2.806***	-4.769***	-5.767***	-5.326***	-5.256***
	(0.701)	(0.717)	(0.723)	(0.661)	(0.563)
$HOME_j$	0.409	0.699**	7.943***	6.865***	5.794***
	(0.283)	(0.318)	(1.383)	(1.399)	(1.548)
Vsh^k_t		6.574***	8.039***	3.425	-0.813
		(0.963)	(1.134)	(3.272)	(3.591)
$\ln(WV^k)$		-1.212***	-1.563***	3.344***	4.409***
		(0.184)	(0.152)	(0.589)	(0.619)
$(\ln(WV^k))^2$		-0.149***	-0.124***	0.543***	0.578***
		(0.0374)	(0.0301)	(0.129)	(0.140)
$Ctnr^k_t$		-4.276***	-4.818***	6.793***	8.392***
		(0.198)	(0.221)	(1.254)	(1.358)
$Vsh^k_t \times HOME_j$			-7.420***	-5.743***	-4.417***
			(1.360)	(1.320)	(1.459)
$\ln(WV^k) \times HOME_j$			1.654***	-0.0591	-0.281
			(0.169)	(0.189)	(0.229)
$(\ln(WV^k))^2 \times HOME_j$			-0.0290	-0.247***	-0.262***
			(0.0380)	(0.0346)	(0.0417)
$Ctnr^k_t \times HOME_j$			2.533***	-1.502***	-2.018***
			(0.301)	(0.442)	(0.478)
$Vsh^k_t \times \ln(dist_j)$				0.456	0.888*
				(0.435)	(0.465)
$\ln(WV^k) \times \ln(dist_j)$				-0.539***	-0.694***
				(0.0772)	(0.0772)
$(\ln(WV^k))^2 \times \ln(dist_j)$				-0.0748***	-0.0815***
				(0.0180)	(0.0191)
$Ctnr^k_t \times \ln(dist_j)$				-1.272***	-1.432***
				(0.147)	(0.159)
$\ln(1 + tar^k_{i,t})$					-1.401***
					(0.398)
$(\ln(dist_j))^2$	0.131**	0.257***	0.306***	0.260***	0.218***
	(0.0527)	(0.0540)	(0.0546)	(0.0589)	(0.0462)
$IHST(\widetilde{X}^k_{j,t})$	1.175***	1.027***	1.082***	1.082***	1.084***
	(0.0292)	(0.0367)	(0.0317)	(0.0311)	(0.0376)
Constant	2.391	8.098***	10.07***	10.30***	12.93***
	(2.111)	(2.198)	(2.386)	(2.630)	(3.096)
Observations	2,755,385	2,755,385	2,755,385	2,755,385	2,651,571
Year FE	YES	YES	YES	YES	YES
Pseudo R2	0.588	0.683	0.711	0.715	0.723

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Estimates over the sample of HS6 products with values of the upstreamness index > 1.3. The LHS variable in all models is the $M^k_{j,t}$, the total value imported in Bahamas i from place of origin j of product k in year t. All models are estimated using the PPML estimator on Bahamas's import data pooled across years, HS6 digit products and places of origin, with year fixed effects included in the estimation. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation. Model (5) is estimated using fewer observations due to missing trade tariff data. Model (5) is also estimated without PTA dummy variables because the Bahamas has no PTAs in place.

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