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Trade Costs and the Suez and Panama Canals

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Highlights

- We take advantage of three major episodes of international trade to estimate the distance elasticity of trade and characterize its evolution over time.
- Our estimates show that the impact of distance on trade flows is much lower than previously reported in the literature.
- We use these results to provide the first quantification of general equilibrium trade and welfare effects arising from the openings of the Suez and the Panama Canals.

RESEARCH AND EXPERTISE ON THE WORLD ECONOMY

Abstract

Current estimates offer a puzzling picture of the magnitude and historical evolution of the distance elasticity of trade. We take advantage of historical episodes that changed bilateral distance to estimate the distance elasticity in the time dimension and characterize its evolution over time. The openings of the Suez and Panama Canals -- as well as the closure of the Suez Canal from 1967 to 1975 -- allow us to control for unobserved time-invariant country pair characteristics in a gravity setting. Our estimates show that the impact of distance on trade remains particularly low, even if it has increased during the last half century. These results reconcile the distance elasticity of trade with its two components: the elasticity of trade to trade costs and the elasticity of trade costs to distance. In a second stage, we use these estimates to quantify the trade and welfare effects associated with the openings of the Suez and Panama Canals. We also perform the counterfactual exercise of closing the Panama Canal in 2012 to evaluate its current welfare effect.

Keywords

Distance Elasticity, Distance Puzzle, Gravity, Suez Canal, Panama Canal, Welfare Effects of Trade.

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RESEARCH AND EXPERTISE
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Trade costs and the Suez and Panama Canals[1]

Jules Hugot* and Camilo Umana Dajud†.

1. Introduction

This paper tackles two questions. The first one is historical: we shed new light on the impact of the Suez and Panama Canals on trade patterns and welfare. The Suez and Panama Canals opened in 1869 and 1920 respectively.[2] Both canals were considered by their contemporaries as major breakthroughs for international trade and the economic development of some regions of the world (Fletcher, 1958, Maurer and Yu, 2008). No study, however, has quantified the impact of these inter-oceanic canals on international trade patterns and welfare. The second question relates to the "distance puzzle" in the trade literature. The widespread use of the gravity equation has yielded thousands of estimates of the elasticity of trade to distance. The "distance puzzle" groups together two perplexing results: the large magnitude of the distance elasticity – which is generally estimated close to unity – and the finding that the negative effect of distance on trade has risen since 1950 (Head and Mayer, 2013, Disdier and Head, 2008).

Grossman (1998) was among the firsts to notice the large magnitude of the distance elasticity. He remarks that: [these] "*estimates imply that in 1985 West Germany's trade with a partner country located 1,000 miles away was on average 4.7 times as great as that with a country of similar income located 10,000 miles away. In a world of modest transport costs, these findings are unexpected to me.*"[3] He then adds: "*I suspect that shipping costs are no more than perhaps 5 percent of the value of traded goods, on average.* Given this, he highlights that the actual distance elasticity should be less than -0.03. Hereafter, we refer to the unexpected large magnitude of the distance elasticity as the distance puzzle in level.

[1]We are grateful to Thierry Mayer, Kevin H. O'Rourke, Christopher M. Meissner, Dennis Novy, Paul S. Sharp, Costas Arkolakis for helpful comments. This research was improved by the comments from the participants of the World Congress of Cliometrics (Honolulu), ETSG (Paris), Conference on International Economics (San Sebastian and La Coruña), Roundtable on Geography, Trade and Development (Panama City), and seminars at CEPII, Sciences Po and P.U. Javeriana.
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[2]The Suez Canal opened on November 17 1869. The Panama Canal formally opened on August 15, 1914; but it was only fully opened to commercial traffic on July 12, 1920.
[3]Referring to an estimate of 1.21 for the distance elasticity obtained in McCallum (1995).

The second surprising finding is the evolution of the distance elasticity since c. 1950. Disdier and Head (2008) compile 1,467 distance elasticities, estimated in 103 different papers. The authors note that their "*most striking finding is that, after slightly decreasing in the first half of the century, the distance effect begins to rise around 1950*".[4] Once again, this finding challenges the view that the world has become flatter during the latest wave of globalization. We refer to the increase of the effect of distance on trade as the distance puzzle in trend.

In this paper we exploit the opening of the Suez and Panama Canals – as well as the closure of the Suez Canal from 1967 to 1975 – to provide new insights on these puzzles. Specifically, we build upon the methodology introduced by Feyrer (2011) and use the changes in sea distance triggered by these episodes as a source of exogenous variation of shipping distances. We use these events to estimate the distance elasticity in the time dimension, via a gravity equation that includes directional pair fixed effects to control for any long-run pair specific determinants of trade. We thus identify the shipping distance elasticity in the time dimension.

We improve the methodology from Feyrer (2011) in two aspects. First, we follow the most recent developments in the gravity theory. In particular, we include a full set of time-varying origin and destination fixed effects in our regressions. These fixed effects perfectly control for the multilateral resistance terms emphasized in the structural gravity literature.[5] Second, we use the PPML estimator to include zero trade flows and to handle the heteroskesdasticity arising from the log linearization of the gravity equation (Santos Silva and Tenreyro, 2006).

We begin by estimating the distance elasticity using the closing (1967) and the reopening (1975) of the Suez Canal. Our preferred specification yields a trade elasticity of -0.15, which is significantly lower than the typical values found in the literature.[6] In particular, our distance elasticities are compatible with the magnitudes of the trade elasticity of trade costs and the elasticity of trade costs to distance commonly found in the literature. This suggests that our estimation technique reflects more accurately the actual effect of distance on trade patterns, as they are purged of other confounding factors. In a nutshell, we use the unexpected changes in distance triggered by the opening and closing of the Suez Canal to offer a new estimate of the distance elasticity that does not reveal a distance puzzle in its formulation in level.

We then apply the same method to estimate the distance elasticity around the openings of the Suez and Panama Canals. In both cases our estimates of the distance elasticity are lower than those previously reported in the literature. Moreover the sharp difference in the magnitude of the distance elasticity around the opening of the Panama Canal (1920) and the closure and

[4] The rising magnitude of the distance elasticity had been previously mentioned in Leamer and Levinsohn (1994).

[5] Failure to control for multilateral resistance terms has been shown to be a severe source of bias in gravity estimations (Baldwin and Taglioni, 2006) and is inconsistent with the multiple theoretical models that yield the gravity equation (Head and Mayer, 2014). Pair fixed effects are not sufficient since time series correlations between multilateral resistance terms and other variables are not eliminated.

[6] And also significantly lower than the values reported in Feyrer (2011).

reopening of the Suez Canal (1967-1975) casts doubt on the increase of the effect of distance on trade, purged of confounding factors, starting in the 1900s.

In a final step we quantify general equilibrium changes in trade and welfare triggered by the openings of both canals. Specifically, we estimate a structural gravity model using the distance elasticities we have obtained. Then, we construct counterfactual trade patterns and welfare, had the canals not been opened. We show that the opening of the canals significantly affected a number of countries. Moreover, we show the importance of using unbiased estimates of the distance elasticity when evaluating the economic impact of future transportation infrastructure projects. This methodology can be extended to analyze the effects of any changes in shipping distance, whether involved by the construction of new canals or the melting of the ice cap.

Our paper is related to two strands of the literature. The first one, that focuses on the historical economic impact of the Suez and Panama Canals, is fairly narrow. To the best of our knowledge, Fletcher (1958) is the only study on the economic impact of the Suez Canal. He argues that the Suez Canal, "*in bringing India nearly six thousand miles closer to Western Europe, vitally altered the pattern of trade relations which had previously existed*", to the great benefit of the United Kingdom.[7] Contemporary anecdotal evidence from *The Economist* confirms this insight: "*The canal had been cut by French energy and Egyptian money for British advantage*".[8] Our estimates of welfare gains confirm that Britain was indeed the nation that gained the most from the Suez Canal, directly, but also through its territories in Asia.

While the recent expansion of the Panama Canal has received widespread attention, the literature on the economic impact of its opening is extremely reduced. Maurer and Yu (2008, 2011) evaluate the impact of the opening of the Panama Canal on the U.S. economy. As "*only 25 percent of all cargo passing through the canal traveled non-U.S. routes*", they argue that most of the impact of the Panama Canal concentrated on the United States.[9] They find welfare gains for the United States in the range of 27 to 140 million of 1925 constant U.S. dollars per year for the 1921-1937 period, which corresponds to .14% to .76% of the U.S. GDP, depending on the year of interest.[10] They do not, however, take into consideration the impact of the canal on other economies. We formally show here for the first time that even if an important share of the traffic passing through the Panama Canal served coast-to-coast U.S. routes, the canal had a sizable impact on several other economies.

This paper is also linked to the literature on the distance puzzle. A number of solutions to this puzzle have been proposed. Buch and Kleinert (2004) argue that changes in distance-related

[7] pp. 567-568.

[8] The Economist, XXVII, 1869.

[9] p. 702.

[10] See: Table 5.4B, p. 152. We relate the welfare estimates from Maurer and Yu (2011) to the U.S. GDP using data on the U.S. CPI from Officer (2015).

costs are picked up by the constant term in gravity regressions; Bosquet and Boulhol (2013) show that the distance elasticity is close to stable after 1950, when estimated using PPML; Felbermayr and Kohler (2006) find a decline of the distance elasticity over time using Tobit and Probit estimations; but their coefficients remain unexpectedly high. Carrère and De Melo (2009) remark that the rise of the distance elasticity is mainly explained by the expansion of short distance trade among poor countries. Finally, Yotov (2012) shows that the distance elasticity is stable when internal trade flows are included in gravity regressions. Despite all the proposed solutions, the distance puzzle remains virtually unanswered. In particular, the estimated distance elasticities remain large in all of these studies. Besides, the vast majority of them does not document a considerable reduction of the distance elasticity over time.[11]. In the end, Carrere and De Melo (2013) argue that while "*these new developments can change the amplitude of the increase in the trade elasticity to distance, they do not solve the distance puzzle.*" In addition, Head and Mayer (2014) show that the puzzle is robust to the use of different estimators (PPML, OLS, Tobit, etc.) as well as to the use of different samples.

This paper largely relies on data collected for Fouquin and Hugot (2016a). Here we simply emphasize some important features of this data. The bilateral trade statistics after 1948 overwhelmingly come from the Direction of Trade Statistics of the International Monetary Fund (2002 and 2015). The bilateral data before 1948 relies on various sources, detailed in Fouquin and Hugot (2016b). This data is reported in current British pound sterling. The shipping distances with and without the canals has been extracted from Vesseltracker.com (2016).

The next section introduces the method used to estimate the shipping distance elasticity. Section 3 implements that method to estimate the shipping distance elasticity around the time of the Six-Day War. In section 4, we argue that our estimates solve the distance puzzle. In section 5, we estimate the distance elasticity around the openings of the Suez and Panama Canals. Section 6 presents the partial equilibrium trade impacts of the two canals. In section 7, we use a the structural method to obtain the general equilibrium trade and welfare impact of both canals. Section 8 simulates a closure of the Panama Canal in 2014 to illustrate the importance of correctly estimating the impact of distance on trade. Section 9 provides concluding remarks.

2. Estimation of the shipping distance elasticity in the time dimension

Our estimations of the shipping distance elasticity build upon the method introduced by Feyrer (2011). Specifically, Feyrer relies on the changes of shipping distance across time, consecutive

[11] Felbermayr and Kohler (2006) is a noticeable exception where Tobit and Probit estimators reveal a reduction of the distance elasticity over time. However, the magnitude of the distance elasticity remains very high (between -4.5 and -1.7) even for the latest period. Moreover, Santos Silva and Tenreyro (2006) have compellingly shown that the Tobit and Probit estimators introduce a large bias when estimating gravity equations.

to the closing of the Suez Canal that began during the Six-Day War (1967) and lasted until 1975. This unusual feature for a measure of distance allows him to include pair fixed effects in a gravity regression and therefore estimate the distance elasticity in the time dimension. Arguably, this elasticity reveals the trade elasticity of shipping costs in a more precise way compared to cross-sectional estimates. Indeed, distance is correlated with transportation costs but also with a variety of other cross-sectional features that affect trade, including preferences, trade policies and cultural similarities. We refine the method from Feyrer (2011) in two aspects. First we estimate the shipping distance elasticity in a theory-consistent framework.[12] In the context of a panel estimation, the structural gravity equation writes:

$$X_{ijt} = \frac{Y_{it}\, X_{jt}}{P_{it}\, \Pi_{jt}}\, \tau_{ijt}^{\epsilon}, \tag{1}$$

where X_{ijt} are nominal exports from country i to j in year t. Y_{it} and X_{jt} are respectively production in the origin and expenditure in the destination country. P_{it} and Π_{jt} are outward and inward multilateral resistance terms ($P_{it} = \sum_{\ell} \frac{\tau_{i\ell t}^{\epsilon}\, X_{\ell t}}{\Pi_{\ell t}}$ and $\Pi_{jt} = \sum_{\ell} \frac{\tau_{\ell jt}^{\epsilon}\, Y_{\ell t}}{P_{\ell t}}$, where ℓ indexes third countries). τ_{ijt} is a bilateral iceberg trade cost. $\epsilon < 0$ is the trade elasticity of trade costs.

We model trade costs as follows:

$$\tau_{ijt} = SeaDist_{ijt}^{\alpha} \times Z_{ij} \times \eta_{ijt}, \tag{2}$$

where $SeaDist_{ijt}$ is the (time-varying) bilateral shipping distance. Z_{ij} reflects the time-invariant bilateral components of trade costs, together with their respective elasticity to trade costs. η_{ijt} reflects the unobserved bilateral time-varying components of trade costs.

Structural gravity equations systematically include multilateral resistance terms. In fact, it seems intuitive that bilateral trade should not only be affected by bilateral frictions and countries' economic size, but also by every country's alternative options for allocating its trade. In structural gravity equations, the inward and outward resistance term respectively reflect the overall accessibility of the origin and destination market. Yet P_{it} and Π_{jt} are not observable and therefore omitted from atheoretical estimations. Moreover, τ_{ijt} enters in the definition of the multilateral resistance terms. In turn, trade costs are correlated with multilateral resistance terms. Any estimation of the impact of trade costs on trade is therefore biased as long as the correlation with the multilateral resistance terms is not accounted for.[13]

[12]For a review of the gravity literature, see: Head and Mayer (2014).

[13]Baldwin and Taglioni (2006) have coined the failure to control for the multilateral resistance terms the "gold medal mistake" in the gravity literature.

Feyrer (2011) only includes country-pair effects to control for these terms, because he later uses changes in distance to instrument changes in trade. This procedure prevents him from including country-year effects to fully control for the correlation between omitted resistance and the error term. In fact, the pair effects in Feyrer's regressions only remove the time invariant omitted determinants of multilateral resistance. The resulting estimates are therefore biased.

In our case, both shipping distance and bilateral trade costs vary over time. We assume that distance affects bilateral trade costs through elasticity α. Yet trade costs are included in the multilateral resistance terms. This implies that shipping distance and multilateral resistance terms are correlated in the time dimension. We therefore follow Baldwin and Taglioni (2006) and add time-varying country effects to ensure that our estimates of trade cost are unbiased.[14] Finally, contrary to Feyrer, we do not include year dummies, as they would be perfectly collinear with the time-varying country effects.

While Feyrer (2011) estimates the distance elasticity using OLS, our preferred estimates rely on the PPML estimator. First, the PPML allows the inclusion of observed zero trade flows.[15] These flows are not randomly distributed among trade partners and contain information on trade costs. Second, PPML estimates are robust to several patterns of heteroskedasticity arising in gravity equations (Santos Silva and Tenreyro, 2006).[16] Our benchmark results therefore rely on the structural gravity equation estimated using the PPML estimator:

$$X_{ijt} = F_{ij} + F_{it} + F_{jt} + \beta \text{ ln } SeaDist_{ijt} + \text{ln } \eta_{ijt}. \tag{3}$$

β is the shipping distance elasticity ($\beta = \alpha \times \epsilon$). η_{ijt} is an error term. F_{ij} is a direction-specific pair fixed effect. F_{it} and F_{jt} are respectively origin and destination-year effects, that perfectly control for the monadic determinants of trade, including multilateral resistance terms. Any β estimated from equation (3) is therefore a structural estimate of the trade elasticity of distance.

[14] *"Country dummies are not enough in panel data. Omitted terms Ω and P reflect factors that vary every year. If the researcher ignores this point and includes time-invariant country dummies (as is common practice) then only part of the bias is eliminated."* (Baldwin and Taglioni, 2006).

[15] Zero trade observations account for 42% of the data from Fouquin and Hugot (2016b), from which we draw the samples used in this paper.

[16] It should be noted that incidental parameter bias is a minor concern for estimations of the gravity equation using the PPML. Fernández-Val and Weidner (2014) prove that in panels with large N and T, there is no incidental parameter bias when the regressors are strictly exogenous. Similarly Jochmans (2015) proposes a strategy to construct GMM estimators that completely eliminate incidental parameter bias with two-way fixed effects and disturbances that enter in a multiplicative manner. Thes resulting estimations are very close to those obtained using the PPML, suggesting that incidental parameter bias is of no concern.

3. The shipping distance elasticity around the Six-Day War

We begin by replicating the results from Feyrer (2011) using the same equation:[17]

$$\ln X_{ijt} = F_{ij} + F_t + \beta \ln SeaDist_{ijt} + \ln \eta_{ijt}, \quad (4)$$

where F_{ij} is a (non direction-specific) pair fixed effect and F_t is a year effect. The error term captures the bilateral time-varying components of trade costs that are not related to distance, as well as time-varying country-pair characteristics. In turn, the omitted multilateral resistance terms are correlated with the error term, which is a source of bias for the estimates of β.

Table 1 compares our results with Feyrer's. Our samples are between four and five larger. Our estimates are systematically lower than Feyrer's (Table 1, columns 2 and 4). The difference is significant at the 5% level for the unbalanced sample.

Table 1 – Replication of the results from Feyrer (2011)

	(1) Feyrer (2011)	(2) This paper	(3) Feyrer (2011)	(4) This paper
Distance elasticity	-0.27***	-0.19***	-0.46***	-0.24***
	(0.07)	(0.04)	(0.08)	(0.05)
R-squared	0.87	0.88	0.90	0.86
Observations	46,726	183,381	27,174	113,474
Country pairs	2,605	6,235	1,294	2,581
Sample	1958-1984	1958-1984	1958-1984	1958-1984
Balanced sample	–	–	Yes	Yes
Simple Pair effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses, clustered by directional country pair.

Table 2 reports the shipping distance elasticities that are obtained through our more constraining OLS and PPML specifications, that include i) country-year fixed effects, as required by the structural gravity literature, ii) directional pair fixed effects, and iii) standard errors clustered at the country pair level. Columns (1) and (4) reproduce the results from Feyrer (2011), respectively for his unbalanced and balanced sample. Columns (2-3) and (5-6) report our estimates,

[17] As in Feyrer (2011), we estimate equation 4 using OLS on data for 1958-1984, excluding i) the two shock years – 1967 and 1975 – as well as the two following years, ii) the countries for which oil accounts for more than 50% of exports in 1970 and iii) the countries involved in the Six-Day War and their immediate neighbors.

respectively for our unbalanced and balanced sample. Our estimates are very close to -0.15, regardless of the sample and estimation technique and they are significantly lower than those obtained by Feyrer (2011). On top of the data itself, the mis-specification of Feyrer's equation thus leads to upward biased estimates, as the correlation between trade costs and the multilateral resistance terms is not entirely neutralized. These results suggest that our more constraining specifications yield estimates that better reflect the actual effect of shipping distance on trade.

Table 2 – Shipping distance elasticities estimated on the closing of the Suez Canal during the Six-Day War

	(1) Feyrer (2011)	(2) This paper	(3) This paper	(4) Feyrer (2011)	(5) This paper	(6) This paper
Distance elasticity	-0.27***	-0.17***	-0.15	-0.46***	-0.14***	-0.14
	(0.07)	(0.05)	(0.095)	(0.08)	(0.06)	(0.10)
R-squared	0.87	0.90	–	0.90	0.96	–
Observations	46,726	183,381	64,800	27,174	113,474	53,175
Country pairs	2,605	6,235	3,204	1,294	2,580	2,405
Estimator	OLS	OLS	PPML	OLS	OLS	PPML
Sample	1958-84	1958-84	1958-84	1958-84	1958-84	1958-84
Balanced sample	–	–	–	Yes	Yes	Yes
Simple Pair effects	Yes	–	–	Yes	–	–
Year effects	Yes	–	–	Yes	–	–
Directional Pair effects	–	Yes	Yes	–	Yes	Yes
Country-year effects	–	Yes	Yes	–	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses, clustered by directional country pair.

Table 3 breaks the data in two sub-samples that cover 1958-1970 and 1970-1984. The identification therefore respectively comes from the 1967 closing and the 1975 re-opening of the Suez Canal. Interestingly, the estimates using these sub-samples are somewhat lower compared to the estimation obtained from the broader sample, which includes both shocks. Figure 1 plots the two estimates from the unbalanced samples of Table 3 against shipping distance elasticities estimated in the cross section for each year, extracted from Fouquin and Hugot (2016a). The time-dimension estimates are remarkably lower than cross section estimates.

Table 3 – PPML Shipping distance elasticities estimated around the closing (1958-1970) and the re-opening (1970-1984) of the Suez Canal

	(2)	(3)	(4)	(5)
Distance elasticity	-0.07***	-0.05***	-0.09***	-0.09***
	(0.023)	(0.024)	(0.012)	(0.012)
Observations	30,263	25,524	30,263	25,524
Country pairs	3,204	2,405	3,203	2,405
Sample	1958-1970	1958-1970	1970-1984	1970-1984
Balanced Sample	–	Yes	–	Yes
Directional pair effects	Yes	Yes	Yes	Yes
Country-year effects	Yes	Yes	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.

4. Time dimension shipping distance elasticities and the distance puzzle

As emphasized in the previous section, our estimations of the shipping distance elasticity around the Six-Day War are significantly lower than the traditional cross-sectional estimates. How plausible are these numbers? The trade elasticity of distance can be decomposed into a trade-to-trade costs elasticity and a trade cost-to-distance elasticity:

$$\beta = \epsilon \times \alpha = \frac{\partial \ln \text{Trade}}{\partial \ln \text{Trade costs}} \times \frac{\partial \ln \text{Trade costs}}{\partial \ln \text{Distance}}. \quad (5)$$

When the distance elasticity is estimated in the cross section, α captures the response of trade costs to shipping distance, but also to other characteristics that are correlated with distance, including cultural proximity, migration history, etc. The lower magnitude of our time dimension distance elasticities is thus a sign that our estimates are purged from these factors.

In order to evaluate the realism of our estimates, we need to compare them to the available measures of ϵ and α. Head and Mayer (2014) perform a meta-analysis of 744 estimates of ϵ, extracted from 32 articles mostly based on post-World War II data. In structural gravity frameworks, they find a median elasticity of -3.78. Fouquin and Hugot (2016a) provide estimates of the trade elasticity for 1829-1913 and find median coefficients of -4.84 and -5.07, respectively in a cross sectional and a longitudinal specification. The available estimates of the trade elasticity therefore lie in the range of -3 to -6. In section 7 we also estimate the trade elasticity for the period around the turn of the twentieth century using the variation of tariffs (Table 9) and wages (Table 10). We obtain values ranging from -2 to -4.

The effect of distance on delivery costs (α) has been estimated using different methods. FOB and CIF values have been used to deduce transport costs from customs data (Geraci and Prewo, 1977, Limao and Venables, 2001, Hummels, 2007). An alternative method uses data on actual shipping costs (Limao and Venables, 2001). Head and Mayer (2014) review these estimates and argue that any reasonable values lies in the range of 0.01 to 0.07.

Based on these estimates, the distance elasticity should therefore fall in the range of -0.03 to -0.42, which considerably deviates from -1, the typical elasticity estimated in a cross-sectional gravity framework.[18] Head and Mayer (2013) coin the term "dark distance cost" to refer to the correlation between distance and trade that is not due to shipping costs. They attribute these hidden costs to various characteristics that are both detrimental to trade and correlated with distance, including cultural and linguistic barriers. The shipping distance elasticities we estimate for the closing of the Suez Canal lie roughly halfway between these two values, around -0.15 (Tables 2 and 3). Contrary to traditional estimates of the distance elasticity, our estimates can thus be reconciled with reasonable values of both the trade elasticity and the freight costs-to-distance elasticity. This suggests that our estimates constitute a reasonable approximation of the actual effect of shipping costs on trade. It is also remarkable that Grossman's (1998) guess of the correct trade elasticity of distance lies inside almost every 95% confidence interval of the estimates reported in Tables 2 and 3.

5. Long run changes in the shipping distance elasticity of trade

We now turn to estimations of the shipping distance for the years around the opening of the Suez and Panama Canals. The construction of these canals offers an ideal framework for estimating the impact of shipping distance on trade. Beyond triggering large and asymmetric changes in distance, these complex infrastructure projects were subject to large uncertainty both in terms of their success and opening date. This uncertainty limited the possibility for merchants to anticipate the opening of the canals by focusing more on the trade routes that would eventually be shortened. In any case, this would reduce the estimated effect of the canals.

The first exploration of the feasibility of the Suez Canal was carried out during the French Campaign in Egypt (1798-1801), under the commandment of Napoleon Bonaparte. The engineer who conducted the study, concluded that the level of the Red Sea was higher than that of the Mediterranean, setting the project back by half a century. In 1833, a second project was proposed before being canceled. The construction of the canal eventually began in 1859, despite the fierce opposition of the British, who feared to lose influence in the region. They succeeded to interrupt the project for the first time in October 1859, and later in 1863. The Suez Canal finally opened to commercial traffic on November 17, 1869.

The construction of the Panama Canal was even more hectic. Ferdinand de Lesseps began supervising the construction in 1881. However, by 1889, the company had gone bankrupt. In 1894, a second French company took over the project but failed again to achieve a successful outcome. In 1903, the U.S. government signed a treaty with the Colombian government granting

[18] $0.01 \times -3 = -0.03$ to $0.07 \times -6 = -0.42$

Table 4 – Largest shipping distance reductions due to the Suez and Panama Canals

Suez Canal				Panama Canal			
Country pair		%	km	Country pair		%	km
EGY	GBRIND	74.1	16,579	CUB	SLV	82.9	18,042
GBRIND	USSR	64.4	14,879	ECU	MTQ	77.4	13,418
GBRIND	GBRMEDI	63.1	13,016	BMU	SLV	75.6	15,868
GBRIND	ITA	57.9	11,821	BMU	ECU	73.9	13,994
FRA	GBRIND	55.9	11,240	BRB	PER	68.3	11,003
ESP	GBRIND	53.9	10,512	BMU	PER	66.2	11,766
FRA	FRAIND	49.5	10,038	BMU	BOL	59.2	10,162
PRT	PRTIND	45.6	8,443	NOR	SLV	53.4	12,792
CHN	USSR	44.0	12,718	NLD	SLV	52.0	11,932
GBR	IRN	43.9	9,486	BEL	SLV	51.8	11,932
GBR	GBRIND	42.6	8,803	GBR	SLV	51.7	11,934
GBRIND	NLD	42.4	8,803	FRA	SLV	51.6	11,538
CHISL	CHN	42.3	14,179	SLV	SWE	51.3	12,290
BEL	GBRIND	42.1	8,803	DEU	SLV	50.7	11,932
GBRIND	ZOLL	41.4	8,803	ESP	SLV	50.4	10,805
Simple world mean		4.0	909	Simple world mean		1.5	316
Trade-weighted mean		4.2	911	Trade-weighted mean		0.3	51

Data for 1871 and 1921, respectively for the Suez and Panama Canal.
Sample limited to country pairs for which bilateral trade data is available.

a renewable lease on the land required to build the canal. When the Colombian Senate refused to ratify the treaty, the U.S. government financed a revolution in Panama, which remained a U.S. protectorate until 1939. In 1904, the United States bought the French assets and resumed the construction of the canal, which eventually opened in 1914 to military vessels. The trade disruptions associated with World War I as well as a series of landslides postponed the opening to commercial traffic to 1920.

Table 4 reports the fifteen trade routes for which shipping distance was reduced the most by the openings of the Suez and Panama Canals. Table 5 reports the fifteen countries that were affected by the largest gain of accessibility to world markets, measured by the trade-weighted change in distance with all trading partners the year after the opening of each canal.[19]

For each canal, we estimate equation (3) on an unbalanced and a balanced sample, respectively covering 18 and 8 years of data.[20] Table 6 reports the resulting elasticities. For the Suez Canal, both estimates lie around -0.7 (i.e. between 5 and 14 times the value obtained for 1958-1984). For the Panama Canal, the elasticity estimated on the unbalanced sample is close to -1, while

[19]The correspondence table for country codes can be found in Table 4 of Fouquin and Hugot (2016b).
[20]We drop the opening year of each canal to limit potential noise in the data. Both the magnitude and significance of our results are robust to changes in the window of estimation. Specific results are available upon demand.

Table 5 – Countries with the largest trade-weighted mean distance reductions due to the Suez and Panama Canals

Suez Canal		Panama Canal	
Country	%	Country	%
GBRIND	30.56	ECU	30.97
CHN	12.97	SLV	21.15
GBR	5.68	BOL	19.30
NLD	3.16	PER	17.48
AUSVIC	2.51	CHL	12.16
FRA	2.06	NZL	1.52
AUSNSW	1.80	TON	1.23
ITA	1.50	FJI	1.23
USSR	0.55	GBR	0.41
ESP	0.31	BEL	0.31
USA	0.22	ESP	0.24
ZOLL	0.14	NOR	0.22
PRT	0.11	FRA	0.22
BEL	0.06	SWE	0.17
NOR	0.02	DEU	0.17

Data for 1871 and 1921, respectively for the Suez and Panama Canal.
Sample limited to countries with bilateral trade data available for at least 15 trade partners.

the elasticity estimated on the balanced sample is −2.70. Due to data limitations, our balanced samples are quite small (3,624 and 7,408 observations for Suez and Panama, respectively). For this reason, our preferred estimates are those obtained using the unbalanced samples.

Figure 1 plots the time-dimension shipping distance elasticities obtained from our unbalanced samples against cross-sectional estimates of the same elasticity. Interestingly, the longitudinal elasticities estimated around the openings of both canals are larger than in the cross section, though not significantly different. On the other hand, our elasticities are remarkably lower than their cross-sectional counterpart for 1958-1970 and 1970-1984. These results offer two important insights. First, the (absolute) shipping distance elasticity is much lower for 1958-1984 than for 1912-1930, which is precisely the opposite of the conclusion of the literature on the distance puzzle in trend. Second, the difference between the longitudinal and the cross-sectional estimates is significant in the second half of the twentieth century, but not around the openings of the Suez and Panama Canals. This suggests that the cross-sectional factors (apart from shipping distance) that are correlated with distance and hamper trade have become more important since the interwar period.

Table 6 – PPML estimates of the shipping distance elasticity: Openings of the Suez and Panama Canals

	(1) Suez	(2) Suez	(3) Panama	(4) Panama
Distance elasticity	-0.71***	-0.72***	-0.95***	-2.72***
	(0.29)	(0.28)	(0.30)	(0.57)
Observations	13,508	3,624	39,521	7,408
Country pairs	1,221	470	4,212	982
Sample	1861-1879	1866-1874	1912-1930	1917-1925
Panel	Unbalanced	Balanced	Unbalanced	Balanced
Directional pair effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses, clustered by directional country pair.

In the next step, we track the recent evolution of the shipping distance elasticity by estimating the difference between the distance elasticity in 1958 and later years. The estimates are obtained through the following equation, using PPML on an unbalanced sample that covers 1958-2012:

$$X_{ijt} = F_{ij} + F_{it} + F_{jt} + \beta \ \ln \ SeaDist_{ijt} + \sum_{k=1959}^{2012} (\alpha_k \cdot D_k \cdot \ \ln \ SeaDist_{ijk}) + \ln \ \eta_{ijt}, \qquad (6)$$

where α_k are year-specific coefficients and D_k is a set of dummies set to one in year k. F_{ij}, F_{it} and F_{jt} are respectively country pair, origin-year and destination-year fixed effects. α_k is the difference between the shipping distance coefficient for 1958 and year k. The shipping distance elasticity for year k is therefore: $\beta + \alpha_k$.

Figure 2 reports i) the difference between the distance coefficient in 1958 and later years and ii) the distance elasticity obtained by adding the coefficient for 1958 (β) to the estimated yearly difference (α_k). Figure 2 shows that the shipping distance elasticity decreases until 2003.

The results summarized in Figures 1 and 2 directly relate to the distance puzzle. First, they show that when controlling for multilateral resistance and unobserved pair characteristics, the distance puzzle in level does not hold. The shipping distance elasticity is above -0.42 for the whole period, which is far from the magnitude close to -1 that is commonly estimated in the cross-section. This suggests that unobserved distance-related trade barriers – the "dark distance costs" of Head and Mayer (2013) – explain the large magnitude of the cross-sectional distance elasticity. Second, these results show that the distance puzzle in trend is robust to an

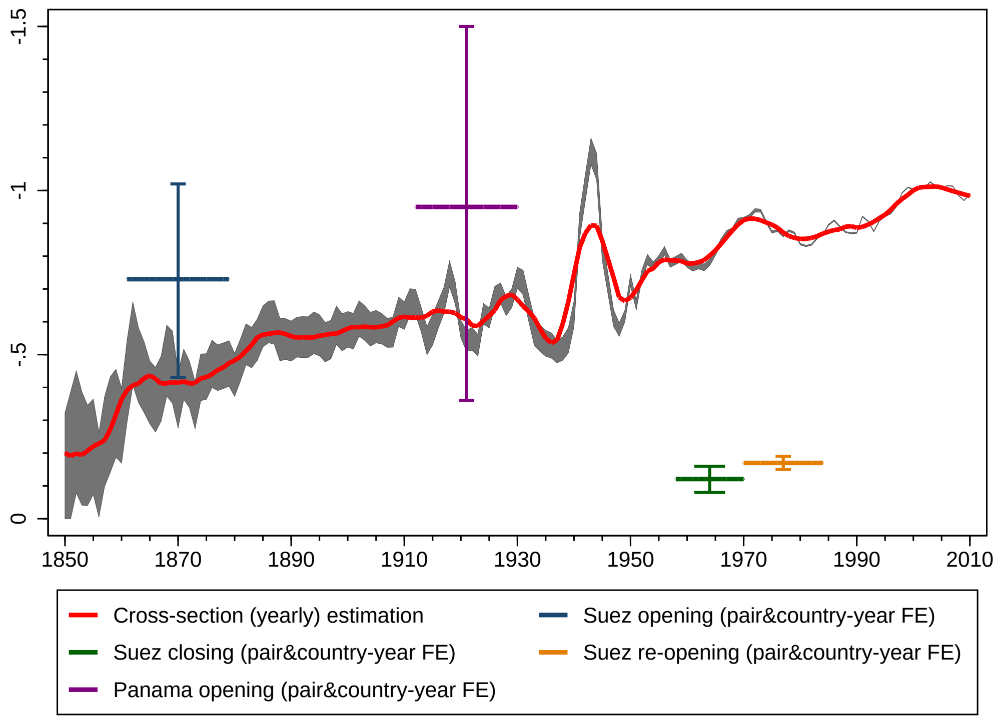

Figure 1 – Shipping distance elasticity: Cross section PPML vs. Time dimension PPML, unbalanced samples

Note: The length of horizontal bars represents the year coverage of the sample. The vertical bars and shaded areas represent 95% confidence intervals. Standard errors clustered at the country pair level.

estimation in the time dimension, at least during the 1958-2003 period. Indeed, as in cross-sectional estimates, the (absolute) distance elasticity increases, which suggests that the distance puzzle in trend is linked to an increase in the reaction of trade to actual shipping distance.

Nonetheless, the distance puzzle in trends is much less of a puzzle given the lower values estimated. With the shipping distance elasticity as low as in our estimates, should we expect a decrease over time? Energy prices being an obvious determinant of shipping costs, the answer is not that obvious. Figure 3 clearly illustrates the negative relationship between our yearly estimates of the shipping distance elasticity (estimated through equation 6) and real oil prices. Table 7 shows that the (absolute) shipping distance elasticity is indeed strongly associated with real oil prices. More precisely, a 10% increase in real oil prices is associated with a 1.22% increase of the distance elasticity. It is also remarkable that the variation of real oil prices explains almost 30% of the variation of the longitudinal shipping distance elasticity.

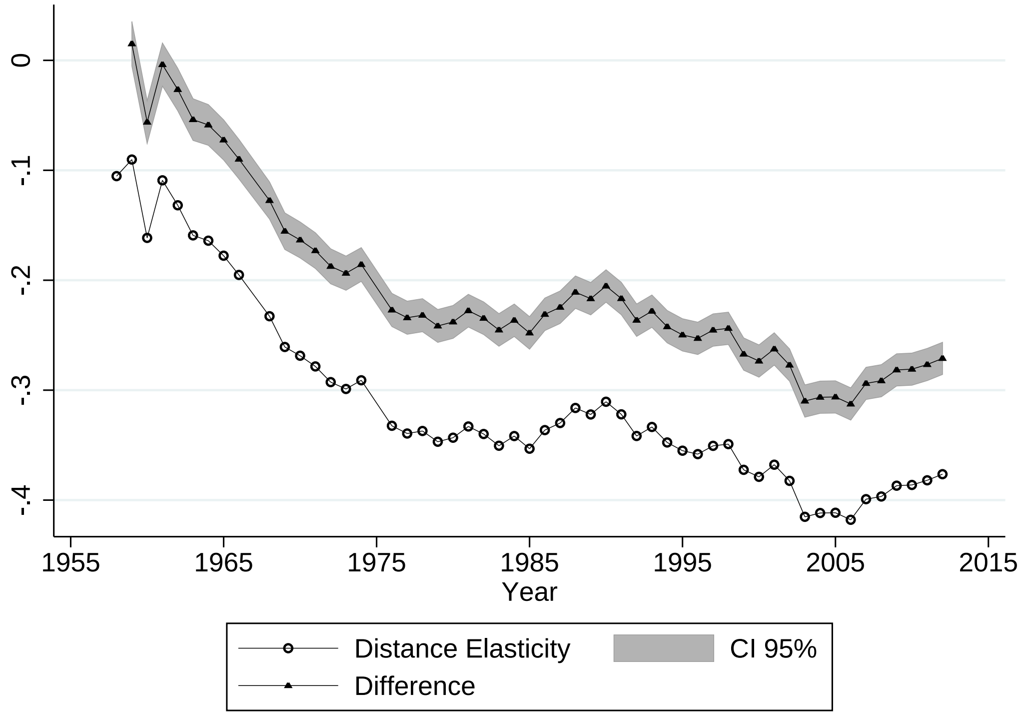

Figure 2 – Yearly distance coefficients

Note: This graph plots the difference between yearly coefficients and the distance coefficient for 1958. The circles represent the distance elasticity for each year. The shaded areas represent 95% confidence intervals.

6. Partial equilibrium trade impact

We now assess the Partial equilibrium Trade Impact (hereafter: PTI) of both canals. More precisely, we use our longitudinal shipping distance elasticities to map counterfactual trade flows, had the canals not been opened.[21] Replacing the actual distance by the distance without the canal in equation (3) yields counterfactual trade flows. We obtain the associated trade-creation for the country pairs that were "brought closer" by the canals, while trade among countries that remained as distant as before is not affected (i.e. the PTI approach ignores trade reallocation). By construction, the pairs for which distance is most reduced appear as the most affected. Table 8 reports the PTI by country and Figures 4 and 5 map PTI changes in total trade.

For the Suez Canal, two regions are particularly affected: Western Europe and Asia. In Europe, the canal has a trade-increasing effect above 2% for Britain, the Netherlands and France. In Asia, trade increases by at least 2% in nine countries: British India, Japan, the Dutch East Indies, Ceylon, China, the Straits Settlements, Southern and Western Australia, Mauritius Island.

[21]We use the PPML estimates of the distance elasticity obtained from the unbalanced samples (columns 1 and 3 of Table 6). We extend counterfactual trade predictions out of the sample by predicting actual as well as counterfactual trade using the estimated coefficients of the fixed effects.

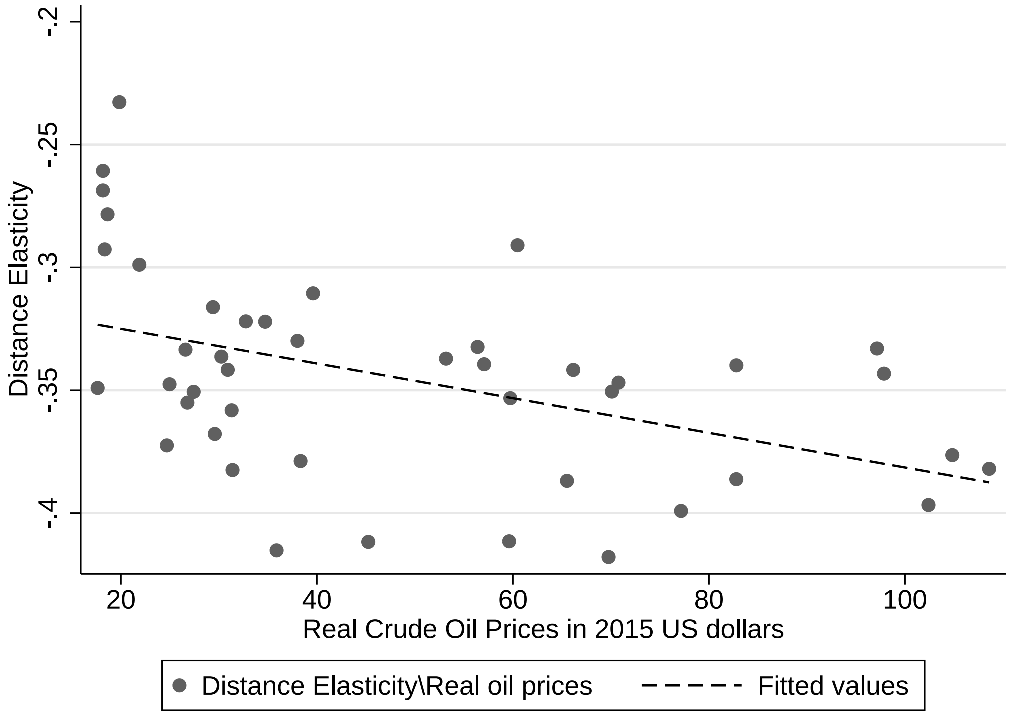

Figure 3 – Yearly distance coefficients vs Real oil prices

Note: Yearly σ's are given by the estimation of equation 6. Data on real oil prices are from the U.S. Energy Information Administration.

Britain, together with its colonies accounts for 64% of the total effect – 42% for Britain itself and 22% for British India –, which confirms the suspicion by *The Economist* that: "*The canal had been cut by French energy and Egyptian money for British advantage*".[22]

For the Panama Canal, Western Europe and western Latin America are particularly affected. In Europe, the trade-increasing effect lies above 0.2% for Britain, Norway, Spain, France, Belgium and Germany. In western Latin America, trade increases by at least 10% in Ecuador, El Salvador, Peru, Bolivia and Chile. Latin American countries account for 40% of the trade-creating effect, while Western European concentrates 48% of the effect. This suggests that the Panama Canal was a major stimulus for the world integration of western Latin America.

7. General equilibrium trade and welfare impact

Changes in bilateral trade costs not only impact bilateral trade, but also trade between third countries. This adjustment is channeled through the multilateral resistance terms – which reflect expenditure-weighted averages of relative access – and subsequent changes in income. In other

[22] The Economist, XXVII, 1869.

Table 7 – Shipping distance elasticity and real oil prices

	Log Bilateral Trade
Log Real Oil Prices	0.122***
	(0.030)
R-squared	0.285
Observations	44

*** p<0.01, ** p<0.05, * p<0.1
Standard errors in parentheses.

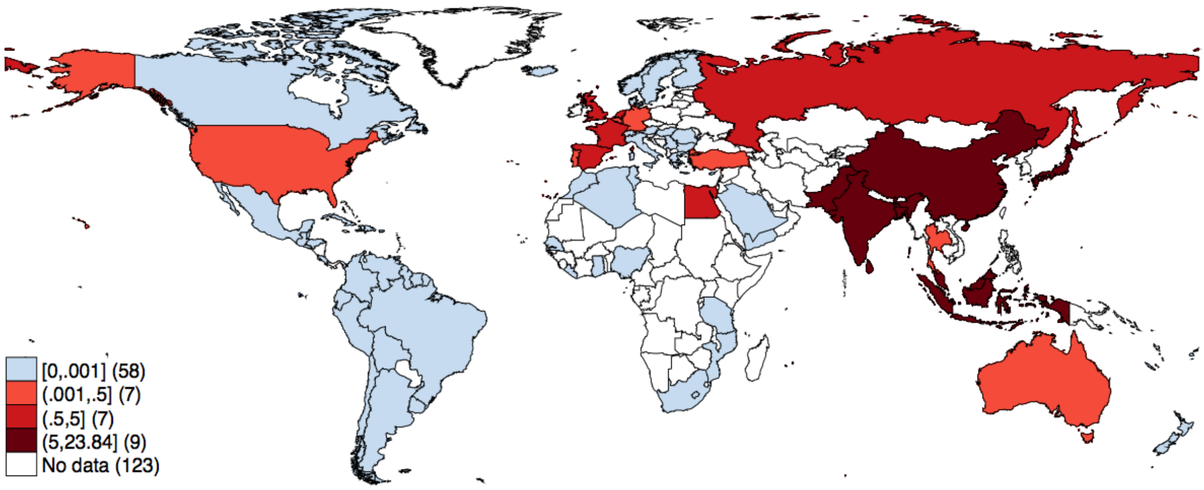

Figure 4 – Partial equilibrium aggregate trade creation: Suez 1879, Full sample (current British pounds)

words, bilateral trade for any country pair can be affected by third country bilateral trade cost changes. The PTI presented in section 6 therefore only partially account for the effect of changes in trade costs. In this section, we rely on a general equilibrium framework, to fully take into account those trade reallocation mechanisms.

We use the method introduced by Dekle and Eaton (2007, 2008) to estimate general equilibrium counterfactual trade patterns. In this approach, multilateral resistance terms and income adjust to changes in trade cost for any third country pair. This procedure has three main advantages. First, Dekle and Eaton (2007, 2008) express the gravity model in terms of changes which greatly reduces the number of parameters to perform counterfactual experiments. Second, the model allows changes in income through changes in wages. The counterfactuals can therefore be rightly considered general equilibrium counterfactuals. Third, Arkolakis and Costinot (2012) show that a broad class of trade models yield the welfare expression of Dekle and Eaton (2007, 2008), including Anderson and van Wincoop (2003), Eaton and Kortum (2002) and Chaney (2008). The robustness of our results are less dependent on a specific trade model or market

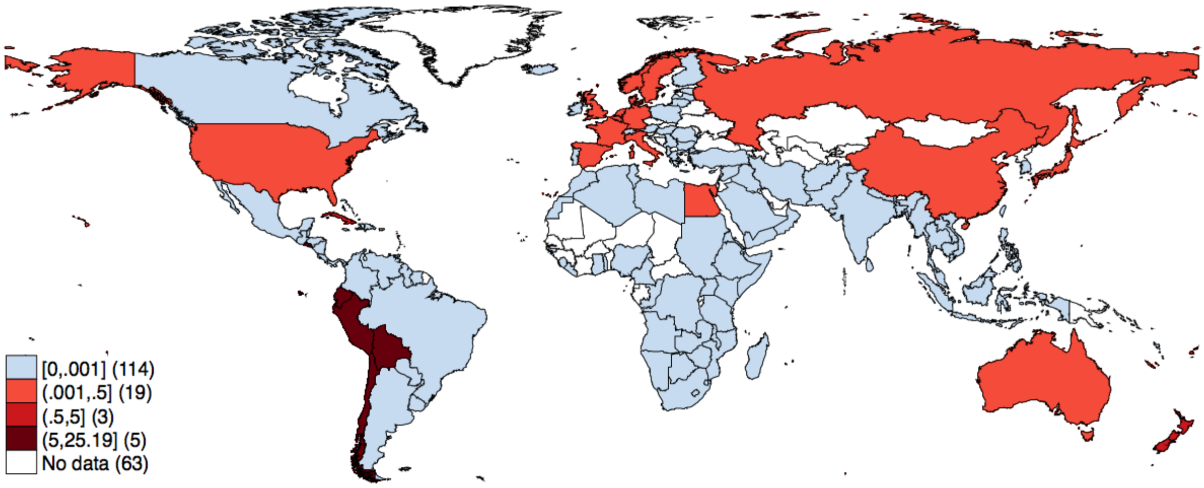

Figure 5 – Partial equilibrium aggregate trade creation: Panama 1930, Full sample (current British pounds)

structure. In practice, Arkolakis and Costinot (2012) show that the welfare effects of trade can be computed using only two sufficient statistics:

$$\widehat{W_j} = \widehat{\pi_{jj}}^{1/\epsilon} \tag{7}$$

where $\widehat{W_j}$ is the change in real income, $\widehat{\pi_{jj}}$ is the change in the share of domestic expenditures and $\epsilon < 0$ is the trade elasticity of trade costs.

This does not tell us, however, how trade costs affect the share of domestic expenditure in a general equilibrium framework. For this purpose, we turn to the procedure proposed by Dekle and Eaton (2007, 2008), in which two important but unobservable endogenous parameters of the model – trade costs and multilateral resistance terms – are perfectly identified by two endogenous but observable parameters: income and trade shares. In turn, these two unobservable parameters can be identified using data on bilateral flows and income. Assuming constant markups and labor as the only source of income, Arkolakis and Costinot (2012) show that trade shares π_{ij} (i.e. the share of i's expenditure allocated to the consumption of j's goods) can be written as follows in most of the trade models that yield structural gravity:

$$\pi_{ij} = \frac{\chi_{ij} N_i (w_i \tau_{ij})^{\epsilon}}{\sum_{\ell} \chi_{j\ell} N_{\ell} (w_{\ell} \tau_{j\ell})^{\epsilon}}, \tag{8}$$

where ℓ indexes third countries. χ_{ij} can be a particular parameter of some model yielding a gravity equation. N_i the number of goods produced. w_i are wages and $\tau_{j\ell}$ is the trade cost between j and third country ℓ. The counterfactual trade shares can be the expressed as:

$$\pi'_{ij} = \frac{\chi_{ij} N'_i (w_i \tau_{ij})^{\epsilon}}{\sum_{\ell} \chi_{j\ell} N'_{\ell} (w_{\ell} \tau_{j\ell})^{\epsilon}}. \tag{9}$$

Under the assumption that N_i is constant, Dekle and Eaton (2008) show that by dividing actual by counterfactual expenditure shares, changes in the share of i in j's spending write:[23]

$$\hat{\pi}_{ij} = \frac{\left(\hat{Y}_i \hat{\tau}_{ij}\right)^{\epsilon}}{\sum_{\ell} \pi_{j\ell} \left(\hat{Y}_i \hat{\tau}_{ij}\right)^{\epsilon}}, \tag{10}$$

where $\hat{Y}_i$ denotes changes in income of country i and $\hat{\tau}_{ij}$ changes in bilateral trade flows.

Using the market clearing condition and equation (10) we obtain changes in income. Finally, we can solve for counterfactual trade flows, incomes and multilateral resistance terms using an iterative procedure.[24]

As noted above, this counterfactual exercise requires a value for the trade elasticity. We estimate ϵ using two different methods. We also provide results using the median estimate from the meta-study of structural trade elasticities of Head and Mayer (2014).[25] Our own estimations rely on data for periods that are close to the opening of the Suez and Panama Canals. They are therefore less subject to the external validity concerns that could arise from using a value extracted from Head and Mayer (2014), which mainly relies on recent data. The first method uses bilateral tariffs as a cost shifter to identify ϵ. We use data for four countries (Algeria, Belgium, France and Spain), spanning 1895-1906 and 1908-1930 to estimate the following equation:

$$\ln X_{ijt} = F_{ij} + F_{it} + F_{jt} + \delta \, D_{ijt} + \epsilon \, \ln\left(1 + Tariff_{ijt}\right) + \ln \, \eta_{ijt}, \tag{11}$$

where X_{ijt} is bilateral trade. D_{ij} is a vector of country pair time-varying controls that includes shipping distance and colonial relationship. F_{it}, F_{jt} and F_{ij} are respectively origin-year, destination-year and directional pair fixed effects. $Tariff_{ijt}$ is a time-varying measure of bilateral

[23] Head and Mayer (2013) re-express that link in a more convenient manner.
[24] Alvarez and Lucas (2007) show that the model has a unique equilibrium.
[25] i.e. −3.78, taken from Table 5, p. 33.

tariffs.[26] Tariffs are approximated by customs duties-to-bilateral imports ratios. It should be noted that this measure is subject to endogeneity, as bilateral imports lie on both sides of the regression. Moreover, customs duties-to-imports ratios are an imperfect measure of tariffs. In the extreme case, prohibitive tariffs cannot be observed as they reduce imports to zero. In turn, our measure of tariffs reflects a lower bound of their actual level. Our estimates are therefore lower (absolute) bounds of the actual value of ϵ.

Table 9 reports the results, estimated with OLS. Columns (1) to (3) report results from less constrained estimations. Columns (1) and (2) exclude directional pair effects. Columns (1) and (3) only include the variable of interest as well as fixed effects. Because the directional pair effects are omitted from Column (2), controls include additional bilateral variables that are fixed across time: $Evercol$, $Comlang$ and $Contig$.[27] Bilateral tariffs have a systematically negative coefficient in the range of -1.34 to -2.11. In our preferred specification (i.e. the most constrained by the fixed effects), ϵ is strongly significant and equal to -2.08 (column 4).

The second method builds upon Eaton and Kortum (2002), who use cross sectional estimates of country fixed effects to capture competitiveness. In a second step, they use wages as a cost shifter to identify ϵ. However, their method suffers from a possible omitted variable bias. We address this concern by exploiting the time variation of our data. Instead of estimating a single country effect, we use our panel to estimate origin-year effects. This enables us to introduce country effects in the second stage, reducing the endogeneity arising from the omitted variable bias. The first step of this method consists in estimating the following equation using OLS:

$$ln\, X_{ijt} = F_{it} + F_{jt} + F_t + \beta \text{ ln } SeaDist_{ijt} + \text{ln } \eta_{ijt}. \tag{12}$$

We then extract the origin-year effects and estimate in a second step:

$$F_{it} = F_i + \alpha \text{ ln } literacyrate_{it} + \epsilon \text{ ln } wage_{it} + \text{ln } \eta_{it}, \tag{13}$$

where $literacyrate$ is a proxy for technology and wages are the cost shifter that enables us to identify the trade elasticity. Because F_{it} varies over time, we can include country effects to control for cross-sectional unobserved factors affecting both competitiveness and wages.

The first column of Table 10 reports the baseline results. Country effects are added in column (2) and standard errors are clustered at the country level in column (3). The log of wages takes the expected sign in all specifications. In columns (1) and (2), ϵ is significant at the 1% level. In our preferred specification, ϵ is equal to -3.95 (column 2).

[26] More details on this variable can be found in section 3 of Fouquin and Hugot (2016b).
[27] See variable definitions in Table 10 of Fouquin and Hugot (2016b).

The general equilibrium procedure we implement requires restricting the sample to a squared matrix. Given the scarcity of historical current price GDP data, we use reflated real GDP data from Maddison (2003) instead.[28] We choose the countries to be included in the squared data set so as to maximize the number of countries for which we have trade flows with all other partners, as well as GDP. In the end, we assess general equilibrium impacts on samples of 12 and 38 countries, respectively for the opening of the Suez and Panama Canals.[29] The results are presented using three different trade elasticities: the median structural elasticity from Head and Mayer (2014), the elasticity estimated through bilateral tariffs (equation 11) and the elasticity obtained using wages (equation 13). We present three different sets of results. Table 11 reports the general equilibrium trade creation effects. Table 12 reports changes in trade openness ratios. Table 13 summarizes changes in welfare arising from the opening of each canal.

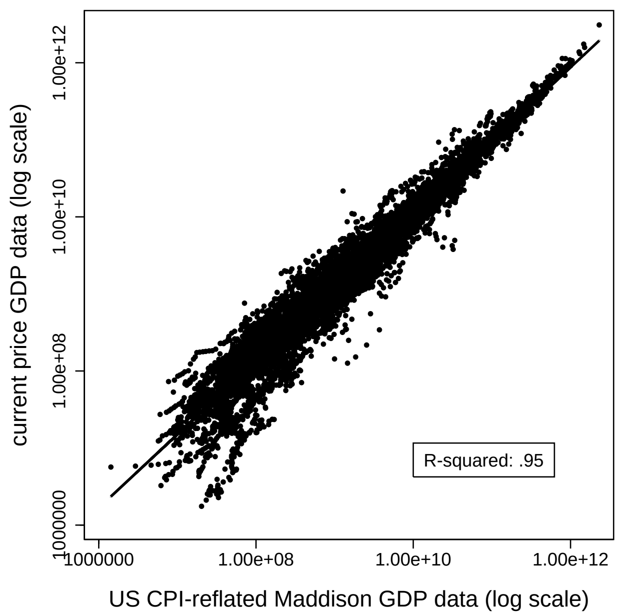

Figure 6 – Correlation between current price GDP data and U.S. CPI-reflated constant price Maddison (2003) GDP data

The opening of the Suez Canal has a positive impact on aggregate trade flows, regardless of the value of ϵ. We comment results based on $\epsilon = -2.08$, because i) this estimate relies on data for the period of the opening of the Suez Canal and ii) the robustness of the estimate is confirmed by the similar value obtained using a different method (equation 13). The resulting increase in trade ranges from $-.5\%$ (Norway) to 41% (British India). The top five largest trade creations affect British India, Japan, Britain, Italy and France. Changes in trade openness range from $-.02\%$ to 1.7%. Finally, welfare increases for five countries: from .02% (Italy) to .7%

[28]We reflate Maddison's data using the U.S. price index from Officer (2015). Figure 6 plots reflated GDP against the nominal GDP data from Fouquin and Hugot (2016b). Reassuringly, the correlation is about .95.
[29]The samples respectively cover 54% and 85% of total trade, as recorded in the data set.

(British India). The largest gains from the Suez Canal are concentrated in Britain and British India. Japan, The Netherlands, France and Italy also experience welfare gains, ranging from .02% to .11%. For the Panama Canal, the trade effect ranges from −.06% (Argentina) to 41% (El Salvador). Trade gains concentrate in Latin America, with impacts above 15% for El Salvador, Ecuador and Peru. Changes in trade openness range from .01% (Italy) to 2.9% (El Salvador), with Peru and Ecuador also affected by more than 2.5%. Outside of Latin America, New Zealand also experiences a large change. Finally, welfare gains range from .01% (Sweden) to 1.4% (El Salvador), with four Latin American countries in the top five winners.

8. A closure of the Panama Canal?

In this section we simulate the impact of a hypothetical closure of the Panama Canal in 2012. Our objective is twofold: i) we show the importance of correctly estimating the impact of distance on trade flows and ii) we use the thought experiment of closing the Panama Canal to show how our method can be used to assess the impact of infrastructures or climatic effects that affect shipping distance. More precisely, we use the general equilibrium approach introduced in the previous section to simulate the closing of the Panama Canal, by replacing actual shipping distances by shipping distances prior to the canal. We perform this counterfactual exercise using three different distance elasticities, in order to highlight the sensitivity of the welfare measures of changes in distance. We first select a "standard" cross-sectional distance elasticity, equal to −1.1.[30] We then set the distance elasticity to −0.38, which is the sum of coefficients β and α_k for $k = 2012$, obtained from equation 6. Finally, we set the distance elasticity to −0.09, which is the smallest longitudinal distance elasticity that we obtain (columns 4 and 5 of Table 3). Table 14 reports the largest trade effects arising from these three counterfactuals.

The magnitude of trade reductions is very sensitive to the distance elasticity. With a value of −1.1, the closing of the Panama Canal would reduce Ecuador's exports by 16%. By contrast, with a distance elasticity of −0.09, Ecuador's exports would fall by less than 2%. More generally, the estimated effect of a closure of the Panama Canal is about nine times larger when the "standard" distance elasticity is favored over its longitudinal counterpart. This large difference illustrates the need to correctly assess the impact of distance on trade before attempting to measure the effect of any change in distance. In particular, it appears crucial to disentangle between the actual effect of shipping distance on trade (longitudinal elasticity) and any other other distance-related resistance to trade. In the end, using a "standard" cross-sectional distance elasticity yields overestimated trade and welfare effects of any change in distance.

9. Conclusion

We assessed the historical and contemporaneous impacts of the Suez and Panama Canals on trade and welfare in a general equilibrium framework. To do so, we estimated the shipping

[30] Average of the structural cross-sectional distance elasticities from the meta-study of Head and Mayer (2014).

distance elasticity in the time dimension. The smaller values obtained – compared to cross-sectional estimations – solve the border effect in both its formulation in level and trend. Indeed, our estimates can be reconciled with both the trade-to-trade costs and the trade costs-to-distance elasticities, which product should be equal to the trade elasticity of distance. We also showed that the longitudinal shipping distance elasticity is much smaller around the time of the Six-Day War than when the Suez and Panama Canals opened. This suggests that the negative impact of shipping distance on trade may have become less stringent, contrary to what the absolute rise of the cross-sectional distance elasticity suggests.

We then evaluated the partial and general equilibrium trade and welfare effects of the opening of both canals. The Suez Canal considerably increased British welfare, directly (+.20%), but also through British India (+.83%). Japan, as well as other European countries also benefited from the canal. The Panama Canal considerably benefited the countries located on the west coast of Latin America. The welfare gains for these countries range from .35 to 1.41%.

Finally, we showed that using biased estimates of the shipping distance elasticity of trade to assess the impact of future distance reductions yields overestimated gains.

Table 8 – Partial equilibrium trade impact for the Suez and Panama Canals

Suez Canal			Panama Canal		
Country	Extra Trade (current £)	Extra Trade (%)	Country	Extra Trade (current £)	Extra Trade (%)
GBRIND	7,536,319	23.84	ECU	663,203	25.19
JPN	679,198	11.25	SLV	438,529	18.12
IDN	1,000,457	8.64	PER	1,852,094	16.43
LKA	337,946	7.87	BOL	598,460	13,93
REU	77,724	7.55	CHL	3,556,509	10.19
CHN	1,303,598	6.22	FJI	29,712	2.44
STRAITS	734,938	5.50	NZL	439,778	1.03
AUSWST	18,015	4.42	CUB	271,690	.81
GBR	14,500,000	4.01	GBR	5,032,816	.48
AUSSTH	162,063	3.23	NOR	137,754	.38
NLD	1,946,410	2.78	ESP	341,971	.37
MUS	46,067	2.35	FRA	1,023,231	.24
FRA	3,887,531	2.14	USA	1,390,059	.22
AUSVIC	241,840	1.61	BEL	388,631	.22
EGY	83,937	1.61	DEU	1,078,982	.21
AUSNSW	177,540	1.37	NLD	354,383	.18
AUSTAS	13,063	1.03	SWE	156,612	.17
AUSQUE	29,323	.95	PYF	533	.14
RUS	416,365	.73	ITA	234,375	.13
ESP	107,434	.52	GLP	1,948	.11
THA	6,079	.50	NCL	825	.07
TUR	73,433	.42	AUS	79,473	.06
USA	281,623	.30	CHN	5,2428	.06
DEU	56,091	.05	ZAF	36,638	.06
BEL	21,342	.04	EGY	26,740	.05
PRT	1,059	.01	RUS	33,392	.04
HKG	596,007		JPN	36,651	.02
PHL	165,731		DNK	13,116	.01
IRN	18,160		HWI	3,211	.01
FRAIND	12,401				
GBRWINDIES	10,111				
MDG	4,017				
INDOCHI	2,968				
Total	34,600,000			18,300,000	

Based on unbalanced samples, for 1879 and 1929 respectively for the Suez and Panama Canal.

Table 9 – Trade elasticity estimates using tariffs as a cost shifter

	(1)	(2)	(3)	(4)
Ln (1+ Bilateral Tariff)	-2.049*	-1.338	-2.107***	-2.078***
	(1.220)	(1.112)	(0.611)	(0.609)
Ln Shipping Distance		-0.098		-11.046
		(0.173)		(32.507)
Current colonial relationship		1.485**		1.127**
		(0.629)		(0.796)
Ever colonial relationship		0.858		
		(0.574)		
Common language		0.727*		
		(0.388)		
Contiguity		1.062*		
		(0.587)		
R-squared	0.841	0.866	0.960	0.960
Observations	3,595	3,583	3,595	3,583
Country-year effects	Yes	Yes	Yes	Yes
Directional pair effects		–	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses, clustered by directional country pair.

Table 10 – Trade elasticity estimates using wages as a cost shifter

	(1)	(2)	(3)
Ln Wages	-3.740**	-3.947***	-3.947
	(1.453)	(1.093)	(1.403)
Ln Literacy rate	13.300***	1.259	1.259
	(2.075)	(2.585)	(5.916)
R-squared	0.869	0.282	0.282
Observations	46	46	46
Country effects	–	Yes	Yes
Clustered SE	–	–	Yes

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.

Table 11 – General equilibrium trade effect of the Suez and Panama Canals

Suez Canal				Panama Canal			
Country	ϵ = -2.08	ϵ = -3.78	ϵ = -3.95	Country	ϵ = -2.08	ϵ = -3.78	ϵ = -3.95
GBRIND	41.31	39.22	39.15	SLV	41.46	39.97	39.88
JPN	15.47	15.90	15.92	ECU	31.27	31.31	31.31
GBR	5.94	5.98	5.98	PER	15.81	15.35	15.32
ITA	1.13	1.40	1.41	CHL	11.72	11.48	11.47
FRA	.86	1.06	1.07	NZL	1.36	1.33	1.33
NLD	.17	.32	.33	GBR	.51	.52	.52
PRT	-.12	-.03	-.02	CUB	.44	.46	.46
USA	-.14	-.01	.00	DEU	.34	.35	.35
ESP	-.124	-.07	-.06	FRA	.31	.33	.33
DEU	-.41	-.25	-.25	ITA	.31	.32	.32
BEL	-.47	-.28	-.27	ESP	.26	.29	.29
NOR	-.53	-.39	-.38	SWE	.26	.27	.27
				NOR	.24	.26	.26
				BGR	.16	.17	.17
				USA	.15	.16	.16
				BEL	.15	.16	.16
				NLD	.07	.09	.09
				PRT	.06	.08	.08
				TUR	.05	.06	.06
				GRC	.04	.05	.05
				JPN	.02	.03	.03
				YUG	.02	.04	.04
				CHN	.02	.03	.03
				AUT	.01	.02	.02
				ROM	.00	.01	.01
				THA	.00	.01	.01
				FIN	-.02	-.01	-.01
				IRL	-.03	-.01	-.01
				ZAF	-.03	-.02	-.01
				CAN	-.03	-.02	-.02
				MEX	-.03	-.02	-.02
				GBRIND	-.04	-.02	-.02
				DNK	-.04	-.03	-.02
				URY	-.05	-.04	-.04
				AUS	-.05	-.03	-.03
				IRN	-.05	-.04	-.04
				BRA	-.05	-.04	-.04
				ARG	-.06	-.05	-.05

The figures reported in the table are countries' percentage change in total trade flows due to the canals.
Data for 1879 and 1929, respectively for the Suez and Panama Canal.

Table 12 – General equilibrium trade openess change due to the Suez and Panama Canals

Suez Canal				Panama Canal			
Country	ϵ = -2.08	ϵ = -3.78	ϵ = -3.95	Country	ϵ = -2.08	ϵ = -3.78	ϵ = -3.95
GBRIND	1.72	1.75	1.75	SLV	2.91	2.99	3.00
GBR	.41	.41	.41	ECU	2.71	2.71	2.71
NLD	.28	.26	.26	PER	2.50	2.53	2.54
JPN	.22	.22	.22	CHL	.73	.74	.74
FRA	.08	.08	.08	NZL	.25	.25	.25
ITA	.06	.06	.06	CUB	.15	.15	.15
PRT	.00	.00	.00	GBR	.04	.04	.04
USA	.00	.00	.00	SWE	.04	.04	.04
ESP	.00	.00	.00	BEL	.03	.03	.03
BEL	-.01	-.01	-.01	NOR	.03	.03	.03
DEU	-.01	.00	.00	DEU	.03	.03	.03
NOR	-.02	-.02	-.02	NLD	.02	.02	.02
				FRA	.02	.02	.02
				BGR	.01	.01	.01
				ESP	.01	.01	.01
				GRC	.01	.01	.01
				ITA	.01	.01	.01
				IRN	.00	.00	.00
				THA	.00	.00	.00
				PRT	.00	.00	.00
				AUT	.00	.00	.00
				BRA	.00	.00	.00
				ROM	.00	.00	.00
				GBRIND	.00	.00	.00
				IRL	.00	.00	.00
				URY	.00	.00	.00
				CAN	.00	.00	.00
				TUR	.00	.00	.00
				MEX	.00	.00	.00
				YUG	.00	.00	.00
				ZAF	.00	.00	.00
				FIN	.00	.00	.00
				CHN	.00	.00	.00
				USA	.00	.00	.00
				DNK	.00	.00	.00
				JPN	.00	.00	.00
				ARG	.00	.00	.00

The figures reported in the table are countries' percentage change in trade openness due to the canals.
Data for 1879 and 1929, respectively for the Suez and Panama Canal.

Table 13 – General equilibrium welfare effect of the Suez and Panama Canals

Suez Canal				Panama Canal			
Country	ϵ = -2.08	ϵ = -3.78	ϵ = -3.95	Country	ϵ = -2.08	ϵ = -3.78	ϵ = -3.95
GBRIND	.83	.46	.45	SLV	1.41	.80	.77
GBR	.20	.11	.10	ECU	1.31	.72	.69
NLD	.14	.07	.07	PER	1.21	.68	.65
JPN	.11	.06	.05	CHL	.35	.20	.19
FRA	.04	.02	.02	NZL	.12	.07	.06
ITA	.03	.02	.01	CUB	.07	.04	.04
PRT	.00	.00	.00	BEL	.02	.01	.01
USA	.00	.00	.00	GBR	.02	.01	.01
ESP	.00	.00	.00	ITA	.01	.00	.00
BEL	.00	.00	.00	ESP	.01	.00	.00
DEU	.00	.00	.00	NOR	.01	.01	.01
NOR	-.01	.00	.00	NLD	.01	.01	.01
				DEU	.01	.01	.01
				SWE	.01	.01	.01
				FRA	.00	.00	.00
				GBRIND	.00	.00	.00
				BRA	.00	.00	.00
				USA	.00	.00	.00
				PRT	.00	.00	.00
				IRL	.00	.00	.00
				AUT	.00	.00	.00
				IRN	.00	.00	.00
				MEX	.00	.00	.00
				AUS	.00	.00	.00
				GRC	.00	.00	.00
				CHN	.00	.00	.00
				CAN	.00	.00	.00
				JPN	.00	.00	.00
				ZAF	.00	.00	.00
				BGR	.00	.00	.00
				FIN	.00	.00	.00
				URY	.00	.00	.00
				THA	.00	.00	.00
				ROM	.00	.00	.00
				YUG	.00	.00	.00
				ARG	.00	.00	.00
				TUR	.00	.00	.00
				DNK	.00	.00	.00

The figures reported in the table are countries' percentage change in welfare due to the canals.
Data for 1879 and 1929, respectively for the Suez and Panama Canal.

Table 14 – Largest trade effects of closing the Panama Canal in 2012

	Values of the distance elasticity		
Country	$\beta = -1.1$	$\beta = -0.38$	$\beta = -0.09$
ECU	-15.59	-6.72	-1.77
BMU	-14.56	-5.55	-1.37
PER	-10.40	-4.23	-1.08
VEN	-6.88	-2.91	-.76
SLV	-6.39	-3.04	-.84
JAM	-4.59	-1.91	-.49
HTI	-4.59	-2.00	-.53
CHL	-4.19	-1.55	-.38
DOM	-3.77	-1.72	-.47
BLZ	-3.69	-1.63	-.44
SUR	-2.53	-.98	-.24
GUY	-2.43	-.92	-.23
FJI	-1.70	-.64	-.16
CPV	-1.30	-.58	-.15
GMB	-.85	-.36	-.09
STP	-.75	-.29	-.07
NZL	-.44	-.16	-.04
ESP	-.39	-.16	-.04
FIN	-.21	-.08	-.02
USA	-.18	-.06	-.02
Sample mean	-.88	-.37	-.10

The table reports percentage changes from actual to counterfactual trade (with a closed Panama Canal).

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