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

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Abstract

We estimate the economic burden placed on Puerto Rico (PR) by the "Jones Act," a United States (US) law that protects the domestic maritime shipping market from foreign competition. We show that the supply of freight shipping to PR that satisfies Jones Act (JA) requirements lacks capacity for hauling general cargo and bulk commodities. The absence of such ships makes it likely that the costs the law imposes on sea-shipped freight are magnified for products that are physically heavy and/or bulky. We outline a theory that proposes different trade responses for final and upstream products, and estimate an empirical model that allows the effects of the JA to differ across the two product classes. Among final goods, we find evidence that PR buyers substitute away from US sources among products that are a) sea-shipped, b) physically heavy, and c) not typically shipped in containers. Among upstream products, we observe large relative reductions in sea-shipped imports from all sources, rather than differential reductions from US sources, an outcome that is consistent with the policy having influenced PR's industrial mix in the long run. In order to put the results in context, we estimate structural JA trade costs for final products, and calculate a (static) burden on household spending of about \$203 (1.2%) per person per year. Dynamic costs of the policy are more difficult to quantify, but we uncover two pieces of evidence that point towards much larger (dynamic) losses: the strong bias against sea-shipped imports of upstream products, and high implied costs on purchases of final products used for investment in PR.

Keywords: Maritime Shipping, Cabotage, Jones Act, Gravity Model, Puerto Rico
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1 Introduction

The *US Merchant Marine Act of 1920* (the Jones Act) requires that maritime vessels moving goods from one United States (US) port to another must be US-built, US-owned and US-operated.[1] This protectionist policy raises the cost of intra-national maritime shipping in the US, and imposes a disproportionate burden on residents of US 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 US outlying areas. In this paper we estimate the economic effects of the Jones Act (JA) on Puerto Rico (PR), an island territory of the United States.[2]

We begin our investigation with an exploration of 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 JA ships with others that call in PR, and with ships calling elsewhere in the Caribbean. This exercise reveals a striking pattern; the JA fleet serving PR contains no ships designed solely for the purpose of moving general cargo or bulk commodities. A small number of JA-compliant barges carry these kinds of freight, but larger-capacity general cargo / bulk shipping used elsewhere in the Caribbean is missing from this segment of the US cabotage market. Most waterborne trade between PR and the US mainland is carried by container ships dedicated to serving the US-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.

A maintained hypothesis in what follows is that the JA is responsible for the absence of bulk, general cargo and tanker capacity serving US-PR routes. We briefly describe the mechanism here. Brancaccio et al. (2020) explain that ships of the kind we find missing on US-PR routes typically act in world freight markets as taxis do in urban transportation; after unloading in one destination

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[1] Specifically, the Jones Act requires that every vessel serving any US domestic route must be (1) at least 75% owned by US citizens; (2) built in the US; (3) crewed by US citizens or permanent residents; and (4) registered in the US (Jones, 1921). At least 75% of the crew should be US citizens, and all of its officers and engineers (Beason et al. (2015), cited in Olney (2020)).

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

they search 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. The opportunity costs of search time for high-cost US-built ships would be high, even as the limited number of solely domestic routes available would increase the length of their search times. These features of the market reduce JA-compliant shipping companies' purchases of ships of the kind we find missing. JA-compliant ships are more likely to be economically viable on fixed routes that allow US-owned shipping companies to use the rents they accrue from JA protection to offset the higher costs of purchasing US-built ships. Since PR is not involved in the production of primary commodities or their processing, its needs would best be served by taxi-like providers of bulk, general cargo and tanker shipping that is cost competitive on foreign routes.[3] Our data shows that foreign (built and owned) ships of these types do arrive at PR ports, but JA-compliant ships that are allowed to deliver cargo either to or from US mainland ports are missing.[4] These fleet composition effects 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 their freight charges to the physical weight of the products they transport.[5]

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 US mainland sources in products that are 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. Substitution effects are possible, as with final products, but trade in upstream products may also be reduced through the "production

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[3] There are JA-compliant tanker, bulk and general cargo ships active in US waters, but these appear to participate primarily on high volume back-and-forth routes. A November 2023 review of US-flagged vessels built after 2014 on `vesselfinder.com` identifies several oil/chemical tankers working in the Gulf of Mexico, and others linking the US west coast either to Alaska or to Hawaii and then sometimes Guam (some ships that serve Guam also stop in Asian ports). A large US-flagged bulk ship of recent vintage is active in the Great Lakes region. One general cargo vessel appeared to be serving a back-and-forth route between Hawaii and the US West Coast.

[4] The US government's waiver of JA restrictions on a single non-JA compliant tanker that delivered 300,000 barrels of diesel fuel to PR after Hurricane Fiona in September of 2022 is probably indicative of the particularly high burden the JA imposes on bulk shipments. The most feasible large supplier of diesel fuel on short notice was the US, but there were no JA-compliant ships available to deliver it. See Page and Restuccia (2022) for a description of this particular episode.

[5] 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.

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 further processing in PR choose not to locate in PR at all. The consequence may be reduced levels of *total* import demand among sea-shipped products, rather than mere substitution away from products shipped from US mainland sources.

Our primary tool of analysis is a pooled product-level gravity model that we use 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 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 US import data (net of flows from Canada and Mexico). In our sample of final goods imports, we find evidence consistent with the hypothesis that PR's home bias towards imports coming from the US 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 US sources is much less apparent; instead we find that 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 made PR less viable as a participant in regional supply chains involving sea-shipped goods, though other policies may have also affected the overall composition of PR's import demand.

Since we are estimating 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 we apply to PR to the imports of three comparison countries in the Caribbean: the Dominican Republic (DOM), Jamaica (JAM) and the Bahamas (BHS). The patterns we uncover in PR do not appear in these other countries; lending credence to the view that the effects we observe for PR are due to the JA, rather than to other anomalies in US-Caribbean trade.

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[6] We focus on imports because most of the vessel freight between the US and PR travels in the direction of PR. The container ships that work the route return to the US mainland with less than full loads and, anecdotally, much lower shipping charges. The unavailability of general cargo/bulk freight may also affect PR's exports to the US, but given PR's industrial mix this does not seem likely to be a quantitatively important problem (in a static sense, at least).

In order to provide quantitative context for our estimates, we incorporate external estimates of the elasticity of substitution to estimate product-level tariff-equivalent JA trade costs in final demand, and conduct a compensating variation (CV) calculation of removing these tariff-equivalent costs. Our preferred specification produces an average tariff equivalent of the JA of 30.6 percent among final products. Our CV calculation suggests an associated (static) annual welfare burden of the policy of $1.4 billion (in 2016 dollars). Focusing on household consumption alone, the estimates suggest a burden of 1.2 percent of expenditure, or $203 per citizen per year.

Our estimates of missing trade in JA-affected products among upstream goods are much more difficult to attribute directly to the JA, but are potentially much more important because they suggest important dynamic effects of the policy. Our results suggest that one of the policy's long-run effects has been to make unviable in PR industries that would otherwise use sea-shipped products as imported inputs. PR's imports of sea-shipped upstream products are approximately 77% lower than otherwise equivalent air-shipped products. Similar calculations for DOM, JAM and BHS finds no bias against JA-affected products in upstream import demand. Indeed, these islands' import demand for upstream products appears to be biased *towards* those that are sea-shipped. 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 there is little evidence of additional bias against US sources of such imports. We therefore refrain from including in our welfare estimates the effects we observe among upstream products. If even a fraction of the effects we estimate are in fact due to the JA, the policy would have imposed quite sizable dynamic costs on PR's long-run development.[7]

There is a relatively small academic literature on the JA. The paper that is closest to ours is Olney (2020), who shows evidence of substitution away from waterborne shipping among data on shipments arriving in US coastal states. Our econometric exercise is similar, but with a few key differences. First, we focus on PR (an island) rather than coastal US states, and use data on Puerto Rican imports rather than freight movements destined for US mainland ports.[8] Our

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[7] Yet another potential source of dynamic losses from the JA are higher costs of investment expenditures that arise from purchasing final products. Our CV calculations for final products purchased for the purpose of investment indicate that removing the JA would be equivalent to reducing the cost of investment in PR by 3.0 percent.

[8] Throughout the paper we will refer to shipments arriving to PR from the US as "imports." We will distinguish imports by their origin: US or rest of the world.

focus on Puerto Rican trade means that only two modes of transport are relevant in our data (air and sea), while Olney's data contain possibilities for easier substitution towards rail and road transport. We measure product characteristics (e.g. how likely is a shipment to move by sea?) in US import data (ex PR), while Olney uses the transport mode of the arriving shipment to make inferences similar to ours. Since mode choice is endogenous to the presence of the JA, including the transport mode choice on the right hand side introduces a potential endogeneity problem. Unlike Olney, we estimate a structural parameter, the tariff-equivalent cost of JA restrictions that explains the 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 unsuited for container shipping for other reasons (such as size or shape). We combine this information with evidence on Puerto Rican expenditure patterns to calculate the implied burden of the JA on PR. Our evidence that the composition of PR's imports of upstream products is strongly biased against sea-shipped products from all sources is different than the substitution away from US-sourced products that Olney estimates in his sample of all products. These are different samples, but the different results may also be a result of PR's island status making industry location decisions there more sensitive to elevated costs of sea-shipping than they would be in the collection of US coastal states that Olney studies.

Francois et al. (1996) use a computable general equilibrium (CGE) model of the entire US to measure the equivalent variation of removing the JA for the US economy as a whole. These authors calculate that the welfare cost of the JA to the US economy was approximately $3 billion in 1989.[9] 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.[10] Our CV calculations thus consider only distortions to purchases

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[9] Estimates using this methodology also appear in USITC (1991, 1993, 1999, 2002). The estimated burden of the JA fell over time in these exercises, largely because the demand for intra-national waterborne freight movements in the US appeared to fall. PR was not considered part of the US economy in the CGE studies cited here.

[10] 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 the industrial mix allowed for greater participation in US/regional supply chains.

by final demand, and rely solely on an expenditure/cost function.[11]

There is also a consulting and/or policy literature on the JA.[12] The most relevant of these studies 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, showing that the vast majority of US-PR maritime trade travels by container ship. The John Dunham & Associates (2019) study estimates the cost differential for shipping products to PR on US and foreign routes using two different products over 10 different routes. These excess freight cost margins are imposed on every sector of the PR economy, and the effects of the JA on output, jobs and wages calculated in an input-output model. Instead, we exploit product-level variation in goods' physical weight, dependence on ocean-shipping and on container ships to measure the degree to which PR importers substitute away from US products that rely on non-containerized freight (such as general cargo and bulk ships). We allow economic responses to trade costs to differ across final and upstream products. Among final products, we estimate structural parameters and calculate tariff-equivalent costs of the JA. Rather than an input-output framework, we employ a CV exercise to calculate the burden that the policy imposes on final demand.

The remainder of the paper is organized as follows. Section 2 briefly reviews the unusual features of the Puerto Rican economy that are relevant to the exercise. Section 3 describes the data. Section 4 summarizes data on ship arrivals in the Caribbean, and compares characteristics of the JA fleet to other suppliers of freight services on Caribbean routes. Section 5 describes the theoretical framework and empirical estimation approach. In section 6 we report estimation results. Section 7 performs welfare calculations for the distortions we estimate among final products. Section 8 concludes.

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[11] Protectionist measures like the JA also generate rents for domestic suppliers (US shipbuilders, owners of US ships, and US crews). Our calculations assume that these benefits accrue to residents of the US mainland, not to Puerto Ricans.

[12] See e.g., FED-NY (2012), GAO (1988, 2013), Grennes (2017), Kashian et al. (2017), Advantage Business Consulting (2019) and John Dunham & Associates (2019). There is also a Spanish language literature discussing the burden the JA puts on PR (e.g. Herrero-Rodríguez et al. (2003) and Valentin-Mari and Alameda-Lozada (2012)). Herrero-Rodríguez et al. (2003) reviews this literature and points to important early Spanish-language studies of the JA, including Pesquera (1965) and Quinonez-Dominguez (1990).

2 Structure of the Puerto Rican Economy

The effects of US sovereignty on the Puerto Rican economy are wide-ranging and important.[13] Separating the consequences of the JA from those of US sovereignty more broadly is thus a challenge. In this section we offer a brief description of the Puerto Rican economy, focusing on a particular US policy that complicates measurement of the JA's long-run consequences.

Table 1 reports the gross output and employment shares of various sectors of the Puerto Rican economy. Manufacturing is a dominant sector, accounting for 45.2 percent of gross output and 11.8 percent of employment.[14] Table 2 disaggregates the data on manufacturing activity. Pharmaceuticals and related manufacturing account for 64.6 percent of the manufacturing sector's gross output in PR, and 17.7 percent of its employment.[15]

The outsized importance of the pharmaceutical sector may be *partially* attributable to the JA. It is likely that both the sector's inputs and outputs have low weight-to-value ratios that make air shipping cost-effective. But a far more important reason for the sector's outsize importance is a legacy of tax exemptions given to firms located in PR. The "Possession Tax Credit" - commonly known as Section 936 - offered qualifying firms a US federal tax credit equal to their total US tax liability.[16] The tax credit was especially advantageous for firms with intangible assets (such as patents).[17] While Section 936 was phased out by 2006, the continuing importance of the pharmaceutical sector is evidence that PR's existing industrial structure remains a legacy of Section 936. This matters for our study, for at least two reasons. First, a large share of PR's trade occurs in pharmaceuticals (20.9 percent of imports and 74.0 percent of exports). Second, the composition of demand for imports of upstream products is driven by the composition of downstream output. The large skew of manufacturing towards pharmaceutical products (and other goods affected by Section 936) makes it difficult to observe effects of the JA on trade in intermediates. We exclude

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[13] For example, Marein (2020) finds that the average height of Puerto Rican males rose by 4.2 cm relative to their counterparts in the Caribbean during a 50-year period following US annexation.

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

[15] While there appear to be no published data on the value added by the Puerto Rican Pharmaceuticals and Related Manufacturing sector itself, the sector does account 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 manufacturing.

[16] For a fuller discussion of Section 936, see GAO (1993).

[17] See Feliciano and Chen (2021), who study the effects of the ending of Section 936 on Puerto Rican manufacturing.

trade in pharmaceutical products from our regressions in order to avoid attributing to the JA the lingering effects of Section 936 on input trade.

3 Data

We exploit three main sources of data. Comprehensive data on ship ports-of-call in the Caribbean help us to understand the relative supply of different types of JA and other shipping. We also estimate an empirical gravity model using data on PR's imports – from both foreign and US mainland sources. 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 Lloyd's List Intelligence (LLI). This is a commercial firm that provides these data to support "decisions in compliance, risk management, and operations."[18] The only other academic use of these data of which we are aware is Taylor (2021), who studies the impact of large oceangoing vessels on the reproduction rates of Southern Right Killer Wales. We report summary statistics from these data to guide and motivate our subsequent analysis of Puerto Rican import data.

The data offer comprehensive information on ports of call by freight hauling vessels in the Caribbean during the years 2004-2020. Each observation in the database 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 important characteristics of the 16,188 freight-hauling vessels in our database. The following information is available for nearly every vessel: the vessel identification number, vessel type (bulk, containership, tanker, etc.), flag of registry, year and place of build, the vessel's owner, and its dead-weight tonnage (DWT).[19]

We use these data in two ways. First, the vessel characteristics data report information on the place-

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[18] `https://www.lloydslistintelligence.com/`

[19] Some records do not contain DWT. Out of the total 16,188 vessels in the sample serving the Caribbean during 2004-2020, LLI data do not report the DWT of 202 vessels.

of-build, flag-of-registry and ownership, which allows us to identify ships that are JA compliant.[20] Second, we combine the vessel characteristics and the port-of-call data sets 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 fleet that calls in PR and the fleet that calls in other Caribbean ports.

3.2 Puerto Rican import data

The empirical gravity model that we estimate relies on data documenting flows of imports into PR. These data are provided by the Instituto de Estadísticas de Puerto Rico (IEPR) for 2010-2017.[21] The IEPR constructs this data set by joining two data sets released by the US Census: (1) US merchandise trade imports; and (2) trade with US Possessions. The resulting data set reports information for monthly imports to PR disaggregated by HS10-digit product code, origin country (for foreign imports) and US customs district (for US-origin shipments).[22] The data report the value of imports (defined in FOB terms) and imported quantities (measured in kg.).[23]

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 US customs district to the port of San Juan.[24] 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. The export supply measures are calculated using the BACI data for non-US origins and US export data for US origins.

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[20] Because tracking changes in ownership over time is somewhat onerous, we screen first for US-built and US-flagged ships. We then check by hand to verify that the firms that own the ships we initially identified are located in the US. The JA also requires domestic crewing. Our data lack comprehensive data on the crews. We assume for these calculations that the ships arriving in PR that meet observable JA requirements are also US-crewed. This assumption only affects our initial summary statistics; it is irrelevant to our main results.

[21] We retrieved the data from `https://datos.estadisticas.pr/dataset/comercio-externo/resource/b4d10e3d-0924-498c-9c0d-81f00c958ca6`

[22] 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.

[23] The data do not report port of destination in PR, so for the purpose of calculating shipping distances we make a working assumption that all seaborne freight traffic goes through San Juan. Our port-of-call data from LLI shows this to be imperfect, but quite reasonable.

[24] We retrieve the GPS coordinates from `https://simplemaps.com/data/world-cities`

Our analysis also relies on product characteristics. In particular, we exploit cross-product variation 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 US import data so that they are exogenous to the flows we observe involving PR.[25] All US export and import data files were retrieved from Peter Schott's web page.[26] We estimate the model separately over subdivisions of final and upstream goods. 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.[27]

Our gravity regressions also include trade policy measures that enter as control variables: a) the US statutory MFN tariff rate taken from USITC (2018), and b) dummy variables indicating countries that are members of a preferential trade agreement (PTA) with the US.[28] Finally, we include in the regressions (as data) product-level elasticities of substitution estimated in Fontagné et al. (2022). The inclusion of these elasticities in the estimation allows us to interpret the regression coefficients we estimate as directly informative of tariff-equivalent trade costs.

3.3 Puerto Rico's Production Structure

Calculation of the welfare costs of the JA requires information that is more comprehensive than what we have available in the trade flow data. A critical element for such calculations is data on PR's purchases of its own output, data 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 US sources). The IO table was produced by the Junta de

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[25] We exclude imports from Canada and Mexico in these calculations so the US 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 US import shipments.

[26] `https://sompks4.github.io/sub_data.html`. All dollar values are deflated by the US consumer price index and expressed in 2019 dollars.

[27] We specifically use Revision 4 of the BEC classification and the conversion from HS2017 produced by United Nations (2022).

[28] We take the list of US PTAs from the US Trade Representative web site: `https://ustr.gov/trade-agreements/free-trade-agreements`.

Planificación de Puerto Rico for the years 2006-2007.[29] This table reports final demand for every sector in PR's economy at the 4-digit NAICS code level. It also disaggregates final demand into several components: consumption, investment, exports, and government expenditures. The table also reports - for every purchasing NAICS code including final demands - expenditures on local production and on imported products, respectively. We match the trade data to the NAICS codes, and calculate US and rest of world (ROW) shares of imports for each NAICS code. This exercise allows us to calculate expenditure shares on purchases from PR, the US and ROW for each NAICS code.

4 Stylized Facts

In order to better understand the characteristics of the supply of JA-compliant shipping, we use the LLI port-of-call data to describe the supply of ocean shipping in the Caribbean. We first use data on vessel characteristics to identify the vessels that satisfy JA regulations. We compare the observed supply of JA-compliant shipping services to other ships that call in PR and to ships calling in other Caribbean ports. Finally, we use PR's import data to describe mode choices across source countries and across aggregations of up- and down-stream products.

4.1 Type of vessels serving in the Caribbean

In 2019, 3,155 freight-hauling vessels made a port of call somewhere in the Caribbean (See Panel A in Table 3).[30] Tankers accounted for 37.9 percent of these vessels, followed by bulk ships (21.5 percent), container ships (17.0), and general cargo ships (14.7).[31] Tankers and bulk ships provided most of the shipping capacity (70.6 percent of the total offered Deadweight Tonnage (DWT)). Container and general cargo ships made more frequent ports of call in the Caribbean, accounting for 51.2 percent of the total, compared to 30.8 percent for tankers and bulk carriers.

The type of vessels serving PR in 2019 were similar to those serving the broader Caribbean. In 2019,

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[29] The Puerto Rican government has been under severe financial stress in recent decades, limiting its ability to produce economic statistics in 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. The dated nature of the IO table is a limitation.

[30] The Caribbean in our sample includes all territories geographically located in the Caribbean sea in a (roughly rectangular) area contained by The Bahamas, Cayman Islands, Trinidad and Tobago and Montserrat.

[31] We use the year 2019 as the benchmark year instead of 2020 (the latest in the sample), because the global COVID-19 pandemic very likely affected market outcomes in 2020.

363 vessels arrived in PR, accounting for approximately 11.5 percent of the vessels active in the Caribbean market (See Panel B in Table 3). Tankers accounted for 52.1 percent of the vessels calling in PR, followed by container ships (13.8 percent), bulk ships (13.2), and general cargo ships (11.3). Tankers and bulk ships also supplied most of the shipping capacity (73.8 percent of DWT). However, container ships arrived relatively more frequently in PR than in the broader Caribbean, making 41.7 percent of the port calls on the island.

In order to distinguish JA-compliant ships from others serving PR, we use the LLI data to identify vessels that were (1) built in the US; (2) US flagged and (3) US owned. Only 9 vessels that called in PR in 2019 satisfied these conditions (See Panel C in Table 3). The types of JA vessels serving PR were very different from others calling in PR, and from vessels operating in the broader Caribbean. Container ships accounted for 82.1 percent of the ports of call that JA vessels made in PR, and 80.8 percent of the reported DWT.[32]

The most notable fact about the JA fleet for our analysis is that the fleet of JA-compliant ships serving PR contain no bulk ships, tankers or general cargo vessels. JA-compliant barges carry bulk freight and general cargo, but there are no larger-capacity bulk or general cargo ships serving the US-PR market, even though such ships play an important role in Caribbean and PR shipping more broadly. This fact motivates our subsequent exercises involving the gravity model of trade.

4.2 Composition of Puerto Rico's Imports

Our primary tool of analysis is a gravity model of trade that pools across products. Before turning to this model, we report some aggregate statistics that inform the overall composition of PR's imports. We divide the data by origin (US vs. rest of world (ROW)) and mode of transport (Air vs Sea). We also separate products based on their position in vertical supply chains, using the 'Upstreamness' index proposed by Antràs et al. (2012). We classify products with an upstreamness index of 1.3 or less as final goods, since these products are primarily purchased by final demand. Products with an upstreamness index greater than 1.3 are considered upstream goods that are frequently purchased for further processing. We distinguish between final and upstream goods because product-level expenditures on upstream goods are highly sensitive to the industrial structure of the destination,

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[32] One JA barge lacked data on DWT, so these figures overstate somewhat the share of containers in DWT calling in PR.

and because PR's industrial structure is idiosyncratic among US regions and among Caribbean islands.

Table 4 shows the value and share of PR's imports in 2016 by stage of production, by mode of transportation, and by the shipments' origin. Upstream products account for 86.7 percent of PR's total import value. 56.6 percent of PR's import value moved by oceangoing vessel. The US share in PR's total import value is 48.8 percent. 71.1 percent of PR's imports from the US are shipped by sea, as are 42.8 percent of imports from the ROW. 90 percent of final product imports move by sea, but only 51.5 percent of upstream products. Finally, the US accounts for 80.9 percent of PR's final goods imports, but only 43.8 percent of upstream imports.

There are two takeaways from the data description exercises. First, PR's imports of final products are highly dependent on JA shipping. The US supplies most of PR's final imports, and final products are heavily dependent on maritime shipping. Second, inputs into production are much more likely to be shipped by air than are final products. The JA may be partially responsible for this outcome.

5 Theory

The theoretical framework we use to motivate our empirical work is an extended version of Krugman and Venables (1996). The model's prediction for trade in final goods is similar to those of conventional theories that predict the gravity model of trade. Among final goods trade costs induce substitution among imported varieties. Among upstream products, the model allows for substitution of this kind, but also allows trade to respond to trade costs through a channel involving firm location choices. Hillberry and Hummels (2002) propose 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 US freight movements. The implications of production location effects in PR are somewhat different than in the US mainland. In this setting, artificially high trade costs with an important supplier may lead industries to avoid locating in PR altogether. One implication of such changes would be changes in the demand for PR's import demand for upstream products.

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. The reader is referred to Hillberry and Hummels (2002) for more detailed discussion of the links between Krugman and Venables (1996) and the bilateral trade prediction. One modification we make is that we separate products k into two categories - final and upstream - rather than assuming that products serve both functions, as Krugman and Venables (1996) do.

We begin by characterizing consumers' demand for final products. The representative agent in PR has the following utility function U over products $k \in F$, where F is the set of final goods:

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

where 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.[33]

Maximizing (1) subject to PR's household income, Y, returns a conventional gravity model 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 Dixit-Stiglitz price index for good k in PR, defined as:

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

Under the common assumption that α^k is fixed, expenditure for final goods will be proportional to destination-region GDP, and therefore not endogenous to trade costs. Among final goods, the only

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

behavioral response to τ_j^k is substitution across sources of k.[34]

Among upstream products, the expenditure on a given 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 Z^s. The cost function for purchasing a unit of Z^s follows:

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

where w is the price of the productive factor(s) in PR, μ_L^s is the cost share of productive factor(s), K^s the set of upstream input products used in production of sector s output, $\widetilde{P}^k$ again the conventional CES price index of k in PR, and μ^{ks} the Cobb-Douglas share of product k in sector s production. The μ parameters 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 Z^s to produce q^s according to:

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

where a_0^s and a_1^s are the fixed and marginal input requirements, respectively. A key point for what follows are the participation constraints associated with the monopolistic competition model.[35] Firms in PR will choose to produce no output ($q^s = 0$) if

$$c(Z^s) > p^s \frac{\sigma^s - 1}{\sigma^s}. \tag{6}$$

Similarly, an entry condition determines that there will be no active firms in the industry ($n_s = 0$) if firm revenues are insufficient to cover the fixed costs of entry:

$$a_0^s c(Z^s) > \frac{p_s q_s}{a_1^s \sigma^s}. \tag{7}$$

The relationships in (3),(4), (6) and (7) demonstrate how trade costs on inputs can affect the industrial structure of a region. If a given location j (e.g. the US mainland) hosts a large number

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[34] 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 (measured in F.O.B. prices) 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.

[35] The following inequalities replicate those in Balistreri and Rutherford (2013), who demonstrate a mixed complementarity method for computing monopolistic competition models of trade. That formulation generates the inequalities we use here.

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 $c(Z^s)$ will be high, leading gross output in sector s ($X^s = n^s q^s p^s$) to be low, possibly even zero. In this way, PR becomes an unsuitable location for sector s if it would otherwise purchase high-cost inputs from the US. 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.[36]

The bilateral trade prediction for upstream goods takes the form:

$$\left(M_j^k/\tau_j^k\right)|_{k\in V} = n_j^k \times p_j^k \times q_j^k = n_j^k \left(\frac{p_j^k}{\widetilde{P}^k}\right)^{1-\sigma^k} (\tau_j^k)^{-\sigma^k} \sum_s \mu^{ks} X^s. \tag{8}$$

where V is the set of upstream products. Variation in τ_j^k affects bilateral trade through substitution according to $-\sigma^k$, but also through its effects on X^s through (6) and (7).

5.2 Modeling JA trade costs

Our first empirical exercises focus on final products, under the assumption that production location effects are not important for interpreting the pattern of trade in final products. In this exercise, the focus of our interest shall be the form of the trade cost term, τ_j^k. 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 (where $K = 1$), Anderson and Van Wincoop (2003) specify the trade cost function as follows:

$$\tau_j = dist_j^{\rho}(b)^{1-HOME_j} \tag{9}$$

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 US, and $HOME_j$ is an indicator that the product originated in the US.

We amend (9) to include an effect of the JA on PR's imports from the US. We assume that the JA imposes an additional tariff-equivalent cost on PR's imports from the US, and that the tariff-

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[36] 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.

equivalent JA cost varies across products according to product characteristics related to the manner in which the product is usually shipped. We specify another parameter like b,

$$JA^k = 1 + \tau_{JA}^k, \tag{10}$$

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:

$$\tau_j^k = dist_j^{\rho}(b)^{1-HOME_j}(JA^k)^{HOME_j}. \tag{11}$$

We exploit product-level variation in the response of bilateral trade to the $HOME_j$ dummy to parameterize JA^k.[37]

5.2.1 Parameterizing JA_j^k

Conceptually, our approach to parameterizing JA trade costs is as follows. All imports, regardless of transport mode, pay a common (average) tariff equivalent border cost, which takes the form τ_{HB} and is estimated via the parameter b. Goods that are shipped from the US by sea also pay a penalty (relative to goods shipped from the US by air). This trade cost takes the form τ_{JA}^k and is estimated by the parameter JA^k.[38] A simple approach to parameterizing JA^k would be to assume a common JA trade cost that applies to all US-origin shipments that move by sea. In a pooled product-level gravity model, the effects of the JA would be identified through the coefficient on the interaction of the $HOME_j$ dummy and with an indicator that the goods moved by sea.[39] The $HOME_j$ coefficient (without an interaction term) would measure home bias toward US products among air-shipped goods. The interaction terms would capture the reduction in home bias that is revealed among sea-shipped goods.

The absence of bulk/general cargo carriers on US-PR routes is likely to cause important cross-product variation in the burden the JA imposes on sea-shipped goods from the US. 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

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[37] Equation (11) is for purposes of illustration. When we move to the estimation model, we allow flexible effects of distance on trade costs. Non-linearities and cross-product variation in the effects of distance are allowed.

[38] 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.

[39] This is the approach that Olney (2020) takes, though he does not attempt to estimate structural trade costs.

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 the parameter JA^k as the inner product of the product characteristics $\overrightarrow{Z}^k$ and a vector of characteristic weights $\overrightarrow{\gamma}$, multiplied by the $HOME_j$ dummy:

$$ln(JA^k) = -\overrightarrow{\gamma}' \overrightarrow{Z}^k \times HOME_j. \tag{12}$$

In a reduced-form gravity model, the elements of $\overrightarrow{\gamma}$ are not fully identified. The response of trade to any trade friction also relies on a trade elasticity. In our exercise this applies to the $HOME_j$ dummy itself as well to the responses that emerge from $ln(JA^k)$. Let β be the estimated coefficient on $HOME_j$ without an interaction, and $\overrightarrow{\beta}$ be the coefficients on the interactions of $\overrightarrow{Z}^k$ with $HOME_j$. In this case, response of trade to $HOME_j$ appears as:

$$\frac{\partial lnM^k_{j,t}}{\partial HOME_j} = \beta - \overrightarrow{\beta}' \overrightarrow{Z}^k_t. \tag{13}$$

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 the 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 trade cost components $\overrightarrow{\gamma}$. We specify four $\overrightarrow{Z}^k$ variables that are intended to measure reliance on waterborne shipping and other relevant characteristics. The observable product characteristics we use are as follows: 1) the value share of US imports that travel by oceangoing vessel in a given year, Vsh^k_t, 2) the log of the median (across years) of the weight-to-value ratio of product k in US imports, $ln(WV^k)$, 3) the square of the logged median weight-to-value ratio $(ln(WV^k))^2$, and 4) the share of the product's US imports that were shipped in containers in a given year, $Ctnr^k_t$. 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 the estimates of $\overrightarrow{\gamma}$ to predict JA^k, and infer τ^k_{JA}.

Prior to turning to the structural model, we first estimate a reduced form gravity regression that links cross-product variation in estimated home biases to the characteristics of $\overrightarrow{Z}^k$. Before turning to the specification of this regression, it is useful to note some challenges that the data/estimation strategy imposes, and how we address them.

First, it is now conventional to estimate gravity regressions with vectors of fixed effects that sweep out important variation in the data. For example, many authors include some combination of origin-, destination-, product-, and time- fixed effects. 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/or geographic remoteness of the destination.[40] In a time series context origin-product-year and destination-product-year fixed effects sweep out heterogeneous supplies and demands, as well as shocks to both supply and demand.

Our regressions use data from a single destination, Puerto Rico. This means that including destination-product fixed effects in the regression sweeps out cross-product variation in the data. Instead we attempt to parameterize import demand.[41] Since our identification strategy relies on the interaction between product characteristics and the $HOME_j$ dummy, the key threat to identification is if variation across products in the levels of demand (operating through the α^k's and the $\widetilde{P}^k$'s) are 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 product characteristics themselves (without the interaction) in the regression. In this way we control for cross-product variation in the level of demand that might bias the coefficients on the interaction terms. The way in which the characteristics affect total import demand is also important when we move to estimating in the sample of upstream goods.

Second, rather than sweep out variation in export supply with product-origin-year fixed effects, we

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[40] See e.g. Anderson and Yotov (2016).

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

include in the regression explicit measures of export supply (of a given commodity from a given origin in a given year). We do this because of our interest in the $HOME_j$ dummy variable, which would be co-linear with the usual full set of product-origin-year 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.[42] Our parameterization of export supply allows us to estimate coefficients on the $HOME_j$ dummy itself, not only on the associated interaction terms.

5.3.1 Model Specifications

Our reduced-form regression model follows a Poisson Pseudo Maximum Likelihood (PPML) specification:

$$M^k_{j,t} = \exp\left[\delta\left(h^{-1}(X^k_{j,t})\right) + f\left(dist_j, \overrightarrow{Z}^k_t, \rho\right) + \beta HOME_j + \overrightarrow{\omega}\overrightarrow{Z^k_t} + \overrightarrow{\beta}\,\overrightarrow{Z}^k_t HOME_j\right] + \epsilon^k_{jt} \quad (14)$$

where $h^{-1}\left(X^k_{j,t}\right)$ is the inverse hyperbolic sine of the value of total exports of commodity k in year t from each region j, and δ the associated regression coefficient, $f\left(dist_j, \overrightarrow{Z}^k_t, \rho\right)$ is a flexible function of distance, product characteristics and parameters that controls for a region's distance to PR, and allows the effects of distance on trade to vary with product characteristics. $\overrightarrow{\omega}$ is a vector of estimated coefficients on the product characteristics themselves.[43] β, $\overrightarrow{\beta}$ and $\overrightarrow{Z}^k_j$ are as described above. We include year fixed effects to account for annual shocks to the level of PR's import demand. In some specifications we also include the log of one plus the US MFN tariff, and a vector of dummy variables indicating that a country has a preferential trade agreements with the US. 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 specification in (14) is useful for illustrating the cross-product variation in home bias. But for measuring welfare we need to translate these estimates into trade costs. The basic problem is that the regression coefficients in (14) conflate the effects of trade costs and trade responses. We cannot infer trade cost parameters without an estimate of the σ^k. Our solution to

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[42] 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.

[43] For some purposes we can think of these variables as mere controls for cross-product variation in the level of demand. When we move to estimation involving upstream products we will interpret them as representing the level of import demand for our characteristics of interest.

this problem is to incorporate into 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 the $HOME_j$ dummy, and with the interactions of these variables with $\overrightarrow{Z}^k_t$. According to our 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:

$$M^k_{j,t} = \exp\left[\delta\left(h^{-1}(X^k_{j,t})\right) + f\left(dist_j, \sigma^k, \overrightarrow{Z}^k_t, \rho\right) + \gamma\sigma^k HOME_j + \overrightarrow{\omega}\overrightarrow{Z^k_t} + \varepsilon\sigma^k + \overrightarrow{\gamma}\overrightarrow{Z}^k_t\sigma^k HOME_j\right] + \epsilon^k_{jt} \tag{15}$$

where σ^k is the product-specific estimate of the elasticity of substitution from Fontagné et al. (2022), and ε is a reduced form estimate of the conditional correlation between σ^k and $M^k_{j,t}$. The key difference between this specification and that in (14) 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 (9), and $\overrightarrow{\gamma} \times \overrightarrow{Z}^k_t \times HOME_j$ produces a predicted distribution of tariff-equivalent trade costs associated with the JA. 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 take this approach because PR has a highly unusual industrial structure, and it is likely that this has been shaped by the JA. In our primary set of estimates, 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, and define products with upstreamness index values greater than 1.3 as upstream goods.[44] This amounts to an assumption that $\alpha^k = 0$ for upstream goods, and $\mu^{ks} = 0$ for final goods.

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[44] We chose this threshold by inspection before estimating our regressions. Several industries near the 1.3 threshold but below it are clearly household consumption items (wine, apparel, frozen food). There are some industries that produce consumption items above the 1.3 threshold (books, cutlery), but even near the threshold most are products that are less obviously final goods (analytical laboratory instruments, support for oil and gas operations, miscellaneous electrical equipment, etc.). Another way of describing our upstreamness threshold is that all products with values less than 1.3 sell at least 70% of gross output to final demand.

6.1 Final goods

We begin our estimates with regressions over the sample of final goods. These estimates are the easiest to interpret in the gravity model framework, since the only margin of adjustment is the substitution effect that is common to the gravity literature.

6.1.1 Reduced form estimates

We report the results of reduced form gravity regressions for final goods in Table 5. All specifications include supply variables defined as above. All specifications also include both logged distance and the square of logged distance.[45] We focus on the coefficient on the $HOME_j$ dummy and its interactions with the product characteristic variables, $\overrightarrow{Z}$.

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

Column 2 includes, as controls, the $\overrightarrow{Z}$ variables that we interact with $HOME_j$ in subsequent regressions. These coefficients tell us whether the product characteristics help predict cross-product variation in the level of commodity k imports. Since we have controlled for variation in export supply, these coefficients can be interpreted as capturing cross-commodity variation with respect to the Z^k in the level of PR's import demand. All coefficients are 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 consumer's taste parameters α^k are associated with the Z^k variables. The $HOME_j$ coefficient is basically unchanged when we include the $\overrightarrow{Z}$ variables in the regression.

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[45] The second order term is included to allow the effects of distance on trade to vary with distance. The US is much closer to PR than are other developed countries with a similar export mix, so we wish to 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.

Column 3 is the first specification containing interactions of the $HOME$ dummy with the product characteristics. All the interaction coefficients are of the hypothesized sign, and all but the interaction of $HOME_j$ with $(\ln(WV^k))^2$ is statistically significant. Products typically shipped by sea have lower estimated home bias, which is consistent with the JA causing substitution away from US sources among sea-shipped final products. As predicted, 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 places an even larger burden on products shipped in bulk carriers or general cargo 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 US Most Favored Nation tariff on product k and a vector of dummy variables indicating that the supplying country is a member of a PTA with the US. The coefficient on the US MFN tariff variable can be interpreted as an estimate of the elasticity of substitution that is common across products, with $\sigma = 2.785$.

6.1.2 Structural estimates

We now turn to the structural estimates. The theoretical model implies that trade responses to geographic frictions can be decomposed into the product of a trade cost parameter 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. We also include σ^k alone in the estimation model, in order to control for covariation of σ^k with the level of PR's imports of that commodity. The estimates of σ^k that we use in our primary results come from Fontagné et al. (2022), although we also use estimates from Soderbery (2015) in a robustness check. Our primary results appear in Table 6.

The results in Column 1 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. The absence of interaction terms in this regression means that the estimate, $\widehat{\gamma} = 0.237$, is assumed to be common across commodities. Accounting for functional form, the estimate implies a tariff-equivalent trade cost associated with home bias of $\widehat{\tau}_{HB} = 0.267$.[46] In other words, our estimate is that the various commonalities that PR shares with the US mainland

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[46] $e^{0.237} - 1 = 0.267$.

(a common legal system and currency, free movement of people, etc.) amounts to an equivalent tariff of 26.7 percent on foreign imports.[47] This estimate of $\widehat{\tau}_{HB}$ is biased downward because it ignores the counteracting effects of the JA on sea-shipped goods; we include it here as a guide to interpretation.

When we add the $\overrightarrow{Z}$ variables to the regression in Column 2, $\widehat{\gamma}$ is largely unchanged. The estimate grows slightly in column 3, where we include the interaction of the $HOME_j$ dummy with $\overrightarrow{Z}$. In this case $\widehat{\gamma}$ should be interpreted carefully: the inclusion of interaction terms in the regression means that it no longer captures a cross-product average trade cost, it now represents an estimated cost for a product with particular characteristics. In this case, the coefficient captures the effect of an implied average tariff equivalent of home bias for a good that is air-shipped, is not typically containerized, and has a weight-to-value ratio of 1 (which means that $\ln(WV^k) = 0$). This estimate of $\widehat{\gamma}$ is somewhat larger than earlier estimates that applied to all commodities, an expected result because column 3 results control for the counteracting effects of the JA among sea-shipped goods.

It is the coefficients on the interaction terms that are of greatest interest. They retain the same intuitive sign pattern as in the reduced form regression. The coefficient estimate (-0.206) 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 $e^{0.206}$. If this coefficient were completely informative about the JA trade cost, it would imply an estimate of $e^{0.206} - 1 = 0.229$, a 23 percent tariff-equivalent effect of the JA. 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 full containerization largely offsets the estimated costs attributed to shipping a product by sea when a product's physical weight is low.

In columns 4 and 5, we allow for further flexibility in the response of trade to distance, and to US trade policy variables. These change the magnitudes of the coefficients of interest, 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

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

flexible distance effects and effects of explicit trade policies produces a higher estimate of $\widehat{\tau}_{HB}$. The $HOME_j$ dummy coefficient of 0.37 implies $\widehat{\tau}_{HB}$ of approximately 45 percent (for non-containerized air-shipped goods with weight-to-value ratios of 1). The coefficients on the interaction terms also grew in magnitude, relative to column 3, which implies larger tariff-equivalent estimates of the JA.

In order to illustrate the joint implications of the coefficients we calculate predicted values for the tariff-equivalent. The coefficient estimates themselves are only directly informative about relative trade costs; in order to produce predictions for absolute tariff-equivalents, we must identify a set of parameters that we associate with a tariff-equivalent of zero. Our reference product is air-shipped, not containerized and has the median weight to value ratio for air-shipped products. We calculate this value as 0.0247653 kg/\$.[48] The formula for the predicted τ^k_{JA} is:

$$\widehat{\tau}^k_{JA} = e^{-\left[\gamma_{Vsh} Vsh^k_y + \gamma_{WV}\left(ln(WV^k) - ln(0.0247653)\right) + \gamma_{WV2}\left((ln(WV))^2 - (ln(0.0247653))^2\right) + \gamma_{Ctnr} Ctnr^k_y\right]} - 1 \quad (16)$$

Using (16) we calculate the values of $\widehat{\tau}^k_{JA}$ using estimates from columns 3-5 of Table 6. The column 5 estimates are our preferred estimates of JA trade costs, and we show the distribution of these fitted values in the top portion of Figure 1, which plots the value of $\widehat{\tau}^k_{JA,2016}$'s against each product's weight-to-value ratio.

Figure 1 illustrates the role that product weight plays in generating 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 (HS220190-*Non-mineral or aerated waters*, and HS220110-*Mineral or aerated waters*); both these products have predicted JA tariff-equivalents of nearly 100 percent. 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 HS110429-*Cereal grains of barley* (with a tariff-equivalent of 114.3 percent), HS200911-*Frozen orange juice* (113.8 percent) and HS870530-*Fire fighting vehicles* (99.0 percent). Nineteen products are not imported at all from the US; 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 predicted tariff-equivalent trade costs. Most of these are light-weight air-shipped products; to illustrate this point we shade data-points

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[48] 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.

in proportion to their dependence on vessel-shipping in US-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 our 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 US.[49] If our estimating strategy were to falsely attribute some unusual feature of exports from the Southeastern US 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 figures at the bottom of Figure 1 show, 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 JA tariff-equivalent is near zero for most products, except for some air-shipped products with large negative predictions of $\widehat{\tau}^k_{JA}$. 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 even noisier, but the distribution is still much 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 effects on trade of the shipping characteristics associate with the JA reflect actual consequences of the JA, rather than some artifact of our estimation procedure.

We next report summary statistics for the implied distribution of JA-tariff equivalents. Our estimates of $\widehat{\tau}^k_{JA,t}$ return values for all final products, including those that travel primarily by air. Since the reference air-shipped product is the one 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 via 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 US 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 US in an oceangoing vessel in year t.[50] The values of $\overline{\tau}^k_{JA,t}$ that follow from this adjustment are our estimated JA trade costs going forward.[51] For these calculations we also assign zero values to the small number of

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

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

[51] 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

sea-shipped products with fitted values of $\widehat{\tau}^k_{JA,t}$ below zero.[52]

Table 7 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 the columns 3-5 in Table 6. Our preferred estimates - labelled "All Controls" in Table 7 - come from the estimates in Column 5, which include flexibly defined distance terms and US trade policy controls. In these estimates, 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 7 shows estimates of 2016 $\overline{\tau}^k_{JA}$'s calculated with the same methods, but calculated from estimates from Column 4 of Table 6. That regression excludes the trade policy controls. In this set of estimates, the simple average value of $\overline{\tau}^k_{JA,2016}$ is 35.5 percent. The third row is constructed with estimates from column 3, which do not allow for flexibly defined distance in the regression. This specification produced rather lower values of $\overline{\tau}^k_{JA,2016}$, with a simple average of 6.4 percent. We prefer the estimates in the first row of Table 7 because they contain the largest set of control variables.

We undertake a number of exercises to check the robustness of our results. 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 7. All of the results in Table 7 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 inferences about the 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.

(ROW) products and away from US products. It is likely that the JA also causes US 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.

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

6.2 Upstream product results

We next turn to results for the set of upstream products. We focus on the structural estimates, which are reported in Table 8. The structural estimates are more stable across specifications, and are easier to interpret than the reduced form estimates. The corresponding reduced form estimates appear in Table C1 of Appendix C.

Our primary focus is on the coefficients associated with the $\overrightarrow{Z}$ variables themselves. These estimates capture the degree to which the product characteristics we study explain cross-commodity variation in the level of PR's total import demand. These variables first appear in column 2, where all of the 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. Moving across the table (as we add interactions with the $HOME_j$ dummy, flexible distance related costs, and trade policy variables) the only coefficient that remains robust to the inclusion of our control variables is that on Vsh_t^k, which takes a large negative value in all specifications. The quantitative implication of the coefficient estimate (of - 1.476) in Column 5 is that PR's imports of vessel-shipped products are 77% lower than otherwise equivalent air-shipped products.[53] Although the coefficients on the other $\overrightarrow{Z}$ variables change in both magnitude and levels of statistical significance across the columns, the magnitude of 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.[54]

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 US mainland. When we turn to the coefficients on the interactions with the $HOME_j$ dummy, 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 US imports is small, and its quantitative effects more than completely offset

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[53] $e^{-1.476} = 0.228$.

[54] The reduced form estimates also show a persistent negative sign on Vsh_t^k, though this is offset for heavy and containerized goods in two of the four specifications. In the sample of upstream products, the distance coefficients are estimated imprecisely in the reduced form, and are highly sensitive to the inclusion of control variables. This appears to generate volatility in the coefficients of interest. The inclusion of σ^k as a product-level control appears to be important in keeping the structural estimates more stable.

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 heavier products also works to offset the effect operating through the bias against sea-shipped products from the US). The apparent implication of the estimates is that production location effects dominate substitution effects in the sample of upstream products, reducing imports of sea-shipped products from all sources, not only the US.

We do not see the same patterns emerge in our comparison countries (we refer the reader to results of our structural regressions for these countries in appendix tables C2, C3, and C4). 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 by containerization in JAM and BHS). Differential effects on imports from the US (i.e. substitution effects) are muted in all three cases, as would be expected. If anything it seems that that there is a small relative bias in favor of heavy products from the US in the three comparison countries. In BHS, an apparent bias against US sea-shipped goods nearly disappears if the goods are physically heavy or containerized.[55]

7 Static Welfare Effects

Although the dearth of sea-shipped imports of upstream products to PR suggests potentially important dynamic costs of the JA, it is more difficult to attribute these effects directly to the policy alone. Section 936 is likely another source of these effects. 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 US shipbuilders, shipping companies and crews are received by agents on the US mainland, CV is an appropriate measure of PR's (static) welfare losses from the JA.

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[55] 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.

Consider an expenditure function $E(P, U)$ that reflects the minimized cost of purchasing an optimal consumption basket in PR.[56] The expenditure function that is dual to the utility function above is the product of a specific numerical level of utility $\overline{U}$, and the true cost of living index $P_t = \prod_l (\widetilde{P}^l_t)^{\alpha_l}$, where l indicates a NAICS sector that is an aggregate of the set of products $k \in l$.[57] The sub-indices $\widetilde{P}^l_t$ are CES aggregates of the delivered prices in sector l, $(p^l_j \tau^l_j)$, and the elasticity of substitution at the sector l level, σ^l.[58] Abstracting away from the possibility that changes in trade costs might induce increases in the number of varieties that PR purchases from the US mainland, for counterfactual analysis we define the price sub-index in sector l as:

$$\widetilde{P}^l_t = \left[\sum_j \theta^l_{j,t} (1 + \tilde{\tau}^l_{j,t})^{1-\sigma^l} \right]^{\frac{1}{1-\sigma^l}} \tag{17}$$

where $\theta^l_{j,t}$ acts an Armington distribution weight, and $\tilde{\tau}^l_{j,t}$ is a trade cost in sector l that is set for removal in counterfactual analysis.[59] The set of regions j we consider in this analysis are US, ROW, and PR. In the case of US shipments $\tilde{\tau}^l_{j,t}$ is the JA tariff-equivalent; in the case of ROW shipments it is the trade-weighted average US tariff.

It is straightforward to calibrate this expenditure function. Let $S^l_{j,t}$ be region $j's$ observed share of Puerto Rican purchases of sector l in year t. The presence of JA trade costs (in the case of the US mainland), and tariffs (in the case of ROW) means that the data shares are larger than the true 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. The α^l parameters are the observed expenditure shares from 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.

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

[57] 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 aggregation as we use in the motivation for the structural regressions, so we replace superscript k with l.

[58] σ^l is a trade-weighted average of σ^k's.

[59] The link between the Armington and the monopolistic competition frameworks is: $\theta^l_{j,t} = n_{j,t} \left(\frac{p^l_{j,t}\tau^l_{j,t}}{\alpha^l (1+\tilde{\tau}^l_{j,t})} \right)^{1-\sigma^l}$. This shift allows us to be more transparent in our calculation of CV. It also makes clear that we are not attributing to the JA any increase in product variety. This is another attempt to be conservative; the welfare losses from the JA are larger if high freight costs limit product variety in PR. This is likely but difficult to quantify without observing the results of a policy change.

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_t^0 and observed expenditures $E(P_t^0, \overline{U}_t)^0$. In counterfactual analysis we remove $\tilde{\tau}_{j,t}^l$ in (17) on US and ROW imports, respectively, assuming no change in prices at the origin.[60] Given new values of the price index P_t^1, we calculate an updated value of the expenditure function $E(P_t^1, \overline{U}_t)^1$. The compensating variation of the price change is calculated as

$$CV = E(P_t^0, \overline{U}_t)^0 - E(P_t^1, \overline{U}_t)^1 \tag{18}$$

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

7.1 Aggregating trade costs to NAICS sectors

A proper welfare analysis of the JA requires a model that allows consumers to choose products from the US mainland, ROW and from PR itself. Since we lack detailed data on intra-PR trade, we are unable to do these calculations at the HS6 level for which we have trade statistics. Fortunately, PR produces an input-output table that allows formal welfare analysis. The sectors in the table are defined at the 4-digit level of the North American Industrial Classification System (NAICS). We describe here the process of aggregating the $\tilde{\tau}_{JA}^k$ estimates to the 4-digit NAICS sector level.

The table contains a square matrix of intermediate expenditures (each NAICS category's expenditures on all the others), a row of each sector's payments to domestic factors, and six columns of final expenditures on each NAICS sector's output. The categories of final expenditure include consumption, exports, and governmental expenditure.[61] Investment encompasses three columns, which we aggregate together.[62] Each cell of the table reports purchases from PR sources and from

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[60] The assumption of perfectly elastic supply to the Puerto Rican market is highly reasonable for US and ROW imports. Our calculations also 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. Falling domestic prices would raise our estimate of CV. But these additional welfare gains would be partially offset by reduced Puerto Rican income (absent any additional 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.

[61] The architecture of the table allows us to split government expenditure into three categories: local, municipal and federal. Each of these subcategories appears as a purchasing sector in the IO table, and each sells its "output" to government purchases in final demand. We restructure the table so that each of the components of government expenditure enters separately as final demand sector.

[62] The table splits investment into three categories: machinery and equipment, investment in construction, and changes in inventories. Changes in inventories can take positive and negative values, which can lead aggregate

imports, where reported imports include imports from both domestic and foreign sources. We use a concordance of HS6 products to NAICS sectors provided by the US Census.

We must make three adjustments to the table to support our welfare analysis. First, we divide PR's reported imports in the table between US and ROW sources. Second, we map up- and down-stream products onto NAICS-level US imports. Finally, we must reconcile the fact that the most recent IO table that we consider credible is from 2006-7, while our trade data are available for a later period of time.

We address the first and second problems jointly. In mapping the HS6 data to the NAICS codes we keep track of both the US and ROW share of imports in each NAICS code and the share of up- and down-stream products for each NAICS sector and origin-region. For each NAICS sector, we calculate US and ROW shares of up- and down-stream import value, respectively, and apply the average US and ROW shares for 2010-2017 to the import flows that the table reports for each NAICS code.

These calculations give estimated trade shares that we use in the welfare analysis. We must also generate JA-tariff equivalent trade costs at the NAICS level. Let $s_{k,l}$ be the share of each downstream HS product k in PR's imports from the US in NAICS sector l. We calculate trade-weighted average JA tariff equivalents by multiplying these shares by the values of $\overline{\tau}^{k}_{JA}$. Summing over these values within each NAICS sector generates a value of $\overline{\tau}^{l}_{JA}$ for each NAICS sector. In order to offer a comparison to US tariffs, we conduct a similar exercise that weights US MFN tariffs by shares of downstream imports of product k sector l.[63] We also calculate σ^l as a trade weighted average of σ^k's.

A final set of adjustments that must be made to these figures is to inflate the expenditure values in the 2006-2007 input-output table to 2016 values. In the absence of a more recent input-output table for PR, we assume that the structure of input-output relationships is unchanged over time. One advantage to limiting our analysis to final goods is that we do not require an assumption

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investment to be less than zero. We zero out changes in inventories, treating machinery and equipment investment and investment in construction as the only source of final demand expenditures in our calculations.

[63] Products from regions that are PTA partners with the US are assumed to face zero tariffs in this aggregation.

that intermediate demands remained unchanged over this period. We are unable to account for changes across sectors l in either a) the share of each NAICS sector in each final demand category's expenditure, b) the relative sizes of final expenditure categories, and c) PR's share of total sales within a NAICS category. We simply adjust the level of nominal expenditure in the table to the 2016 level by applying observed changes in GDP since 2006.[64] Puerto Rican nominal GDP grew by a factor of 1.195 between 2006 and 2016.

Table 9 provides information that is relevant to our welfare calculations.[65] Column 1 reports the share of each final demand category in total final expenditures. Household consumption accounts for nearly 52.6 percent of total final expenditures. Exports account for an additional 20.4 percent. Investment and the three government spending categories account for just over 27 percent of total final expenditures.

We also calculate the share of US imports for each final expenditure category; investment is the most dependent on US imports. We then report US trade-weighted averages of $\tilde{t}^l_{JA}$ for each expenditure category. The average JA trade cost for all of final demand is 8.0 percent; the value for private consumption is 9.2 percent.[66]

7.2 Back-of-the-Envelope CV Estimates

Before moving to the detailed CV estimates, we first conduct a back-of-the-envelope calculation to provide a transparent illustration of the approximate magnitudes implied by our estimates. We apply average information from our sample to PR's final expenditure levels, in order to make our calculations transparent. Subsequent calculations exploit the rich cross-product heterogeneity present in our estimates.

The parameter inputs into our aggregate calculation are as follows. With just a single aggregate sector, $\alpha^l = 1$. We calculate a trade-weighted average σ of 3.478.[67] Imports from the US face a JA

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[64] We calculate and report values in terms of 2016 nominal dollars. Our trade data for 2016 are reported in nominal dollars, and we inflate the older input-output data accordingly.

[65] All these calculations exclude the NAICS codes in PR's IO table that contain pharmaceutical production: NAICS 3251, 3254 and 3391. US Census concordances maps HS2 code 30 to these NAICS codes.

[66] Investment has the highest average tariff equivalent costs, 17.1 percent. The high average tariff-equivalent is primarily attributable to the sector's purchases of cars and of other motor vehicles.

[67] In this calculation, NAICS categories without trade have an assumed σ^l of 1.

tariff equivalent of 8 percent *ad valorem*. PR's expenditure shares on its own goods and services and on US and ROW imports are 81.6, 13.7, and 4.7 percent respectively. In the true-cost-of-living index P_j, the associated distribution parameters θ_j for the products of PR and imports from the US and ROW are, respectively, 0.816, 0.166, and 0.049. In this setting the removal of JA trade costs $\overline{\tau}^k_{JA}$ from US products reduces P_j by 1.2 percent. A 1.2 percent reduction in P_j means that purchasers of final demand in PR could reduce their expenditure by an equivalent percentage, and still maintain their current standard of living. Our expansion of final expenditure puts it at an estimated value of \$107.3 billion in 2016. This implies a welfare cost of the JA of approximately \$1.3 billion in the back-of-the-envelope calculation.

7.3 CV Estimates from removing JA tariff equivalent and US tariff.

We apply this same approach to our disaggregated data, with $\overline{\tau}^l_{JA}$ and σ^l varying across NAICS sectors l. Using our preferred estimates of $\overline{\tau}^l_{JA}$, we calculate that final expenditure in Puerto Rico would be \$1.4 billion (about 1.3 percent) lower in 2016 without the JA. When we decompose this value into burdens on particular types of final expenditure, Table 10 indicates that consumption spending would be \$691 million (about 1.2 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 suggests an additional source of dynamic welfare losses that implies even larger costs to the JA than we calculate here.

Using the same approach, but considering the removal of US MFN tariffs for all goods arriving from non PTA partners, we calculate that final expenditure could be US\$133 million (about 0.1 percent) lower and produce the same level of utility as if US tariffs were removed. Table 11 indicates that MFN tariffs on Puerto Rican households' imports of non-PTA partner goods costs them approximately \$92 million, or \$27 per person per year. The cost of the JA for Puerto Rican households is 7.5 times larger than the cost imposed by remaining US tariffs.

8 Conclusion

Standard international trade theory acknowledges a potential role for trade policy in meeting non-economic objectives such as national defense. The initial motivation for the JA was to ensure a market for domestically-owned and -produced ships that could serve the country in times of war.

Although the merits of the JA as a national defense policy seem dubious, an assessment of the national security benefits of the policy is beyond the scope of this paper.

Our objective is to measure the economic consequences of the policy for PR. Relative to earlier estimates - notably the economy-wide welfare calculations done in various USITC reports - our estimates also highlight that the policy has important distributional consequences. Residents of US controlled islands bear a heavy share of the economic burden of the JA. We study the particular case of PR, which is large enough to collect suitable data for our exercise and close enough to the US to be highly dependent on the mainland for consumption goods.

We use data on ship movements in the Caribbean to characterize key differences between the JA-compliant fleet and other freight shipping in the region. Bulk, tanker and general cargo shipping capacity is notably absent from the JA-compliant fleet; most JA shipping to PR is accomplished by container ships. This evidence proves useful in guiding our subsequent approach to estimation. We hypothesize that products that are sea-shipped and physically heavy are likely to face higher trade costs associated with the JA, but also that these costs might be partially offset for products that are often moved in containers.

Noting the unusual industrial structure of PR, we estimate over separate subsamples of the data, which is divided into up- and down-stream products, respectively. In downstream products (those purchased primarily by final sources of demand), we find considerable evidence that trade responds as we hypothesized. Measured home bias is noticeably smaller in products that a) move by sea, b) are not containerized, and c) have high weight to value ratios. Among upstream products, the coefficient pattern is different. Rather than a large bias against US sources, we find lower levels of imports (from all sources) of sea-shipped upstream products. It is likely that the JA contributed to PR's lack of participation in supply chains involving these products, but other policies may also have contributed. These effects are quantitatively large, and plausibly an outcome of the JA, but they are more difficult to attribute directly to the JA. In order to be conservative in our welfare estimates, we focus our attention on the implications of observed substitution away from US sources among sea-shipped final products.

In order to uncover structural trade cost estimates we incorporate into the estimation external estimates of the elasticity of substitution. These allow us to make inferences about the relative size of trade costs across products (that might also differ in the size of their elasticities of substitution). Using these estimates - and comparing to a reference product that is assumed to have no costs linked to the JA because it is air shipped - we are able to infer absolute trade costs. We calculate predicted tariff-equivalent JA trade costs at the product level, and characterize the cross-commodity distribution of these costs.

Finally, we apply data from an input-output table for PR, which allows us to include spending on local goods, to separate final and intermediate expenditures, and investigate the difference in the JA burden across subcategories of final demand. Our estimates suggest that the JA raised the cost of PR's final demand by \$1.4 billion in 2016. The estimated annual burden on consumption alone is \$691 million, or approximately \$203 per PR citizen.

Our welfare estimates are conservative in that they assume only static losses from the JA, but we offer indirect evidence suggesting other forms of dynamic losses from the policy. The final demand category of investment purchases products that are highly exposed to the policy, and higher costs for capital goods would impose even further losses in the long run. We also find evidence of missing imports in sea-shipped upstream products, but the missing imports in this sample appears to be from all sources, rather from the US mainland alone. To the degree that the JA is responsible for long-run decisions that have biased PR's industrial mix against-sea-shipped imports, its effects on PR are much larger than the static losses we quantify.

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9 Tables

Table 1: Sales, Employment and Payroll by Sector in Puerto Rico, 2017

NAICS code	Sector	Sales, value of shipments, or revenue ($1,000)	%	Number of employees	%	Annual payroll ($1,000)	%
31-33	Manufacturing	85,263,498	45.2%	77,005	11.8%	2,854,815	17.3%
44-45	Retail trade	25,456,248	13.5%	132,033	20.3%	2,368,082	14.3%
42	Wholesale trade	19,110,386	10.1%	31,255	4.8%	1,114,254	6.7%
51	Information	14,705,619	7.8%	19,872	3.0%	841,980	5.1%
52	Finance and insurance	14,357,432	7.6%	31,928	4.9%	1,444,679	8.8%
62	Health care and social assistance	7,885,285	4.2%	84,933	13.0%	2,085,097	12.6%
54	Professional, scientific, and technical services	4,481,246	2.4%	34,559	5.3%	1,231,711	7.5%
72	Accommodation and food services	4,313,196	2.3%	82,815	12.7%	1,084,616	6.6%
56	Waste management and remediation services	3,197,260	1.7%	74,461	11.4%	1,445,280	8.8%
23	Construction	2,363,926	1.3%	20,215	3.1%	450,349	2.7%
48-49	Transportation and warehousing	2,345,789	1.2%	15,626	2.4%	424,650	2.6%
53	Real estate and rental and leasing	1,617,282	0.9%	13,101	2.0%	322,424	2.0%
81	Other services (except public administration)	1,106,981	0.6%	13,125	2.0%	250,707	1.5%
55	Management of companies and enterprises	1,040,588	0.6%	6,709	1.0%	342,976	2.1%
22	Utilities	626,611	0.3%	350	0.1%	21,840	0.1%
61	Educational services	418,303	0.2%	9,443	1.4%	149,688	0.9%
71	Arts, entertainment, and recreation	299,586	0.2%	3,811	0.6%	67,179	0.4%
21	Mining, quarrying, and oil and gas extraction	42,785	0.0%	482	0.1%	8,777	0.1%
	Total	188,632,020	100.0%	651,719	100.0%	16,509,101	100.0%

Source: US Economic Census of Island Areas (2017).

Table 2: Sales, Employment and Payroll in Puerto Rico's Manufacturing Sector, 2017

NAICS code	Sector	Sales, value of shipments, or revenue ($1,000)	%	Number of employees	%	Annual payroll ($1,000)	%
3254	Pharmaceutical and medicine manufacturing	55,065,220	64.6%	13,661	17.7%	977,279	34.2%
3391	Medical equipment and supplies manufacturing	12,605,175	14.8%	16,725	21.7%	676,710	23.7%
3121	Beverage manufacturing	3,647,960	4.3%	2,294	3.0%	87,190	3.1%
3119	Other food manufacturing	1,143,133	1.3%	1,997	2.6%	63,490	2.2%
3353	Electrical equipment manufacturing	961,788	1.1%	2,816	3.7%	97,711	3.4%
3152	Cut and sew apparel manufacturing	478,824	0.6%	5,862	7.6%	84,220	3.0%
3118	Bakeries and tortilla manufacturing	475,038	0.6%	6,316	8.2%	106,540	3.7%
3256	Soap, cleaning compound, and toilet preparation manufacturing	452,632	0.5%	1,016	1.3%	44,713	1.6%
3345	Navigational, measuring, electromedical, and control instruments manufacturing	354,382	0.4%	2,269	2.9%	77,901	2.7%
3261	Plastics product manufacturing	291,499	0.3%	1,689	2.2%	46,125	1.6%
	Others	9,787,847	11.5%	22,360	29.0%	592,936	20.8%
	Total	85,263,498	100.0%	77,005	100.0%	2,854,815	100.0%

Source: US Economic Census of Island Areas (2017).

Table 3: Type of Vessels Serving the Caribbean (2019)

Panel A. All vessels in the Caribbean

Type of Vessel	Number of vessels	%	Number of Calls	%	DWT	%
Tanker	1,197	37.9%	8,600	24.0%	83,057,831	50.6%
Bulk	678	21.5%	2,434	6.8%	32,784,710	20.0%
Container ships	535	17.0%	11,650	32.6%	30,111,934	18.4%
General cargo	465	14.7%	6,651	18.6%	5,418,278	3.3%
Others	260	8.2%	5,288	14.8%	12,677,009	7.7%
No DWT reported	20	0.6%	1,165	3.3%	-	0.0%
Total	3,155	100%	35,788	100%	164,049,762	100%

Panel B. All vessels serving Puerto Rico

Type of Vessel	Number of vessels	%	Number of Calls	%	DWT	%
Tanker	189	52.1%	321	16.0%	9,330,379	66.4%
Container ships	50	13.8%	840	41.7%	1,042,222	7.4%
Bulk	48	13.2%	103	5.1%	1,999,501	14.2%
General cargo	41	11.3%	287	14.3%	467,487	3.3%
Others	30	8.3%	251	12.5%	1,205,813	8.6%
No DWT reported	5	1.4%	210	10.4%	-	0.0%
Total	363	100.0%	2,012	100.0%	14,045,402	100.0%

Panel C. Jones Act vessels

Type of Vessel	Number of vessels	%	Number of Calls	%	DWT	%
Container ships	4	44.4%	197	82.1%	118,949	80.8%
Barges, ferries, etc	3	33.3%	3	1.3%	28,073	19.1%
Others	1	11.1%	39	16.3%	163	0.1%
No DWT reported	1	11.1%	1	0.4%	-	0.0%
Total	9	100.0%	240	100.0%	147,185	100.0%

Note: Ship arrival data in the Caribbean, purchased from Lloyd's List Intelligence. DWT refers to the vessels' Deadweight Tonnage. In each case, the reported DWT corresponds to the sum of vessels' DWT per type of vessel. Number of Calls indicates the number of times a vessel stopped in a port. The difference between All vessels serving Puerto Rico and Jones Act vessels is that the latter are those that satisfy Jones Act conditions. In order to generate this table, the year of a shipping movement corresponds to the calendar year in which a vessel arrived at a port. No DWT reported correspond to vessels for which the DWT information is not available. In Panel C. the vessel without reported DWT is a barge.

Table 4: Composition of Puerto Rico's Imports - 2016

Type of Products	Mode	Region	Import value	%	Number of products
Final products	Vessel	US	2,825,407,995	9.6%	543
		ROW	706,846,423	2.4%	386
	Air	US	350,950,163	1.2%	422
		ROW	42,589,807	0.1%	291
Upstream products	Vessel	US	7,419,434,997	25.1%	3,125
		ROW	5,780,715,504	19.6%	1,950
	Air	US	3,807,449,128	12.9%	2,068
		ROW	8,611,250,465	29.1%	883
Total			29,544,644,482	100.0%	

Note: Both panels show Puerto Rico's import value and share of imports for every combination, using the upstreamness index (UI) of Antràs et al. (2012) to classify the products between final (UI<=1.3) and upstream goods (UI>1.3). The number of products corresponds to the number of HS6 codes with positive imports for every combination: Type of Products-Mode-Region. All calculations exclude imports of pharmaceutical products.

Table 5: Reduced Form Estimates for Final Goods

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M^k_{j,t}$		
$\ln(dist_j)$	-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^k_t		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)
$Ctnr^k_t$		-1.060***	-1.935***	-0.171	1.165
		(0.138)	(0.237)	(1.960)	(2.012)
$Vsh^k_t \times HOME_j$			-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)
$Ctnr^k_t \times HOME_j$			1.190***	1.019***	0.722***
			(0.345)	(0.221)	(0.216)
$Vsh^k_t \times \ln(dist_j)$				1.686***	1.696***
				(0.275)	(0.259)
$\ln(WV^k) \times \ln(dist_j)$				-0.0324	-0.0273
				(0.0464)	(0.0485)
$(\ln(WV^k))^2 \times \ln(dist_j)$				0.0217***	0.0226***
				(0.00571)	(0.00584)
$Ctnr^k_t \times \ln(dist_j)$				-0.199	-0.328
				(0.252)	(0.258)
$\ln(1 + tar^k_t)$					-2.785***
					(0.788)
$(\ln(dist_j))^2$	0.0136	0.0535	0.0956	0.151**	0.0964
	(0.0576)	(0.0609)	(0.0602)	(0.0671)	(0.0741)
$IHST(\widetilde{X}^k_{j,t})$	0.679***	0.641***	0.643***	0.647***	0.651***
	(0.0308)	(0.0248)	(0.0249)	(0.0259)	(0.0263)
Constant	11.22***	15.25***	17.73***	33.48***	31.08***
	(2.781)	(2.990)	(2.806)	(3.969)	(4.098)
Observations	1,075,452	1,075,452	1,075,452	1,075,452	1,070,496
Year FE	YES	YES	YES	YES	YES
US PTA's Dummy variables	NO	NO	NO	NO	YES
Pseudo R2	0.494	0.512	0.518	0.521	0.524
Average Weight to Value	0.121	0.121	0.121	0.121	0.121
Average Distance to USA (km)	3,701	3,701	3,701	3,701	3,701

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 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.

Table 6: Structural Estimates for Final Goods

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M_{j,t}^k$		
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_t^k		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)
$Ctnr_t^k$		-1.724***	-2.813***	-1.168***	-1.041***
		(0.158)	(0.190)	(0.350)	(0.358)
$\sigma^k \times Vsh_t^k \times HOME_j$			-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)
$\sigma^k \times Ctnr_t^k \times HOME_j$			0.162***	0.301***	0.281***
			(0.0300)	(0.0460)	(0.0496)
$\sigma^k \times Vsh_t^k \times \ln(dist_j)$				0.0581***	0.0505***
				(0.0188)	(0.0185)
$\sigma^k \times \ln(WV^k) \times \ln(dist_j)$				0.0149***	0.0146***
				(0.00492)	(0.00493)
$\sigma^k \times (\ln(WV^k))^2 \times \ln(dist_j)$				0.000246	0.000291
				(0.000785)	(0.000733)
$\sigma^k \times Ctnr_t^k \times \ln(dist_j)$				-0.0366***	-0.0356***
				(0.00767)	(0.00818)
$\sigma^k \times \ln(1 + tar_t^k)$					-0.548***
					(0.145)
$\sigma^k \times (\ln(dist_j))^2$	-0.0188**	-0.0140*	-0.0107	-0.00416	-0.0116
	(0.00804)	(0.00813)	(0.00872)	(0.00902)	(0.0105)
$IHST(\widetilde{X}_{j,t}^k)$	0.677***	0.612***	0.606***	0.614***	0.616***
	(0.0333)	(0.0239)	(0.0232)	(0.0238)	(0.0242)
Constant	1.181**	3.765***	3.084***	1.633**	1.519*
	(0.566)	(0.430)	(0.450)	(0.832)	(0.827)
Observations	1,075,452	1,075,452	1,075,452	1,075,452	1,070,496
Year FE	YES	YES	YES	YES	YES
US PTAs Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.451	0.479	0.489	0.497	0.499
Average Weight to Value	0.121	0.121	0.121	0.121	0.121
Average Distance to USA (km)	3,701	3,701	3,701	3,701	3,701

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 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.

Table 7: Summary Statistics of Estimated Jones Act Tariff Equivalent - 2016

Control of PR's Imports DA	# Obs.	Simple Average	Trade Weighted Average	Std. Dev	Minimum	Perc. 25%	Median	Perc. 75%	Maximum
Table 6 estimates									
FE: YEAR - All controls	609	30.6%	53.6%	23.8%	0.0%	8.4%	29.5%	46.5%	114.3%
FE: YEAR - No τ + No FTA's	609	35.5%	61.9%	27.4%	0.0%	9.8%	34.8%	54.0%	130.8%
FE: YEAR - No τ + No FTA's + No Dist $\times \overrightarrow{Z}$	609	6.4%	14.2%	5.9%	0.0%	1.8%	5.4%	9.1%	32.2%
Robustness									
FE: YEAR - All controls - BEC	1,099	11.3%	11.2%	5.2%	0.0%	8.9%	14.0%	14.7%	24.0%
FE: YEAR × product (HS6) - All controls	609	11.8%	25.2%	13.4%	0.0%	0.8%	7.4%	17.4%	80.7%
FE: YEAR × sector (HS2) - All controls	609	33.2%	57.2%	25.9%	0.0%	9.0%	32.1%	50.4%	128.5%
FE: YEAR - All controls + Soderbery σ	609	310.0%	555.3%	223.0%	0.0%	91.9%	335.8%	483.3%	917.9%
FE: YEAR - All controls + Common σ	609	49.2%	76.0%	42.6%	0.0%	10.8%	43.6%	76.0%	226.7%

Note: These statistics are calculated as the product of the predicted JA-tariff equivalent for 2016 (calculated by equation (12)) and the vessel share of 2016 US-PR shipments in the corresponding product. Estimates are reported for numerous specifications of the structural regression (in equation (15)). All estimates rely on the σ estimates of Fontagné et al. (2022), except the row labeled "Soderbery σ" (for which we use Soderbery (2015)) and the common's σ case for which we use the coefficient on the US MFN tariff from Table 5. The number of observations when we use the UN BEC classification is greater, because this classification defines more products as consumption goods.

Table 8: Structural Estimates for Upstream Goods

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M^k_{j,t}$		
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^k_t		-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)
$Ctnr^k_t$		-0.298***	-0.460***	0.0481	0.111
		(0.106)	(0.111)	(0.133)	(0.150)
$\sigma^k \times Vsh^k_t \times HOME_j$			-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)
$\sigma^k \times Ctnr^k_t \times HOME_j$			0.0585***	0.0929***	0.114***
			(0.00759)	(0.0165)	(0.0187)
$\sigma^k \times Vsh^k_t \times \ln(dist_j)$				0.00214***	0.00219**
				(0.000813)	(0.00103)
$\sigma^k \times \ln(WV^k) \times \ln(dist_j)$				-0.00411**	-0.00294**
				(0.00161)	(0.00136)
$\sigma^k \times (\ln(WV^k))^2 \times \ln(dist_j)$				-0.000443**	-0.000342**
				(0.000187)	(0.000155)
$\sigma^k \times Ctnr^k_t \times \ln(dist_j)$				-0.00604***	-0.00921***
				(0.00201)	(0.00239)
$\sigma^k \times \ln(1 + tar^k_{j,t})$					1.138***
					(0.0622)
$\sigma^k \times (\ln(dist_j))^2$	0.00167	0.00111	0.00118	0.00217	-0.00950*
	(0.00213)	(0.00207)	(0.00207)	(0.00195)	(0.00563)
$IHST(\widetilde{X}^k_{j,t})$	0.789***	0.802***	0.801***	0.800***	0.825***
	(0.0258)	(0.0321)	(0.0322)	(0.0306)	(0.0340)
Constant	-2.369***	-1.507**	-1.258**	-0.622	-1.714***
	(0.495)	(0.600)	(0.601)	(0.430)	(0.532)
Observations	5,892,852	5,892,852	5,892,852	5,892,852	5,892,852
Year FE	YES	YES	YES	YES	YES
US PTAs Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.420	0.443	0.446	0.453	0.500
Average Weight to Value	0.517	0.517	0.517	0.517	0.517
Average Distance to USA (km)	3,701	3,701	3,701	3,701	3,701

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. 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. Pharmaceutical products are excluded from the estimation. IHST denotes the Inverse Hyperbolic Sine Transformation.

Table 9: Jones Act Tariff Equivalent by Final Demand Categories - 2016

	Share in Puerto Rico's Final Expenditure	Average Share of US in PR Final Expenditure (per NAICS code)	JA Tariff Equivalent		US tariff
			Heterogeneous $\widehat{\sigma}^k$	Common $\widehat{\sigma}^k$	
Final Demand	100.0%	16.8%	8.0%	12.1%	1.7%
Consumption	52.6%	14.4%	9.2%	14.4%	2.3%
Exports	20.4%	24.7%	4.7%	8.1%	1.6%
Investment	12.7%	29.8%	17.1%	22.6%	1.0%
Local Government	10.5%	3.4%	0.0%	0.0%	0.0%
Municipal Government	2.6%	0.5%	0.1%	0.1%	0.0%
Federal Government	1.3%	3.0%	0.0%	0.0%	0.2%

Note: All estimates are calculated as trade-weighted averages of the estimated JA-tariff equivalents summarized in Table 7. Heterogeneous $\widehat{\sigma}^k$ estimates represent JA-tariff equivalents retrieved using the σ^k estimates of Fontagné et al. (2022) for all products. Common $\widehat{\sigma}^k$ estimates represent JA-tariff equivalents that assume a common σ for all products. The US tariff is also calculated as a weighted average of the tariffs for every NAICS code, using as weights the share of the non-US countries in the expenditure of every NAICS code sector. All calculations exclude NAICS codes 3251, 3254 and 3391, which represent pharmaceutical products.

Table 10: Compensating Variation - Jones Act Removal (Heterogeneous $\widehat{\sigma}^k$) - 2016

	Share in Final Demand	Total Value (millions of 2016 $US)	per capita CV (2016 $US)	% Change vs No JA
Final Demand	100.0%	1,390	408	1.3%
Consumption	52.6%	691	203	1.2%
Exports	20.4%	289	85	1.3%
Investment	12.7%	403	118	3.0%
Local Government	10.5%	0	0	0.0%
Municipal Government	2.6%	0	0	0.0%
Federal Government	1.3%	0	0	0.0%

Note: Compensating variation estimates are calculated using the estimated weighted average of the JA-tariff equivalents for every NAICS code. CV is calculated as the difference between the observed expenditure and the expenditure required to produce the same utility with the JA-tariff equivalent trade costs removed. All figures are in 2016 dollars; per capita estimates use PR's population in 2016. All calculations exclude NAICS codes 3251, 3254 and 3391, which represent pharmaceutical products.

Table 11: Compensating Variation - US Tariffs - 2016

	Share in Final Demand	Compensating Variation (millions of 2016 $US)	per capita CV (2016 $US)	% Change vs No tariffs
Final Demand	100.0%	133	39	0.1%
Consumption	52.6%	92	27	0.2%
Exports	20.4%	34	10	0.2%
Investment	12.7%	7	2	0.1%
Local Government	10.5%	0	0	0.0%
Municipal Government	2.6%	0	0	0.0%
Federal Government	1.3%	0	0	0.0%

Note: Compensating variation estimates are calculated using the trade-weighted average US most-favored nation tariffs for every NAICS code and the US share in PR imports. CV is calculated as the difference between the observed expenditure and the expenditure required to produce the same utility with US tariffs removed. All figures are in 2016 dollars. Per capita estimates use the population level from 2016. All calculations exclude NAICS codes 3251, 3254 and 3391, which are pharmaceutical products.

10 Figures

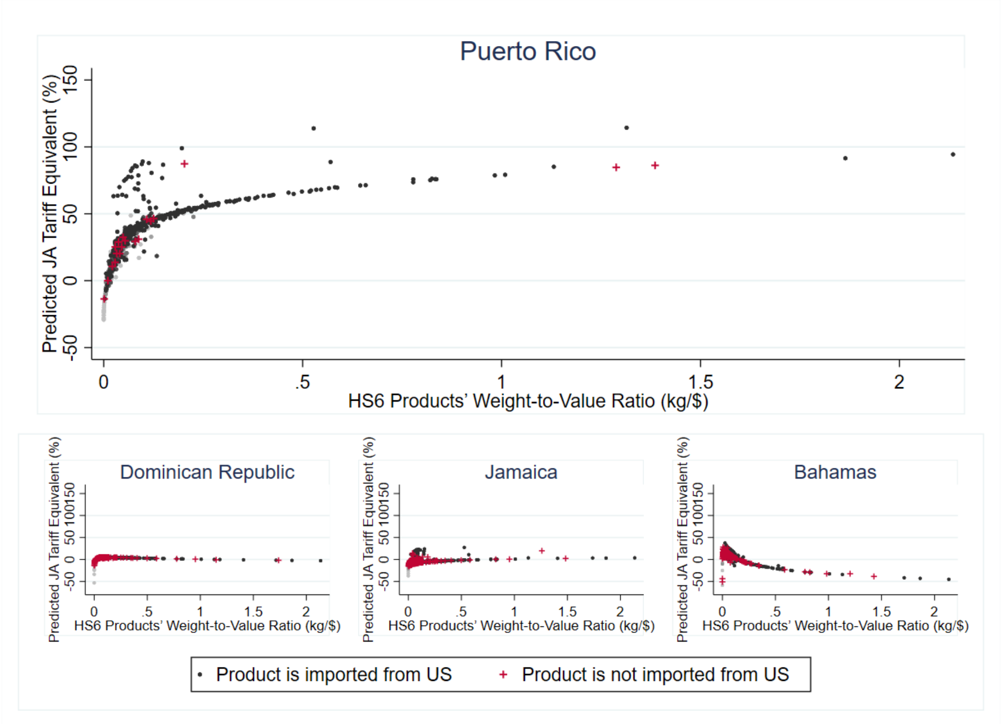

Figure 1: 2016 Jones Act Tariff Equivalent estimates against Weight-to-Value Ratio

Note: Estimates of predicted HS6 product-level JA tariff-equivalents for 2016. All estimates are predicted by applying equation 16 and multiplying by 100. Predicted JA tariff-equivalents rely on parameter estimates from Column 5 of Tables 6, A1, A2, A3 and σ^k estimates from Fontagné et al. (2022). Product level weight-to-value ratios are calculated as the median of the weight-to-value ratios calculated among US imports (net of imports from Canada and Mexico) for the years 2010-2017. Shading of dots on imported products from US indicates the vessel share of every product in imports. Darker dots mean higher vessel share and lighter mean a lower share.

Appendixes

A Gravity Estimates - Final Products

Table A1: Structural Estimates for Final Goods - Dominican Republic

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M^{k}_{j,t}$		
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^k_t		-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)
$Ctnr^k_t$		-0.753***	-0.829***	-1.584***	-1.550***
		(0.150)	(0.145)	(0.349)	(0.354)
$\sigma^k \times Vsh^k_t \times HOME_j$			-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)
$\sigma^k \times Ctnr^k_t \times HOME_j$			0.0195	-0.0253	-0.0120
			(0.0182)	(0.0257)	(0.0257)
$\sigma^k \times Vsh^k_t \times \ln(dist_j)$				-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)
$\sigma^k \times Ctnr^k_t \times \ln(dist_j)$				0.0126***	0.0113***
				(0.00436)	(0.00436)
$\sigma^k \times \ln(1 + tar^k_{j,t})$					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)
$IHST(\widetilde{X}^k_{j,t})$	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's Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.638	0.643	0.644	0.665	0.676
Average Weight to Value	0.121	0.121	0.121	0.121	0.121
Average Distance to USA (km)	3,415	3,415	3,415	3,415	3,415

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 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

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M_{j,t}^k$		
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_t^k		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)
$Ctnr_t^k$		-1.316***	-1.802***	-0.831***	-0.800**
		(0.164)	(0.168)	(0.276)	(0.319)
$\sigma^k \times Vsh_t^k \times HOME_j$			-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)
$\sigma^k \times Ctnr_t^k \times HOME_j$			0.279***	0.298***	0.298***
			(0.0272)	(0.0291)	(0.0294)
$\sigma^k \times Vsh_t^k \times \ln(dist_j)$				-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)
$\sigma^k \times Ctnr_t^k \times \ln(dist_j)$				-0.0123***	-0.0126***
				(0.00330)	(0.00375)
$\sigma^k \times \ln(1 + tar_{j,t}^k)$					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)
$IHST(\widetilde{X}_{j,t}^k)$	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's Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.566	0.592	0.604	0.610	0.610
Average Weight to Value	0.122	0.122	0.122	0.122	0.122
Average Distance to USA (km)	3,129	3,129	3,129	3,129	3,129

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 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

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M^k_{j,t}$		
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^k_t		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)
$Ctnr^k_t$		-0.553***	-0.703***	-0.162	-0.0337
		(0.188)	(0.198)	(0.364)	(0.368)
$\sigma^k \times Vsh^k_t \times HOME_j$			-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)
$\sigma^k \times Ctnr^k_t \times HOME_j$			0.0605*	0.113***	0.0982***
			(0.0310)	(0.0305)	(0.0336)
$\sigma^k \times Vsh^k_t \times \ln(dist_j)$				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)
$\sigma^k \times Ctnr^k_t \times \ln(dist_j)$				-0.00150	-0.00360
				(0.00417)	(0.00465)
$\sigma^k \times \ln(1 + tar^k_{j,t})$					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)
$IHST(\widetilde{X}^k_{j,t})$	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
Average Weight to Value	0.124	0.124	0.124	0.124	0.124
Average Distance to USA (km)	2,321	2,321	2,321	2,321	2,321

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 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's Dummy variables because the Bahamas have no PTA 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 5 and 6, 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.[68] Looking again at the estimates in Table B4 one notes that the sample size is much larger than in the relevant counterpart, Table 6. The BEC sample contains products that are further upstream than the set of final goods in Table 6. 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 7. 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.[69] We therefore focus our remaining attention on the sample defined by products' position in the upstreamness index.

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 $\overrightarrow{Z}$ variables alone

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[68] 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.

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

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 7, which shows a simple average $\overline{\tau}^k_{JA}$ of 11.8 percent and a weighted average of 25.2 percent.[70]

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 US and ROW sources. There are, however, many products for which imports arrive from either the US or the ROW, but not from both regions. Consider the case of imports arriving only from US sources. Suppose a product with relatively high unobserved trade costs from ROW sees imports arrive only from the US. 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 $Vshr^k_t$ and $Cntr^k_t$ 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.

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[70] In unreported results we estimate using fixed effects to control for demand shocks at the HS2-year rather than HS6-year level. The sign patterns are again consistent, and the distribution of $\overline{\tau}^k_{JA}$ for column 5 shows a simple average of 33.2 percent and a traded weighted average of 57.2 percent.

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 US using a version of the Feenstra (1994) estimator. We estimate a set of structural regressions akin to those in Table 6, 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 $\hat{\tau}^k_{JA}$'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).[71] The predicted values of $\overline{\tau}^k_{JA}$'s implied by the Soderbery (2015) estimates are reported in Table 7. 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* 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.[72]

We also consider the implications of using the implied estimate of σ that is the coefficient estimate on the US tariff variable in column 5 of Table 5. 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.[73] 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.

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[71] 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.

[72] 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 $\widehat{\overline{\tau}}^k_{JA}$, 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.

[73] These estimates of $\overrightarrow{\gamma}$ are calculated by dividing the reduced form coefficients $\overrightarrow{\beta}$ (from Table 5) by the estimated value of σ, the coefficient on the MFN tariff in Table 5.

Table B4: Structural Estimates for BEC Consumption Goods

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M_{j,t}^k$		
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_t^k		-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)
$Ctnr_t^k$		1.916***	-0.125	-4.570***	-4.401***
		(0.330)	(0.250)	(0.970)	(0.949)
$\sigma^k \times Vsh_t^k \times HOME_j$			-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)
$\sigma^k \times Ctnr_t^k \times HOME_j$			0.357***	0.0770	0.0483
			(0.0642)	(0.0952)	(0.100)
$\sigma^k \times Vsh_t^k \times \ln(dist_j)$				-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)
$\sigma^k \times Ctnr_t^k \times \ln(dist_j)$				0.106***	0.106***
				(0.0254)	(0.0245)
$\sigma^k \times \ln(1 + tar_{j,t}^k)$					-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)
$IHST(\widetilde{X}_{j,t}^k)$	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
US PTAs Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.395	0.400	0.408	0.411	0.418
Average Weight to Value	0.244	0.244	0.244	0.244	0.244
Average Distance to USA (km)	3,701	3,701	3,701	3,701	3,701

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 $M_{j,t}^k$, 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. 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

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M_{j,t}^k$		
$\ln(dist_j)$	-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_t^k		-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)
$Ctnr_t^k$		-0.465***	-1.737***	8.865***	12.21***
		(0.105)	(0.128)	(1.344)	(1.286)
$Vsh_t^k \times HOME_j$			-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)
$Ctnr_t^k \times HOME_j$			3.598***	2.798***	2.854***
			(0.225)	(0.206)	(0.221)
$Vsh_t^k \times ln(dist_j)$				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)
$Ctnr_t^k \times ln(dist_j)$				-1.235***	-1.658***
				(0.164)	(0.156)
$\ln(1 + tar_{j,t}^k)$					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)
$IHST(\widetilde{X}_{j,t}^k)$	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
US PTAs Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.486	0.503	0.514	0.520	0.563
Average Weight to Value	0.517	0.517	0.517	0.517	0.517
Average Distance to USA (km)	3,701	3,701	3,701	3,701	3,701

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 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

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M^k_{j,t}$		
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's Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.600	0.616	0.617	0.617	0.623
Average Weight to Value	0.500	0.500	0.500	0.500	0.500
Average Distance to USA (km)	3,415	3,415	3,415	3,415	3,415

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

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M_{j,t}^k$		
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_t^k		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)
$Ctnr_t^k$		-0.922***	-0.989***	-1.182***	-1.193***
		(0.135)	(0.138)	(0.208)	(0.209)
$\sigma^k \times Vsh_t^k \times HOME_j$			-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)
$\sigma^k \times Ctnr_t^k \times HOME_j$			0.0166*	-0.00186	0.00206
			(0.00886)	(0.0166)	(0.0162)
$\sigma^k \times Vsh_t^k \times \ln(dist_j)$				-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)
$\sigma^k \times Ctnr_t^k \times \ln(dist_j)$				0.00376	0.00340
				(0.00229)	(0.00230)
$\sigma^k \times \ln(1 + tar_{j,t}^k)$					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)
$IHST(\widetilde{X}_{j,t}^k)$	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's Dummy Variables	NO	NO	NO	NO	YES
Pseudo R2	0.581	0.612	0.612	0.616	0.620
Average Weight to Value	0.499	0.499	0.499	0.499	0.499
Average Distance to USA (km)	3,129	3,129	3,129	3,129	3,129

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 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

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M_{j,t}^k$		
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
Average Weight to Value	0.516	0.516	0.516	0.516	0.516
Average Distance to USA (km)	2,321	2,321	2,321	2,321	2,321

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's Dummy variables because the Bahamas has no PTA in place.

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

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M^k_{j,t}$		
$\ln(dist_j)$	-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^k_t		-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)
$Ctnr^k_t$		0.0927	0.231*	-0.482	1.851***
		(0.104)	(0.119)	(0.766)	(0.660)
$Vsh^k_t \times HOME_j$			-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)
$Ctnr^k_t \times HOME_j$			-0.531***	-0.555***	-0.788***
			(0.186)	(0.192)	(0.192)
$Vsh^k_t \times \ln(dist_j)$				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)
$Ctnr^k_t \times \ln(dist_j)$				0.0918	-0.170**
				(0.0886)	(0.0785)
$\ln(1 + tar^k_{i,t})$					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)
$IHST(\widetilde{X}^k_{j,t})$	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's Dummy variables	NO	NO	NO	NO	YES
Pseudo R2	0.668	0.680	0.684	0.685	0.669
Average Weight to Value	0.500	0.500	0.500	0.500	0.500
Average Distance to USA (km)	3,415	3,415	3,415	3,415	3,415

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 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

	(1)	(2)	(3)	(4)	(5)
VARIABLES			$M_{j,t}^{k}$		
$\ln(dist_j)$	-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's Dummy variables	NO	NO	NO	NO	YES
Pseudo R2	0.649	0.670	0.675	0.678	0.674
Average Weight to Value	0.499	0.499	0.499	0.499	0.499
Average Distance to USA (km)	3,129	3,129	3,129	3,129	3,129

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 Jamaicas'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

	(1)	(2)	(3)	(4)	(5)
VARIABLES	$M^k_{j,t}$				
$\ln(dist_j)$	-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
Average Weight to Value	0.516	0.516	0.516	0.516	0.516
Average Distance to USA (km)	2,321	2,321	2,321	2,321	2,321

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's Dummy variables because the Bahamas has no PTA in place.