Who's Getting Globalized? The Size and Nature of Intranational Trade Costs*

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Abstract

In this paper we develop a new methodology for estimating intranational trade costs, apply our methodology to newly collected CPI micro-data from Ethiopia and Nigeria, and explore how our estimates affect the geographic incidence of globalization within these countries. Our approach confronts three well-known but unresolved challenges that arise when using price gaps to estimate trade costs. First, we work exclusively with a sample of goods that are identified at the barcode-level, to mitigate concerns about unobserved quality differences over space. Second, because price gaps only identify trade costs between pairs of locations that are actually trading the product in question, we collect novel data on the location of production/importation of each product in our sample in order to focus exclusively on trading pairs. Conditioning on this new information raises our estimate of trade costs by a factor of two. Third, we demonstrate how estimates of cost pass-through can be used to correct for potentially varying mark-ups over space. Applying this correction raises our trade cost estimate by a factor of two (again). All said, we estimate that intranational trade costs in our sample are 7-15 times larger than similar estimates for the US. In a final exercise we estimate that intermediaries capture the majority of the surplus created when the world price for an imported product falls, and that intermediaries' share is even higher in remote locations. This sheds new light on the incidence of globalization.

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1 Introduction

Recent decades have seen substantial reductions in the barriers that impede trade between nations, a process commonly referred to as 'globalization'. But trade does not start or stop at national borders. The trading frictions faced by many firms and households—especially those in developing countries—include not only the international trade costs that have fallen in recent times, but also the *intra*-national trade costs that separate these agents from their nearest port or border. Yet we lack rigorous estimates of the size and nature of these costs, especially in particularly data-scarce regions of the world such as sub-Saharan Africa. In this paper we develop a new methodology for estimating trade costs and apply it to newly collected micro-data from Ethiopia and Nigeria (as well as to the United States, for purposes of comparison). In addition, we explore the implications of our estimates for the geographic incidence of globalization within these countries.

To fix ideas, consider a product that is imported from abroad. This product enters a country through port of origin o where it sells to domestic traders at the wholesale price P_o. These traders then sell the product at a destination location d for P_d, where these prices reflect the identity,

$$P_d - P_o = \tau(\mathbf{X_{od}}) + \mu_d, \tag{1}$$

which states that the price gap (ie $P_d - P_o$) reflects both marginal intranational trade costs (i.e. $\tau(\mathbf{X_{od}})$ for some locational cost-shifters $\mathbf{X_{od}}$, such as distance) and the mark-up (i.e. μ_d) charged by traders. Like a voluminous existing literature (discussed below), we seek to estimate how $\tau(\mathbf{X_{od}})$ depends on $\mathbf{X_{od}}$ by drawing inferences from the equilibrium distribution of prices over space—prices for each of a wide range of consumer products, and across hundreds of local markets. But we make progress with respect to this literature by using new data and new tools to overcome three well-known challenges that plague such inferences:

1. *Spatial price gaps may reflect differences in unobserved product characteristics (such as quality) across locations.* Clearly one cannot hope to apply equation (1) by making comparisons across non-identical products. In recognition of this point, and following the pioneering work of Broda and Weinstein (2008) for the US, we have compiled what we believe to be the first dataset on the geography of prices of products defined at the barcode level within a developing country.

2. *Spatial price gaps are only rarely directly informative of trade costs.* It is standard in the literature to assume that trading is perfectly competitive (ie mark-ups $\mu_d = 0$).[1]

[1] Another common assumption is that preferences and market structure belong to the knife-edge case

Under this assumption (which we relax shortly) it is tempting to conclude from equation (1) that price gaps identify trade costs; that is, that $P_d - P_o = \tau(\mathbf{X_{od}})$. But this is only true for location pairs o and d that represent origin and destination locations, respectively. All that can be said for any general pair of locations, i and j, is that prices must reflect the arbitrage restriction

$$P_i - P_j \leq \tau(\mathbf{X_{ij}}), \tag{2}$$

with this inequality binding when these two locations are actually trading the product (ie when one location is actually an origin and the other a destination). Unfortunately, in practice the trade data required to apply equation (1) only to trading pairs—that is only to the pairs that identify $\tau(\mathbf{X_{od}})$—are unavailable. We have therefore collected unique data on the precise origin location (production sites for the case of domestically produced goods, and ports of importation for the case of imported goods) for each product in our sample. Our paper provides the first widespread attempt to collect and condition on this information, and to hence move from the inequality in equation (2) to the equality in equation (1). Figure 1 below illustrates the importance of this point in practice. Here we plot our estimate of $\tau(\mathbf{X_{ij}})$ for all location pairs, and for trading pairs only, under the assumption of perfect competition; our estimates imply that without data on origin locations we would underestimate trade costs by a factor of almost two.

3. *Spatial price gaps may reflect variable mark-ups across locations μ_d, not just the marginal cost of trading $\tau(\mathbf{X_{od}})$.* Put simply, the trading sector may not be perfectly competitive (ie mark-ups $\mu_d \geq 0$). This implies that, as in equation (1), spatial price gaps cannot be used to estimate trade costs $\tau(\mathbf{X_{od}})$ without a correction for the contamination induced by variation in mark-ups across locations. We demonstrate that estimates of the extent to which shocks to P_o pass through into P_d—which we estimate nonparametrically for each location d and product in our sample—can be used to correct for this contamination. The key insight is that estimated pass-through is, by definition, a sufficient statistic for the extent to which mark-ups respond to any change in marginal costs; in other words, the pass-through rate tells us how mark-ups μ_d change across locations as these locations require higher and higher marginal costs $\tau(\mathbf{X_{od}})$ to be accessed. As can be seen in Figure 1, our estimates imply that correcting for varying mark-ups over space changes our trade cost estimates sub-

(CES preferences with atomistic, monopolistically competitive firms) in which mark-ups are positive but do not vary across locations.

stantially, increasing them (again) by a factor of at least two.

To summarize the results in Figure 1, we find that—once two important corrections relative to the existing literature are applied—intranational trade costs $\tau(\mathbf{X_{od}})$ in our sample are considerable. To put these results in context, they are approximately seven to 15 times larger than the marginal cost of distance found by Hummels (2001) for truck shipments between Canada and the US.[2]

The preceding discussion has centered on our new method for estimating $\tau(\mathbf{X_{od}})$ but two additional results follow. The first is an implication of our estimates of how mark-ups vary over space. As can be seen in Figure 1, mark-ups in our sample actually fall as one considers more and more distant locations from a product's origin location. As we detail below, mark-ups could vary across locations due to three (non-exclusive) reasons: preferences could vary, market structure could vary, and even holding preferences and market structure fixed traders' optimal mark-ups could vary as underlying marginal costs vary. We do find evidence that remote locations are less competitive. But we also find that equilibrium pass-through, in nearly all locations and for nearly all products, is less than one, which implies that mark-ups fall as marginal costs rise. On net, this latter effect (of pass-through less than one) dominates.

Secondly, we estimate the relative shares of surplus that accrue to consumers and traders, respectively, following a change in the port price P_o—that is, we estimate the incidence of a global price change. Using an extension of the analysis in Weyl and Fabinger (2011), if we restrict attention to demand systems that take a particular form in which pass-through is constant (and hence CES demand is a special case) the rate of equilibrium pass-through (which we estimate for each location and product) is a sufficient statistic for the distribution of surplus. Crucially, data on quantities of products traded or sold—data that would not be available for most developing countries—are unnecessary. Using this result we find that the incidence of globalization is skewed towards intermediaries and deadweight loss (relative to consumers), and increasingly so in remote locations.

The work in this paper relates to a number of different literatures. Most relevant is a recent and voluminous literature uses aspects of spatial price dispersion in order to identify trade costs.[3] Various segments of the literature have dealt with each of these three challenges in isolation, but we believe that our work is unique in attempting to

[2] An important caveat is that, due to the nature of our restriction to a sample of only extremely narrowly defined consumer products (a restriction which, to us, seems unavoidable in any attempt to measure trade costs with price dispersion), our results may not be representative of the practices used to trade the entire national consumption basket in our sample countries.

[3] Another body of work to which our study relates is the rapidly growing literature on intermediation in trade, including (Ahn, Khandelwal, and Wei, 2011; Antras and Costinot, 2011; Bardhan, Mookherjee, and Tsumagari, 2011; Chau, Goto, and Kanbur, 2009). This work aims to understand when trade is conducted

circumvent all three of these challenges. We discuss the response to these three challenges in the existing literature here in turn.

First, a large strand of this literature argues that inter-spatial arbitrage is free to enter and hence that inter-spatial price gaps place lower bounds on the marginal costs of trade, where these lower bounds are binding among pairs of locations that do trade. See, for instance, Eaton and Kortum (2002), Donaldson (2011), Simonovska (2010) and Simonovska and Waugh (2011a), as well as the work surveyed in Fackler and Goodwin (2001) and Anderson and van Wincoop (2004).[4] A central obstacle in this literature has been the need to work with narrowly defined products and yet also know which location pairs are actually trading those narrowly defined products; our approach exploits unique data on the location of production of each product in our sample.

A second and recent strand of the literature draws on proprietary retailer or consumer scanner datasets from the US and Canada in order to compare prices of extremely narrowly identified goods (that is, goods with unique barcodes) across space (see for example Broda and Weinstein (2008), Burstein and Jaimovich (2009) and Li, Gopinath, Gourinchas, and Hsieh (2011)). However, this work typically lacks information on the region or country of origin so point-identifying the level of trade costs is typically not the focus.[5]

Finally, a third strand of this literature considers, as we do, the possibility that producers or intermediaries have market power (that is, arbitrage is not free to enter) and hence that firms may price to market. (See, for example, Feenstra (1989), Goldberg and Knetter (1997), Goldberg and Hellerstein (2008), Nakamura and Zerom (2010), Fitzgerald and Haller (2010), Li, Gopinath, Gourinchas, and Hsieh (2011), Burstein and Jaimovich (2009), Atkeson and Burstein (2008), Alessandria and Kaboski (2011), and Berman, Martin, and Mayer (2012)). In particular, this literature has placed heavy emphasis on the extent of exchange rate pass-through and its implications for market power. We apply a similar logic to the market for each good and location in our sample with the goal being to infer how intermediaries' market power and equilibrium mark-ups vary across loca-

via intermediaries rather than by producers directly. Our work is instead focused on the consequences of intermediaries—who potentially possess market power—for the magnitude of intranational barriers to trade, the pass-through of world price changes, and the distribution of the gains from trade.

[4]An additional body of work, (see for example Engel and Rogers (1996), Parsley and Wei (2001), Broda and Weinstein (2008) and Keller and Shiue (2007)) uses moments derived from inter-spatial price gaps to infer trade costs without data on which location pairs are actually trading. Because these moments pool together information from location pairs that are trading (on which price gaps are equal to trade costs) and location pairs that are not trading (for which price gaps understate trade costs) it is not clear how these moments estimate the level of trade costs without knowledge of the relative proportions of trading and non-trading pairs in the sample.

[5]Li, Gopinath, Gourinchas, and Hsieh (2011), however, point out that their price gap estimates for location pairs on either side of the Canada-US border do place a lower bound on the cost of trading across this border.

tions, as well as how variable mark-ups over space cloud inference of how the marginal costs of trading vary over space. In this sense, the paper is related to a recent literature that explores the interaction between the gains from trade and variable markups. (See, for example, Arkolakis, Costinot, Donaldson, and Rodriguez-Clare (2012), De Loecker, Goldberg, Khandelwal, and Pavcnik (2012), Edmond, Midrigan, and Xu (2011), Feenstra and Weinstein (2010) and Melitz and Ottaviano (2008)).

The remainder of this paper proceeds as follows. Section 2 describes the new dataset that we have constructed for the purposes of measuring and understanding intranational trade costs in our sample of developing countries. Section 3 outlines a theoretical framework in which intranational trade is carried out by intermediaries who potentially enjoy market power, as well as how we use this framework to inform empirical work that aims to estimate the size of intranational trade costs as well as the distribution of the gains from trade between consumers and intermediaries. Section 4 discusses the empirical implementation of this methodology and presents our findings. Section 5 concludes.

2 Data

The introduction details three challenges faced by researchers hoping to uncover trade costs form spatial price gaps. The methodology that we put forward to solve these challenges requires a data set that satisfies three distinct requirements. In order to deal with the first challenge, that price gaps are equal to trade costs only if the product is identical in both locations, we require the retail price of narrowly-defined products at various points in space (within developing countries). In order to deal with the second challenge, that price gaps are equal to trade costs only if the product is actually traded between the locations, we require the location(s) of production or import of each product in our sample. In order to deal with the third challenge, that price gaps comprise both trade costs and intermediary mark-ups, we require pass through rates calculated using high-frequency price data observed over a long duration. A core component of this paper is the creation of a data set satisfying these three requirements.

Our study draws on two main sources of data: (i) retail price data, and (ii) production source locations data. We describe these two types of data here in turn.

2.1 Data on retail prices

The key requirement for exploring both the magnitude and implications of intranational trade costs is high quality price data. As outlined above, the methodology we propose requires observations of retail prices prevailing at many points in time, across many geographically segmented markets, for extremely narrowly defined products (such that within-product differences in quality over space can be presumed to be small). Fortunately the national statistical agencies of many developing countries collect exactly such data in the process of compiling a consumer price index. The data collection exercise underpinning this paper has involved a search for any Sub-Saharan African countries that collect data that meets these standards and are willing to share their raw data (rather than the typically publicly available aggregates) with researchers.

The two Sub-Saharan African countries in our sample conduct monthly price surveys across many fixed locations throughout the country. Enumerators are asked to survey particular retail establishments and write down the posted price (or typical sale price if a posted price is not available) for a fixed set of very narrowly defined products, and to record no observation if the product is not for sale at the enumeration location on the enumeration date.

Because the product lists in both these countries are typically chosen to provide wide coverage of the a typical consumption basket many of the products surveyed—such as rice, bread or haircuts—are not narrowly defined and we exclude these products from our analysis. We instead work with a sample of consumer products that are uniquely identified by their product descriptions. These descriptions include the product type, brand name, and specific size—such that the descriptions are akin to barcodes that uniquely identify products in consumer scanner datasets in developed countries. For example, one of our products in Nigeria is a 125 gram can of Titus brand Sardines. Additionally, we restricted attention to products that were available across both a majority of locations and time periods within each country. The specific details of each sample are described separate by country in the subsections below. (Several other Sub-Saharan countries that have made their data available to us contain product descriptions that lack unique, brand-level product identifiers and so we could not include these countries in our study.)

At this juncture, it is useful to briefly discuss how representative the products in our sample are. The products chosen for inclusion on the consumer price index are generally the leading products in the most important categories of consumer spending. However, many categories of expenditure that are very important in developing countries are excluded since consumers do not purchase branded products in these categories. We note that the aim of this paper is to understand the size of intra-national trade costs and to explore the implications for the distribution of the gains from globalization within developing countries. For this exercise, what we require is not a set of goods that are representative of consumer spending but are a set of goods whose trade costs are representative of the trade costs faced by the typical imported good. Therefore, our estimates are most relevant to understanding trade costs and the spatial distribution of the gains from trading low-cost branded food and non-food consumer items. The structure of the intermediary sector that transports commodities from remote farms to ports for export may differ dramatically, and our paper cannot shed light on the magnitude of these trade costs.

As with all micro-level price data, our data contain multiple observations that appear to misrecorded.[6] Accordingly, our main analysis uses a cleaned sample of price data where we applied a simple cleaning algorithm.[7] Results are also reported for the uncleaned data set and are similar in terms of both the magnitudes and significance of the results.

The specific details of the two sample are described below.

2.1.1 Ethiopia

The Ethiopian data are collected by the Central Statistical Agency of Ethiopia. Our data consist of monthly price quotes collected at retail outlets in 103 market towns between September 2001 and June 2010.[8] The locations of the market towns are illustrated in the map in Figure 2. Fifteen products are covered, which are detailed in Table 1.

2.1.2 Nigeria

The Nigerian data are collected by the Nigerian National Bureau of Statistics. Our data consist of monthly price quotes collected at retail outlets in the 36 state capitals between January 2001 and July 2010.[9] The locations of the state capitals are illustrated in the map

[6] Some of these errors appear to be errors in recording a correct price quote, while in other cases it appears that an enumerator in one particular location obtained the price for a different size or specification of product.

[7] First, we remove price quotes that lie more than 10 standard deviations away from the log mean price. Second, we remove implausibly low or high price quotes. Third, we eyeball the time series of prices for each product in each location. If a price quote seems unusually high or low, we verify whether nearby prices for that same product in that same period were also unusually high. If they were not, we remove this outlier.

[8] The monthly price quotes obtained from the Central Statistics Agency are actually averages of several price quotes (typically three) obtained at different retail outlets in the same town on the same day. The outlets include open markets, kiosks, groceries, butcheries, pharmacies and super markets. Enumerators do not actually purchase the items in question but interview traders, and on occasion consumers, to obtain price quotes.

[9] As in the Ethiopian case, these are averages of prices across several outlets within the same town. Enumerators collect two prices for each product in each town from different retailers on the same day. For several states, although the state capital is always surveyed, additional urban areas in the state are also sampled using a probability sampling method and included in this average. Outlets are made up of open

in Figure 2. Seventeen products are covered, which are detailed in Table 1.

2.2 Data on production source (factory or import) locations

For the case of domestically-produced products, we have conducted a telephone interview with the firms that produce each of the products in our sample. We ask each firm for the precise location(s) of production that serve markets in each country in our sample, and ask this information retrospectively so as to cover all of the years in our sample. We have also sought to corroborate this information by surveying distributors and carrying out extensive internet searches. For the case of imported products we have contacted distributors to learn the port of entry of each imported product in each country (and year) in our sample. From these two sources we obtain the latitude and longitude of the production location(s) or port of entry for every good in our sample.

3 Theoretical Framework

In this section we first describe a model of intranational trade carried out by intermediaries who potentially enjoy market power. We then go on to discuss how this framework can be used to inform empirical work that aims to estimate the size of intranational trade costs as well as the distribution of the gains from trade between consumers and intermediaries.

3.1 Model Environment

We consider an environment in which there are D isolated locations[10] indexed by d and K products indexed by k. Products k can be either domestically produced or imported from abroad. Domestically produced products are made at a factory location indexed by o and imported products are imported into the country through a port or border crossing at location o; regardless of whether the products are made at home or abroad, the domestic

markets, supermarkets, departmental stores, other shops and roadside stores as well as specialist retailers such as pharmacists. Quotes are collected once per week for processed food items in the state capital and once a month in other urban areas. Prices for miscellaneous goods and services are collected once per month in both locations. All prices are "bargained prices" although enumerators are instructed to avoid actually buying the goods if possible. Instead, enumerators are encouraged to develop a good relationship with the shop owner.

[10] Locations are isolated in the sense that consumers do not travel to economies other than their own to purchase items. More generally, we simply require that intermediaries' marginal costs are sufficiently low (relative to consumers' travel costs) that consumer always buy goods locally from an intermediary rather than traveling themselves to other locations to make their purchases.

'origin' of the product is location o. (Note that we use the mnemonic o for origin and d for destination.) We treat the market for product k traded from location o to location d as an isolated market—that is, we abstract for now from general equilibrium considerations that would introduce interactions in product or factor markets across or within locations.

We assume that any product k is sold on wholesale markets at the source (ie factory gate or port) location o for a price P^k_{ot} at date t. This product is then bought at the origin location o wholesale market and traded from location o to any destination location d by domestic intermediaries. These intermediaries specialize in the activity of purchasing a product in bulk at a wholesale market, transport the product to a destination location, and then finally selling the product to consumers at that location.[11]

Intermediaries incur costs of trading. Each intermediary has a total cost function, $C(q^k_{odt})$, which is the cost of trading q^k_{odt} units of product k from location o to location d at date t. Total costs are the sum of fixed costs of entry into the distribution sector, F^k_{odt}, and per-unit costs of trading. Per-unit costs are themselves the sum of the cost of buying the product at the origin location (which is simply the origin price, P^k_{ot}) and the marginal costs of trading, denoted by $\tau = \tau(\mathbf{X}^k_{odt})$. We assume (in Assumption 1) that marginal costs are 'specific' (ie charged per unit of product shipped) and constant; future work will explore extensions to this basic case. Finally we let $\mathbf{X}^k_{odt}$ denotes a set of marginal cost shifters specific to the route from origin o to destination d (such as the quality of roads along the route) and the product k shipped.

Assumption 1. *The cost to an intermediary of buying q^k_{odt} units of product k from location o at date t (for an origin price P^k_{ot}) is given by the sum of fixed and (constant, specific) marginal costs:*

$$C(q^k_{odt}) = \left[P^k_{ot} + \tau(\mathbf{X}^k_{odt})\right] q^k_{odt} + F^k_{odt}.$$

Intermediaries maximize profits by choosing the amount of the product to sell, q^k_{dt}. Let Q^k_{dt} denote the total amount sold to the market by all intermediaries. The essential strategic interaction across intermediaries is the extent to which an intermediary's actions (his quantity choice, q^k_{dt}) affect other intermediaries' profits through the aggregate quantity Q^k_{dt}. We follow the 'conjectural variations' approach to oligopolistic interactions (e.g. Seade, 1980) and assume (in Assumption 2) that this relationship is summarized by the parameter $\theta^k_{dt} \doteq \frac{dQ^k_{dt}}{dq^k_{dt}}$. The case of symmetric Cournot oligopoly corresponds to $\theta = 1$, the case of a pure monopolist corresponds also to $\theta = 1$, while perfect competition corre-

[11] Note that we assume that there is just one integrated sector that intermediates trade between producers (or importers) and final consumers, combining distribution and retail into one activity.

sponds to $\theta = 0$. In what follows we will not take a stand on the value of θ^k_{dt} because our empirical application will not need—nor be able—to identify this model parameter.

Assumption 2. *Intermediaries selling product k in location d at date t perceive the effect of their sales decision q^k_{dt} on aggregate sales Q^k_{dt} to be given by the parameter $\theta^k_{dt} \doteq \frac{dQ^k_{dt}}{dq^k_{dt}}$ that is fixed in any period. Alternative values of this parameter span a range of market structure assumptions.*

Given the above notation, and denoting consumers' aggregate inverse demand curve by $P^k_{dt}(Q^k_{dt})$, each intermediary's first order condition for profit maximization implies that:

$$P^k_{dt} = \left[P^k_{ot} + \tau(\mathbf{X}^k_{odt})\right] - \theta^k_{dt}\frac{\partial P^k_{dt}(Q^k_{dt})}{\partial Q^k_{dt}}q^k_{dt}. \tag{3}$$

As is the case for any producer, the price that intermediaries' charge here (ie P^k_{dt}) is equal to the intermediaries' total marginal costs (the sum of the purchase price at the origin, P^k_{ot}, and the marginal cost of trading, $\tau(\mathbf{X}^k_{odt})$) plus the markup that intermediaries potentially charge (which we denote by $\mu^k_{dt} \doteq -\theta^k_{dt}\frac{\partial P^k_{dt}(Q^k_{dt})}{\partial Q^k_{dt}}q^k_{dt}$).

It remains to specify the process of entry into the intermediary activity. The stock of potential intermediaries may potentially be constrained by credit constraints, reputation issues, caste or ethnic traditions etc. For this reason we assume (in Assumption 3) that all intermediaries are identical and that the stock of intermediaries buying product k at location o and selling it at location d on date t, denoted by m^k_{odt}, is fixed and exogenous within any period.

Assumption 3. *The number of identical intermediaries trading product k from location o to location d on date t, denoted by m^k_{odt}, is fixed and exogenous.*

Below we make extensive use of the concept of pass-through. This is defined as the amount by which intermediaries' equilibrium prices respond to a change in their marginal costs; that is, we define pass-through as $\rho^k_{odt} \doteq \frac{dP^k_{dt}}{dP^k_{ot}} = \frac{dP^k_{dt}}{d\tau(\mathbf{X}^k_{odt})}$. Differentiating equation (3) it can be shown that, in general, pass-through takes the form

$$\rho^k_{odt} = \left[1 + \frac{(1 + E^k_{dt})}{\phi^k_{odt}}\right]^{-1}, \tag{4}$$

where we define $\phi^k_{odt} \doteq \frac{m^k_{odt}}{\theta^k_{dt}}$ as the 'competitiveness index' (since it rises in the number of intermediaries, m^k_{odt}, and falls in these intermediaries' perceived individual influence on aggregate supply, θ^k_{dt}) and $E^k_{dt} \doteq \frac{Q^k_{dt}}{\left(\frac{\partial P^k_{dt}}{\partial Q^k_{dt}}\right)} \frac{\partial\left(\frac{\partial P^k_{dt}}{\partial Q^k_{dt}}\right)}{\partial Q^k_{dt}} \lesseqgtr 0$ is the elasticity of the slope of inverse demand. (Note that $E^k_{dt} = \frac{1}{e^k_{dt}} - 1 - \frac{Q^k_{dt}}{e^k_{dt}} \frac{\partial e^k_{dt}}{\partial Q^k_{dt}}$, where $e^k_{dt} \doteq \frac{\partial Q^k_{dt}}{\partial P^k_{dt}} \frac{P^k_{dt}}{Q^k_{dt}} \leq 0$ is the elasticity of demand.) As this expression makes clear, pass-through depends on only two market characteristics: the competitiveness (ϕ^k_{odt}) of the market (where importantly it is only $\phi^k_{odt} \doteq \frac{m^k_{odt}}{\theta^k_{dt}}$ that matters, not m^k_{odt} or θ^k_{dt} individually) and the second-order curvature of the demand curve (ie E^k_{dt}, the elasticity of the slope of demand).

The above results hold for any demand curve (or, more generally, to the single-item conditional demand relationships in any demand system). However, in order to simplify a number of results below we will at times make the additional assumption (in Assumption 4) that consumer preferences belong to a particular class of demand for which E^k_{dt} is constant. We refer to this as 'constant pass-through demand' (though note that equilibrium pass-through, ρ^k_{odt} would only be constant under this demand class if the competitiveness index, ϕ^k_{odt}, were also constant). Constant pass-through demand was first identified by Bulow and Pfleiderer (1983) and is a natural generalization of isoelastic demand. Indeed, Bulow and Pfleiderer (1983) prove that the only demand system with constant pass-through is the class introduced here.

Assumption 4. *Consumer preferences take the constant pass-through demand form such that total demand Q^k_{dt} depends on price P^k_{dt} in the following manner:*

$$Q^k_{dt}(P^k_{dt}) = \begin{cases} \left(\frac{a^k_{dt} - P^k_{dt}}{b^k_{dt}}\right)^{\frac{1}{\delta^k_{dt}}} & \text{if } (P^k_{dt} \leq a^k_{dt}, b^k_{dt} > 0 \text{ and } \delta^k_{dt} > 0) \text{ or } (P^k_{dt} > a^k_{dt}, b^k_{dt} < 0 \text{ and } \delta^k_{dt} < 0) \\ 0 & \text{if } P^k_{dt} > a^k_{dt}, b^k_{dt} > 0 \text{ and } \delta^k_{dt} > 0 \\ \infty & \text{if } P^k_{dt} \leq a^k_{dt}, b^k_{dt} < 0 \text{ and } \delta^k_{dt} < 0 \end{cases}$$

with $a^k_{dt} \geq 0$. Accordingly, inverse demand is:

$$P^k_{dt}(Q^k_{dt}) = a^k_{dt} - b^k_{dt} \left(Q^k_{dt}\right)^{\delta^k_{dt}}. \tag{5}$$

For this demand system we have $e^k_{dt} = -\frac{1}{\delta^k_{dt}} \left(\frac{P^k_{dt}}{a^k_{dt} - P^k_{dt}}\right) \leq 0$ and $E^k_{dt} = \delta^k_{dt} - 1 \lesseqgtr 0$; that is, by design, E^k_{dt} is equal to a (constant) model parameter, but this parameter is free to vary. Note that the case of isoelastic demand corresponds to a restriction of this demand class in which $a^k_{dt} = 0$. Hence from equation (4) equilibrium pass-through under

Assumption 4 is equal to

$$\rho^k_{odt} = \left[1 + \frac{\delta^k_{dt}}{\phi^k_{odt}}\right]^{-1} \tag{6}$$

Equilibrium pass-through can be 'incomplete' (ie $\rho^k_{odt} < 1$) for $\delta^k_{dt} > 0$ and 'more than complete' (ie $\rho^k_{odt} > 1$) with $\delta^k_{dt} < 0$. Hence nothing in this class of preferences restricts whether pass-through will rise or fall with the remoteness of locations within a country; the only restriction is that pass-through is constant. Finally, note that, whatever the demand parameter, the state of competitiveness (summarized by ϕ^k_{odt}) matters for equilibrium pass-through; in particular, if competition were perfect (ie $\phi^k_{odt} \to \infty$) then equilibrium pass-through is 'complete' (ie $\rho^k_{odt} = 1$) for any demand parameters.

3.2 Using the Model to Measure Intranational Trade Costs

In what follows our goal is to describe how the theoretical framework introduced above can be used, in conjunction with the data described in Section 2 above, to estimate the magnitude of intranational trade costs. Additionally, we describe how our theoretical framework can be used to estimate the distribution of surplus (among consumers and intermediaries) for each location in our sample. We break down our analysis into three steps as follows.

3.2.1 Step 1: Using price gaps to measure total intranational trade costs

We define *total* intranational trade costs—denoted here by T^k_{odt}—in a manner that we feel is relevant from the perspective of final consumers: total trade costs are the price that a final goods consumer must pay for an intermediary to deliver a good from its origin location to the consumer's location (the intermediary's destination). Equation (3) above describes how in this framework intermediaries are potentially charging a mark-up on trades such that total trade costs are the sum of intermediaries' marginal costs and intermediaries' mark-ups. The following result is then immediate.

Result 1: *Under Assumption 1 the total cost, T^k_{odt}, of trading product k from its origin location o to its destination location d at date t is equal to the price of this product across those two locations on that date (ie $P^k_{dt} - P^k_{ot}$). Further, this total trade cost is equal to the sum of the marginal costs of trading, $\tau(\mathbf{X}^k_{odt})$, and the mark-up charged by intermediaries, μ^k_{dt}. That is:*

$$P^k_{dt} - P^k_{ot} = T^k_{odt} \doteq \tau(\mathbf{X}^k_{odt}) + \mu^k_{dt}. \tag{7}$$

However, the difference in prices for product k among two distinct destination locations, i and j for $i \neq o$ and $j \neq o$, is uninformative about the total cost of trading among those locations. That is:

$$P^k_{jt} - P^k_{it} \gtreqless T^k_{ijt} \text{ for } i \neq o \text{ and } j \neq o. \tag{8}$$

Result 1 is extremely simple, yet it offers a powerful guide to empirical work. Armed with a dataset of prices prevailing for a given product at several locations, Result 1 suggests which price gaps over pairs of locations are informative of total trade costs and which are not. This is important because most researchers do not observe the origin location of each product in each time period, so they do not know which location(s) in their dataset, if any, correspond to the origin location o, which is required to apply Result 1. In Section 4.1 below we use unique data on the production/importation location(s) of each product and year in our dataset and thereby apply Result 1 in order to estimate the magnitude of intranational trade costs for a group of developing countries. We also discuss the size of the bias one would obtain in our dataset without knowledge of origin locations.

3.2.2 Step 2: Estimating pass-through rates

As discussed in the Introduction, our method for inferring the extent of mark-up variation over space (a necessary input into estimating the marginal costs of intranational trade) relies on flexible estimates of the extent of equilibrium pass-through for each product in each location. We discuss here how the theoretical framework outlined above can be used to provide these estimates. As long as exogenous variation in the origin (or border) price can be isolated, a reduced-form pass-through parameter can be estimated for each product k, destination location d and time window (noting that at least two dates t would be required to study how a change in the origin price affects destination prices).

It is straightforward to show, using Equation (6) above, the following result, which characterizes the relationship between destination and origin prices—that is, equilibrium pass-through—as well as the relationship between pass-through and underlying structural parameters (ie m^k_{odt}, θ^k_{dt}, and δ^k_{dt}).

Result 2: *Under Assumptions 1-4 the relationship between destination prices P^k_{dt} and origin* *prices P^k_{ot} for any product k and at any date t satisfies*

$$P^k_{dt} = \rho^k_{odt} P^k_{ot} + \rho^k_{odt} \tau(\mathbf{X}^k_{odt}) + (1 - \rho^k_{odt}) a^k_{dt}, \tag{9}$$

where $\rho^k_{odt} = \left(1 + \frac{\delta^k_{dt}}{\phi^k_{odt}}\right)^{-1}$ *and* $\phi^k_{odt} \doteq \frac{m^k_{odt}}{\theta^k_{dt}}$.

This implies that a regression of destination prices (P^k_{dt}) on origin prices (P^k_{ot}), conditional on controls for both the marginal cost of trading (ie $\tau(\mathbf{X}^k_{odt})$) and local demand shifters (ie a^k_{dt}), would reveal the equilibrium pass-through rate (ρ^k_{odt}) inherent to each destination market and product. Unfortunately, both the marginal cost of trading and local demand shifters are unobservable to researchers—indeed, if these were observable then answers to the questions we pose in this paper would be immediately available. Nevertheless, in Section 4.2 below we propose an empirical strategy that aims to control for these variables and hence provide consistent estimates of the equilibrium pass-through rate (ρ^k_{odt}) prevailing in each destination location d and product k separately. While the principal reason for obtaining these estimates is, as described in the next sub-section, to infer how mark-ups vary over space, Result 2 demonstrates that an additional use for pass-through estimates is to estimate ϕ^k_{odt} via the formula$\rho^k_{odt} = \left(1 + \frac{\delta^k_{dt}}{\phi^k_{odt}}\right)^{-1}$.

3.2.3 Step 3: Using pass-through estimates to estimate the marginal costs of distance

A central aim of much of the literature on the estimation of trade costs has been to understand the determinants of the marginal costs of trading. In a setting of perfect competition, total trade costs—as we have defined them above—are equal to the marginal costs of trading since mark-ups are zero. In such a setting the simple price gap methods described above in Step 1 are sufficient for determining the magnitude and determinants of the marginal costs of trading.

However, once it is possible that intermediaries enjoy market power, price gaps reflect not just the marginal costs of trading over space but also the mark-ups that intermediaries charge when carrying out trades over space. If these mark-ups vary over space (for example because the state of competition in the intermediary sector varies over space, or simply because preferences are such that pass-through is anything but complete), then the change in price gaps over space reflects not just how space imposes marginal costs but also how mark-ups vary over space.

The central challenge here is to separate out these two effects without the ability to separately estimate marginal costs and mark-ups (a challenging prospect in any setting, but one that is especially challenging here where researchers lack access to data on consumer quantities or to producers' input choices). In this section we describe a method—which draws on the estimates of equilibrium pass-through ρ^k_{od} obtained in Step 2 above—that addresses this challenge. The key intuition is that pass-through describes how prices respond to any marginal cost shock. We have described above a way to estimate pass-through by using the observed response of destination prices to origin price shocks. We now use these pass-through estimates to deduce the extent to which the marginal costs of trading affect prices (which, by definition, they do via the extent of pass-through) and hence infer the true marginal costs of trading over space from observed price variation over space. This logic is formalized in Result 3 below which is a direct implication of Result 2 above.

Result 3: *Under Assumptions 1-4 the relationship between 'adjusted price gaps' between origin and destination locations for any product k and at any date t (ie $\frac{P^k_{dt}-\rho^k_{odt}P^k_{ot}}{\rho^k_{odt}}$) and the marginal costs of trading that product between those locations on that date (ie $\tau(\mathbf{X}^k_{odt})$) satisfies:*

$$\frac{P^k_{dt}-\rho^k_{odt}P^k_{ot}}{\rho^k_{odt}} = \tau(\mathbf{X}^k_{odt}) + \frac{(1-\rho^k_{odt})}{\rho^k_{odt}}a^k_{dt}. \tag{10}$$

Recall from Result 1 above that origin-destination price gaps (ie $P^k_{dt} - P^k_{ot}$) are equal to the sum of marginal costs of trade (ie $\tau(\mathbf{X}^k_{odt})$) and mark-ups charged by intermediaries; because mark-ups potentially vary with distance, the extent to which price gaps vary over space does not identify the extent to which the marginal costs of trading vary over space. By contrast, a key message of Result 3 here is that 'adjusted price gaps' (ie $\frac{P^k_{dt}-\rho^k_{odt}P^k_{ot}}{\rho^k_{odt}}$) are equal to sum of the marginal costs of trade (ie $\tau(\mathbf{X}^k_{odt})$) and a pass-through adjusted demand shifter (ie $\frac{(1-\rho^k_{odt})}{\rho^k_{odt}}a^k_{dt}$). This suggests that, with suitable controls for this demand-shifter, the extent to which adjusted price gaps—rather than simple price gaps—vary over space does identify the extent to which the marginal costs of trading vary over space. In Section 4.3 below we apply this method directly in order to estimate how distance (ie a variable $\mathbf{X}^k_{odt}$ that shifts $\tau(\mathbf{X}^k_{odt})$) affects the marginal costs of trading.

3.3 Using the Model to Measure Division of Surplus

In any market setting where producers enjoy market power a natural question concerns the share of surplus accruing to these producers relative to that accruing to consumers. The setting we consider here—in which intranational trade between producers and consumers is carried out by intermediaries who potentially enjoy market power—is no exception. In this setting the surplus in question is essentially the gains from trade. That is, consumers in destination location d benefit from being able to consume product k sourced from the origin location o (be that origin a domestic factory or a port through which foreign producers' goods enter) because there are gains from trade (ie the product would cost more to produce in location d).

Naturally it is challenging to identify the shares of surplus accruing to consumers and intermediaries. And this is especially challenging in settings like ours where researchers lack data on the quantities of narrowly defined products consumed (which could in principle be used to estimate demand relationships, mark-ups and hence the division of surplus). Fortunately, based on an extension of the logic in Weyl and Fabinger (2011), in the theoretical framework we have outlined above there exists a simple connection between pass-through and the division of surplus, which allows an answer to answer this question without the need for data on quantities consumed.

To see this, consider first the calculation of the amount of consumer surplus generated by any partial equilibrium market setting (that is, where the prices in all other markets are held constant) for product k in destination market d at date t. Consumer surplus when Q^k_{dt} is supplied to the market is defined as $CS^k_{dt}(Q^k_{dt}) \doteq \int_{\psi=0}^{Q^k_{dt}} [P^k_{dt}(\psi) - P^k_{dt}(Q^k_{dt})]d\psi$, where $P^k_{dt}(\psi)$ is the consumers' inverse demand curve evaluated at argument ψ and Q^k_{dt} is the total amount consumed in equilibrium in the market. Since $\frac{dCS^k_{dt}(Q^k_{dt}(\psi))}{dP^k_{ot}} = -Q^k_{dt}(\psi)\frac{dP^k_{dt}(Q^k_{dt}(\psi))}{dQ^k_{dt}}\frac{dQ^k_{dt}}{dP^k_{ot}}$ consumer surplus can also be written in a way that stresses its essential connection with pass-through:

$$CS^k_{dt}(Q^k_{dt}) = -\int_{\psi=P^k_{ot}}^{\infty} Q^k_{dt}(\psi)\rho^k_{odt}(\psi)d\psi. \tag{11}$$

Following similar steps we now calculate the amount of surplus captured by intermediaries in this setting. Intermediaries' surplus when Q^k_{dt} is supplied to the market is defined as total variable profits among intermediaries, or $IS^k_{dt}(Q^k_{dt}) \doteq m^k_{odt}\Pi^k_{odt}(q^k_{odt}) = m^k_{odt}\int_{\psi=P^k_{ot}}^{\infty} \frac{d\Pi^k_{odt}(\psi)}{dP^k_{ot}}d\psi$.[12] Differentiating total profits we have:

[12]We work with a notion of surplus defined on total variable profits in part because nothing in our

$$
\begin{aligned}
\frac{d\Pi^k_{odt}(\psi)}{dP^k_{odt}} &= \frac{(m^k_{odt}-\theta^k_{dt})q^k_{odt}(\psi)}{(m^k_{odt}+\theta^k_{dt})+\theta^k_{dt}E^k_{dt}(\psi)} - q^k_{odt}(\psi), \\
&= \left(\frac{\phi^k_{odt}-1}{\phi^k_{odt}}\right)\rho^k_{dt}(\psi)q^k_{odt}(\psi) - q^k_{odt}(\psi),
\end{aligned}
\tag{12}
$$

where, recall, $E^k_{dt}(\psi)$ is the elasticity of the slope of demand and $\rho^k_{odt}(\psi) = \left[1+\frac{(1+E^k_{dt}(\psi))}{\phi^k_{odt}}\right]^{-1}$ when each is evaluated at the argument ψ, and $\phi^k_{odt} \doteq \frac{m^k_{odt}}{\theta^k_{dt}}$ is the 'competitiveness index' introduced above. Using this result, intermediaries' surplus can be written as:

$$
IS^k_{dt}(Q^k_{dt}) = -\int_{\psi=P^k_{ot}}^{\infty} Q^k_{dt}(\psi)d\psi + \left(\frac{\phi^k_{odt}-1}{\phi^k_{odt}}\right)\int_{\psi=P^k_{ot}}^{\infty} Q^k_{dt}(\psi)\rho^k_{odt}(\psi)d\psi. \tag{13}
$$

Applying equations (11) and (13) it is then straightforward to show the following result:

Result 4(a): *Under Assumptions 1-3, the ratio of intermediaries' surplus $IS^k_{dt}(Q^k_{dt})$ to consumer surplus $CS^k_{dt}(Q^k_{dt})$ in the market at destination location d for product k on date t is given by*

$$
\frac{IS^k_{dt}}{CS^k_{dt}}\left(Q^k_{dt}\right) = \frac{1}{\overline{(\rho_Q)}^k_{dt}} + \frac{1-\phi^k_{odt}}{\phi^k_{odt}}, \tag{14}
$$

where $\overline{(\rho_Q)}^k_{dt}$ is a quantity weighted average of the pass-through rate, defined as

$$
\overline{(\rho_Q)}^k_{dt} \doteq \frac{\int_{\psi=P^k_{ot}}^{\infty} Q^k_{dt}(\psi)\rho^k_{odt}(\psi)d\psi}{\int_{\psi=P^k_{ot}}^{\infty} Q^k_{dt}(\psi)d\psi}. \tag{15}
$$

This result, which is derived for a completely general demand structure, highlight the close connection between pass-through and the division of surplus in a general oligopolistic setting. However, pass-through enters these formulae always as a weighted average $\overline{(\rho_Q)}^k_{dt}$ of pass-through values at different quantities). Unfortunately in our setting the weights in this0 weighted average formula (consumption quantities $Q^k_{dt}(\psi)$) are not observed, nor is there any hope of credibly estimating the demand structure so as to estimate

dataset can be used to estimate the fixed costs intermediaries pay. While this overstates intermediaries' total profits it does not overstate consumer surplus or deadweight loss since the fixed costs of production consume resources available to society.

these weights because consumption quantities are not observed. However, in the case of the constant pass-through class of demand (ie that described in Assumption 4), pass-through (conditional on a fixed competitiveness index) is constant and hence weighted averages of this constant are equal to the constant; that is, the weights in Result 4(a) need not be observed. This statement is formalized in Result 4(b):

Result 4(b): *Under Assumptions 1-4, the ratio of intermediaries' surplus $IS^k_{dt}(Q^k_{dt})$ to consumer surplus $CS^k_{dt}(Q^k_{dt})$ in the market at destination location d for product k on date t is given by*

$$\frac{IS^k_{dt}}{CS^k_{dt}}\left(Q^k_{dt}\right) = \frac{1}{\rho^k_{dt}} + \frac{1-\phi^k_{odt}}{\phi^k_{odt}}, \tag{16}$$

where ρ^k_{dt} is the constant equilibrium pass-through rate in this market and $\rho^k_{odt} = \left(1 + \frac{\delta^k_{dt}}{\phi^k_{odt}}\right)^{-1}$.

This result describes how, under Assumption 4 (ie a constant pass-through demand system), shares of surplus distributed in equilibrium among consumers and intermediaries in any market are all simple functions of just the equilibrium pass-through rate ρ^k_{dt} and the competitiveness index ϕ^k_{odt} prevailing in that market. Conditional on obtaining estimates of ρ^k_{dt} and ϕ^k_{odt}, therefore, Result 4(b) provides a direct estimate of the division of surplus. We pursue this in Section 4.4 below.[13]

3.4 Summary of Theoretical Framework

Using the methodology outlined above we can answer the question posed in the Introduction: How large are intranational trade costs? To summarize, our answer to this question is achieved in three steps:

1. *Step 1: Use price gaps to measure total intranational trade costs.* Among the pairs of markets that are actually trading goods, that is between origin and destination mar-

[13]An additional result that holds under Assumptions 1-4 has been generously brought to our attention by Glen Weyl: the ratio of deadweight loss (DWL) to intermediaries' surplus in this environment is given by

$$\frac{DWL^k_{dt}}{IS^k_{dt}}\left(Q^k_{dt}\right) = (1-\rho^k_{dt}) + \rho^k_{dt}\phi^k_{odt} - \left(\frac{\rho^k_{dt}\phi^k_{odt}}{(1-\rho^k_{dt}) + \rho^k_{dt}\phi^k_{odt}}\right)^{\frac{\rho^k_{dt}}{1-\rho^k_{dt}}}\left(\rho^k_{dt}\phi^k_{odt} + 1\right).$$

As with the expression for $\frac{IS^k_{dt}}{CS^k_{dt}}$ in Result 4(b), a significant advantage of this expression is that it only depends on the variables ρ^k_{dt} and ϕ^k_{odt}.

ket pairs, these trade costs (for any good, market pair and point in time) can be identified simply as the price gap, $P^k_{dt} - P^k_{ot}$.

2. *Step 2: Estimate pass-through rates.* For each product k and destination market d we estimate a separate equilibrium pass-through rate $\widehat{\rho^k_{od}}$.

3. *Step 3: Use pass-through adjusted price gaps to measure how distance affects the marginal costs of intranational trade.* The theory above has demonstrated how price gaps over space consist of both marginal costs of trading and intermediaries' mark-ups. However, armed with estimates of pass-through $\widehat{\rho^k_{od}}$ from Step 2 above, we have shown how an 'adjusted price gap' formula does reveal how marginal costs of trade vary with shifters to thoses costs, such as distance. The intuition for this is straightforward: pass-through embodies, by definition, how marginal costs affect equilibrium prices, so once estimates of pass-through are known (from time-series variation) this information is vital for studying marginal costs through observations on prices.

In addition, our model highlights the close connection between pass-through rates and the division of surplus in a partial equilibrium setting. That is, the pass-through estimates obtained in Step 2 above provide sufficient statistics for the calculation of the relative shares of social surplus accruing to intermediaries, to consumers, and to deadweight loss.

4 Empirical Results

4.1 Step 1: Using price gaps to measure total intranational trade costs

As described above, our first goal is to measure the magnitude of the total costs of conducting intranational trade in developing countries. We define these total costs as the price a consumer would have to pay to buy a good produced (or imported from) at a non-local source within her own country. Defined in this way, total intranational trade costs reflect both the marginal costs of intranational trade and the potential mark-ups that intermediaries' charge on intranational trades. But regardless of their composition, these total trade costs reflect the extent to which consumers pay additional costs to purchase non-local goods.

Result 1 above described how, for a given commodity, total trade costs for any given destination consumption location are then simply equal to the difference between the price of that commodity at its source and the price of that same commodity at the destination location. In the notation laid out above, we have

$$P^k_{dt} - P^k_{ot} = \tau(\mathbf{X}^k_{odt}) \quad +\mu^k_{dt} \quad = T^k_{odt},$$

where T^k_{odt} is the total cost of trading good k from location o to location d at time t. By definition this is the difference in price between that at the destination (P^k_{dt}) and that at the origin (P^k_{ot}). The total cost of trading is the sum of the marginal cost of trading ($\tau(\mathbf{X}^k_{odt})$), and the mark-up charged by intermediaries (μ^k_{dt}).

It is important to note that the logic of the above result is only valid for inference drawn product by product, and on data for which it is reasonable to assume that observations on product k at different points in space are effectively exactly the same product. For this reason we work exclusively with products that are extremely narrowly defined, with precision similar to barcode level identifiers. While this affects the representativeness of our basket of goods (in terms of consumption weights) it is hard to imagine pursuing any other approach without confronting serious issues of unobserved quality variation over space.

A second important feature of Result 1 is that the result that $P^k_{dt} - P^k_{ot} = T^k_{od}$, is only true for pairs of locations, o and d, that are actually trading product k. Our theory says nothing about the relationship between price gaps and trade costs for pairs of locations that are not trading. More generally, for any pair of locations i and j all that a theory of arbitrage can say (without knowledge of whether the two locations are trading) is that

$$P^k_{it} - P^k_{jt} \leq T^k_{ijt}.$$

Hence, for pairs of locations for which it is not known that trade is occurring, price gaps say nothing about the actual magnitude of total trade costs—both zero and infinite total trade costs are consistent with any data set. It is for this reason that we proceed in this section using information only on those pairs of locations that are actually trading each particular commodity; all other pairs of locations are effectively uninformative of the costs of trading.

While in principle one could use trade data to infer whether two given locations are trading product k at time t, there are two serious practical obstacles in doing so. First, trade data is rarely available within countries (especially developing countries), and even more rarely with the spatial precision required to study location-to-location trade. Second, trade data are rarely available at the product (ie brand-name) level so there is rarely a chance to know whether product k is traded or not.

Our approach utilizes, in lieu of trade data, a simple approach to infer which location pairs are actually trading each commodity: we simply infer the production (or import) location of each good (in each year) in our sample. While trade may not literally occur from a given source location, separately, to each destination location (for example, trade may follow a hub-and-spoke arrangement where the hub is a location in the center of a country) our approach still identifies the trade cost along the route actually followed from location o to location d. An important limitation of our approach, however, is that there are many pairs of locations that are not trading (the goods in our sample) and between which we therefore cannot infer the costs of trading. For this reason we seek to estimate the fundamental underlying relationship between trade cost shifters (such as distance) and trade costs, rather than the particular costs of trading among every possible pair of markets.

Table 1 describes, by commodity, the average price gap among trading pairs, as well as the standard deviation of these price gaps, the average source price, and the average distance to the source location for the Ethiopian and Nigerian samples. In order to account for inflation over the sample period and different currency units, all prices are converted into 2001 US dollars (using the base period exchange rate).[14] As can be seen, trade costs (ie from the variable, 'price gaps among trading pairs') can be substantial both in absolute units (2001 US dollars) and in relative terms (ie as a percentage of the price of a good at its source). The tables also reports the average price gap among all pairs (ie both trading and non-trading pairs), for comparison.

The variable that we refer to as 'distance' is the simple geodesic (i.e. great circle) distance between two locations, though we explore additional distance metrics (such as the distance along the quickest route and the time taken to travel the quickest route) below.

Figure 4 plots the extent to which these price gaps, among trading pairs only, co-vary with the (log) distance separating the trading pairs (that is the source and destination location). Additionally, the figures plot the extent to which absolute price gaps co-vary with the (log) distance separating the locations for all (unique, non-trivial) pairs of locations. These are semi-parametric regressions that include product-time fixed effects but allow distance to enter non parametrically via a local polynomial. In what follows we will only be able to identify the marginal costs of distance. Hence the plots are normalized such that the cost of distance is zero for all specifications at the bottom of the range of observed distances. As these figures illustrate, on average there is an upward sloping relationship,

[14] The price index for each period is obtained by calculating the average across all goods of the proportional price changes at the good's origin location. The normalized prices are converted into 2001 US dollars using the prevailing exchange rate during the first month of the sample.

implying that distance raises the total costs of intranational trade. The slope is approximately twice as steep when we restrict our sample to only trading pairs, a finding we will return to shortly.

An important lesson from the theory outlined above is that price gaps over space, among trading pairs, reflect both the marginal costs that traders face and the mark-ups that they may charge if they possess market power. Because of this, the relationship of price gaps with distance (as reported nonparametrically in Figure 4) is a mixture of how marginal costs vary with distance (presumably positively and monotonically) and how mark-ups vary with distance (either because the gap between the choke price and costs is higher in inland destinations or because of intermediaries' market power varying over space at destination locations further and further away from the origin location). An important goal of Step 3 below is a separation of these two interacting relationships with distance in order to recover the true effect of distance on the marginal costs of trading.

Finally, Table 2 reports coefficient estimates from regressions in which we regress local currency price gaps between two locations on the (log) distance between the two locations. For the case of Ethiopia, column (2) estimates this relationship on the sample of trading location pairs only, while column (1) estimates this relationship on all (unique, non-trivial) pairs of locations. Columns (5) and (4) for Nigeria and columns (8) and (7) for the United States repeat anologous results respectively. The results in column (2) show that there is a large and statistically significant relationship between price gaps and (log) distance. The estimated coefficient in column (2) corresponds to a rise in the price gap of 2.99 cents and 3.40 cents cents to ship a good for each additional unit of log-distance (measured in minutes of travel time) in Ethiopia and Nigeria respectively.[15] Remarkably, these estimates are similar across the two African countries in our sample yet nothing in our analysis imposed this.

Notably these estimates in column (2), which are obtained from trading location pairs alone, are considerably different than those in column (1) which use all pairs of locations. The estimates obtained in column (1) draw on variation that is informative about the costs of distance (ie trading pairs) and variation from pairs of locations that are not trading and whose variation is therefore completely uninformative about the (point-identified, as opposed to set-identified) costs of distance. The finding that the estimated cost of distance are smaller when the uninformative pairs are included is not surprising. The price gap between any non-trading pair i and j is a function of the difference in trade costs incurred transporting goods from the origin to locations i and form the origin to location j. The

[15]Recall all prices are normalized to base period prices (ie January 2001) and converted to US dollars using the January 2001 exchange rates.

triangle inequality implies that the distance between i and j will be weakly larger than the difference between the distance from o to i and the distance from j to i. Therefore, a regression of uninformative price gaps on the distance between i and j will tend to underestimate the marginal costs of distance.

While the results in column (2) speak to how distance raises total trade costs they do not, for reasons discussed above, indicate that distance necessarily poses significant physical costs of trading. It could simply be the case that intermediaries delivering to increasingly remote locations charge higher mark-ups than do intermediaries at proximate locations. Our analysis in Step 3 below aims to understand how much characteristics such as distance raise actual physical costs of trading (ie intermediaries' marginal costs) by separating the price gap-to-distance relationship into its two constituent parts: the marginal cost-to-distance relationship and the mark-up-to-distance relationship.

4.2 Step 2: Estimating pass-through

In Step 3 below we aim to measure how the marginal cost of intranational trade rises with distance. Doing so requires a method for differentiating the extent to which distance affects the marginal costs of trading from the extent to which distance affects the mark-up charged by traders. Pass-through, defined as the extent to which a marginal cost shock raises the equilibrium price (and is hence equal to one minus the extent to which a marginal cost shock raises mark-ups), is an essential ingredient for this analysis. The current section—Step 2— aims therefore to provide estimates of pass-through for each location d and product k in our sample.

Before constructing these estimates it is worth emphasizing that pass-through is an object of policy interest in its own right. This is for two reasons. First, pass-through measures the extent to which households in developing countries are exposed to changes in economic conditions beyond their borders. In a market economy these effects work through price signals. It is therefore important to understand the extent to which the prices faced by households in developing countries—and especially those in remote segments of developing countries—are actually affected by foreign price developments (such as tariff changes, exchange rate changes, improvement in international shipping technologies, or fluctuations in world demand and supply). If the prices paid by remote households (for imported goods) are largely unaffected by foreign price developments then the question of whether integration with world markets via border policies (such as trade liberalization or exchange rate policy) has been good or bad for these households is a non-starter. Second, as discussed in Result 2 above, the extent of pass-through is also a metric for the extent to which the market in a location is perfectly competitive: perfect competition implies complete pass-through, while incomplete pass-through is *prima facie* evidence for imperfect competition. This logic applies equally to domestically produced goods (ie the extent to which a shock to the price at the factory gate location affects each destination location's retail price) and to imported goods (ie the extent to which a foreign price development, such as an exchange rate appreciation, affects each destination location's retail price).

Recall from Result 2 above that pass-through (ρ^k_{odt}) relates to the extent to which exogenous origin prices (P^k_{ot}) affect endogenous destination prices (P^k_{dt}) in the following manner:

$$P^k_{dt} = \rho^k_{odt} P^k_{ot} + \rho^k_{odt}\tau(\mathbf{X}^k_{odt}) + (1-\rho^k_{odt})a^k_{dt}. \tag{17}$$

When using this equation to estimate pass-through (ρ^k_{odt}) three identification challenges arise.

First, there is no hope of estimating a separate pass-through rate ρ^k_{odt} for each time destination d, product k and time period t. We therefore focus on estimating the average pass-through rate (which we denote ρ^k_{od}) for a destination location d and product k across all time periods in our sample. Because the pass-through rate is always equal to $\rho^k_{odt} = \left(1+\frac{\delta^k_{dt}}{\phi^k_{odt}}\right)^{-1}$ under A1-A4, the assumption that the pass-through rate ρ^k_{od} is constant over time (within a product and location) amounts to assuming that the second-order property of demand δ^k_{dt} (for a product in a location) and the competitiveness parameter ϕ^k_{odt} (for the sale of a product in a location) are constant over time.

Second, estimation of ρ^k_{od} here requires controls for the marginal cost of trading (ie $\tau(\mathbf{X}^k_{odt})$) and for local demand shifters (ie a^k_{dt}). Unfortunately, both the marginal cost of trading and local demand shifters are unobservable to researchers—indeed, if these were observable then answers to the question posed in this paper would be immediately available. In the absence of such controls we make the weakest possible assumption required to identify ρ^k_{od}, namely that the product-specific variation in the marginal cost of trading and local demand shifters within destinations *over time* is orthogonal to the variation in the origin price over time (or at least to an instrument for changes in the origin price over time). That is, we assume that the marginal cost of trading, $\tau(\mathbf{X}^k_{odt})$, can be decomposed into local but time-invariant (β^k_{1od}), local but trending ($\beta^k_{2od}t$), macro but time-varying (β_{3t}) and residual (ζ^k_{odt}) factors as follows: $\tau(\mathbf{X}^k_{odt}) = \beta^k_{1od} + \beta^k_{2od}t + \beta_{3t} + \zeta^k_{odt}$. Analogously, we assume that destination market additive demand shocks, a^k_{dt}, from Equation (5) above can be decomposed as follows: $a^k_{dt} = \alpha^k_{1d} + \alpha^k_{2d}t + \alpha_{3t} + \nu^k_{dt}$. Note that while this assumption places certain restrictions on how the additive demand shifter, a^k_{dt}, varies across locations, time and products, we place no restrictions on the multiplicative demand shifter, b^k_{dt}, from Equation (5) above. Conditional on these assumptions we estimate pass-through rates ρ^k_{od} by location and product by estimating the following specification,

$$P^k_{dt} = \rho^k_{od} P^k_{ot} + \gamma^k_{od} + \gamma^k_{od} t + \gamma_t + \varepsilon^k_{dt}, \tag{18}$$

where P^k_{dt} is the destination price, P^k_{ot} is the origin price, γ^k_{od} and γ_t are product-destination and time fixed-effects, respectively, $\gamma^k_{od} t$ is a product-destination linear time trend, and $\varepsilon^k_{dt} = \rho^k_{od} \zeta^k_{odt} + (1 - \rho^k_{od}) \nu^k_{odt}$ is an unobserved error term.

Third, estimation of equation (18) via OLS requires the additional assumption that $\mathbb{E}\left[P^k_{ot} \zeta^k_{odt}\right] = 0$ and $\mathbb{E}\left[P^k_{ot} \nu^k_{dt}\right] = 0$, namely that the origin price P^k_{ot} is not correlated with the time-varying and local shocks to local (destination location d-specific) trade costs or demand shifter. If origin prices are set abroad (in the case of imported goods), or are pinned down by production costs at the factory gate (in the case of domestic goods), or are set on the basis of demand shocks at the origin location (which we omit from our analysis), then this orthogonality restriction seems plausible. But a nation-wide demand shock for product k (note that a nation-wide demand shock for all goods is controlled for with the γ_t fixed effect) would violate this assumption. In future versions of this paper we aim to explore the plausibility of this assumption by estimating equation (18) via an instrumental variables method in which the IV for the origin price is the price of a production input sourced from abroad (indeed some products k are produced entirely abroad) or the exchange rate of the country producing the input (or the product k). For now it is worth noting that the likely bias from violations of this assumption will be positive, leading us to over-state the rate of pass-through.

Figure 3 contains our estimates of the pass-through rate for all goods and all locations, with pass-through rates (within a destination location averaged across all products) in addition plotted nonparametrically against log source-to-destination distance (again in travel time units).[16] A general tendency in these figures is for the pass-through rate to be lower at destinations that are further distances from the product's source. This is confirmed in column 1 of Table 6 which shows significant negative coefficients from the regression of pass-through estimates on log source-to-destination distance (again in travel time units). Another general tendency is for estimated pass-through to lie below one, often considerably below one; the average estimated pass-through rate in our sam-

[16]For now we estimate only contemporaneous pass-through rates (though due to the high serial correlation in source prices these estimates are similar to those from lagged regressions). In future versions of this paper we aim to estimated distributed lag specifications and hence trace out the entire impulse response in the destination price of a change in the port price, that is both short-run and long-run pass-through.

ple is approximately 0.5. The theory outlined above (indeed virtually any oligopolstic model) places no restrictions on the pass-through rate except that it be positive (a restriction that very few of our estimates violate). But beyond this non-negativity restriction pass-through could be below or above one; our estimates suggest that pass-through below one is a commonplace (and naturally our OLS estimates of the pass-through rate are likely to be, if anything, biased upwards).

While the primary goal of estimating pass-through rates is to feed into Step 3 of our analysis below, below we will also use our estimated pass-through rates (from Step 2 here) to identify the competitiveness parameter ϕ^k_{od} prevailing in each location due to the relationship between pass-through and competitiveness, $\rho^k_{od} = \left(1 + \frac{\delta^k_d}{\phi^k_{od}}\right)^{-1}$ in our model.

4.3 Step 3: Using pass-through adjusted price gaps to measure how distance affects the marginal costs of intranational trade

In section 4.1, we detailed how the price gaps among trading pairs increased with the (log) distance separating the trading pairs. However, this positive relationship is not driven solely by the fact that the marginal costs of trading increase with distance. In addition, intermediaries charge markups, and our model clarifies that the size of the markup may be related to distance for two distinct reasons. The theoretical framework outlined above offers guidance here, and this is particularly easy to see in the case of constant demand preferences (ie Assumption 4) for which, recall, Result 3 is

$$\frac{P^k_{dt} - \rho^k_{odt} P^k_{ot}}{\rho^k_{odt}} = \tau(\mathbf{X}^k_{odt}) + \frac{(1 - \rho^k_{odt})}{\rho^k_{odt}} a^k_{dt}. \tag{19}$$

Recall that in Step 2 above we have obtained estimates of the time-constant (or average over time) pass-through rate in each location d and product k, an estimate that we denote by $\widehat{\rho^k_{od}}$. Using these estimates makes the estimation of $\tau(\mathbf{X}^k_{odt})$ in equation (19) feasible. Again, as in Step 2 above, an identification challenge is posed by the presence of the unobserved demand-shifter a^k_{dt} on the right-hand side of this estimating equation. We therefore assume that a^k_{dt} can be decomposed as follows: $a^k_{dt} = \alpha^k_t + \alpha_d + \nu^k_{dt}$ and, further, that $\mathbb{E}\left[\mathbf{X}^k_{odt} \nu^k_{dt}\right] = 0$. This assumption requires that the variation in additive demand shifters across destination locations (ie the variation, ν^k_{dt}, that remains after macro-level time-product effects, α^k_t, and destination effects, α_d, are removed) is uncorrelated with shifters to the marginal costs of trading across locations, $\mathbf{X}^k_{odt}$. Again, we require no restrictions at all on the multiplicative demand shifters, b^k_{dt}, from Equation (5) above.

With this assumption in place we can now state our main estimating equation for identifying the extent to which distance affects the marginal costs of trading (ie how some marginal cost shifter $\mathbf{X}^k_{odt}$ affects the marginal costs of trading, $\tau(\mathbf{X}^k_{odt})$):

$$\frac{P^k_{dt} - \widehat{\rho^k_{od}} P^k_{ot}}{\widehat{\rho^k_{od}}} = \tau(\mathbf{X}^k_{odt}) + \gamma^k_t \left(\frac{1 - \widehat{\rho^k_{od}}}{\widehat{\rho^k_{od}}} \right) + \gamma_d \left(\frac{1 - \widehat{\rho^k_{od}}}{\widehat{\rho^k_{od}}} \right) + \gamma^k_t + \varepsilon^k_{dt}, \tag{20}$$

where $\widehat{\rho^k_{od}}$ is a consistent estimator of the pass-through rate ρ^k_{od} obtained in Step 2 above, γ^k_t is a product-time fixed-effect, γ_d is a destination fixed effect and $\varepsilon^k_{dt} = \frac{(1-\rho^k_{od})}{\rho^k_{od}} \nu^k_{dt}$ is an error term for which $\mathbb{E}\left[\mathbf{X}^k_{odt} \nu^k_{dt}\right] = 0$.

The key attraction of this equation from an empirical perspective is that it describes a way in which price data across origin-destination pairs can be used, in conjunction with estimates $\widehat{\rho^k_{od}}$ of the pass-through rate (obtained in Step 2 above), to estimate the importance of shifters $\mathbf{X}^k_{odt}$ to the marginal costs of trading. Further, in principle the effect of $\mathbf{X}^k_{odt}$ on $\tau(\mathbf{X}^k_{odt})$ can be estimated entirely non-parametrically. For example, a central question in the study of trade costs concerns the extent to which distance increases the marginal costs of trading. Equation (20) implies that this relationship between distance and the marginal costs of trade is revealed, despite the potential presence of market power in the trading sector, by simply using 'adjusted price gaps' (ie $\frac{P^k_{dt} - \widehat{\rho^k_{od}} P^k_{ot}}{\widehat{\rho^k_{od}}}$) rather than price gaps (ie $P^k_{dt} - P^k_{ot}$) as the dependent variable.

To gain intuition for this expression, consider the following. First, and dropping the sub- and superscript notation for now without the risk of confusion, the size of the markup, $\mu = (1 - \rho)(a - \tau - P_o)$, is proportional to the gap between the choke price a and the total cost to the intermediary, $\tau + P_o$. For the case of incomplete pass through, $\rho < 1$, higher marginal costs of transportation raise prices and hence reduce the markup that intermediaries choose to charge ($\frac{d\mu}{dX_{od}}|_{\left(\frac{m}{\theta}\right)_{od}} = -(1 - \rho)\frac{d\tau}{dX_{od}}$). This channel implies that the marginal costs of distance are understated in section 4.1 if $\rho < 1$ and overstated if $\rho > 1$. Second, the pass-through rate varies across space due to the competitiveness of the distribution sector ($\frac{d\mu}{dX_{od}}|_{\tau} = -(a - \tau - P_o)\frac{d\rho}{d\left(\frac{m}{\theta}\right)_{od}} \frac{d\left(\frac{m}{\theta}\right)_{od}}{dX_{od}}$). For the case of incomplete pass through, if routes that reach interior locations far from major production/import locations are less competitive, pass through rates will be smaller in the interior and markups will be larger. This channel implies that the marginal costs of distance are overstated in section 4.1 if $\rho < 1$, but the direction of bias is ambiguous if $\rho > 1$.

Our aim in this section is to estimate the true marginal costs of distance by correcting for these two biases using the adjusted price gap methodology described in equation (20). We obtain estimates of pass through rates, $\widehat{\rho_{od}^k}$, from section 4.2. Dividing the price gap $P_{dt}^k - P_{ot}^k$ by the pass-through rate purges the price gap of the first bias. Further transforming the price gap by replacing P_{ot}^k with $\widehat{\rho_{od}^k} P_{ot}^k$, as well as including two new sets of independent variables, $\gamma_t^k \left(\frac{1-\widehat{\rho_{od}^k}}{\widehat{\rho_{od}^k}}\right)$ and $\gamma_d \left(\frac{1-\widehat{\rho_{od}^k}}{\widehat{\rho_{od}^k}}\right)$, where γ_t^k and γ_d are product-time and destination fixed effects, explicitly controls for the fact that markups may vary over space due to different levels of competition.

Table 2 presents the results of these regressions, where we model the marginal costs of trading $\tau(\mathbf{X}_{odt}^k)$ as a simple function of (log) distance (from origin location o to destination location d). Column 1 reproduces the unadjusted price gap specification shown in section 4.1 above (for the interpretation of the coefficients in this table, see below). Column 2 goes part-way towards adjusting these estimates for potentially varying mark-ups over space by dividing the price gap through by the pass-through rate. And column 3 estimates equation (20) in the manner suggested by our model—that is, using the appropriate 'adjusted price gap' (ie $\frac{P_{dt}^k - \widehat{\rho_{od}^k} P_{ot}^k}{\widehat{\rho_{od}^k}}$) as the dependent variable and controlling for estimates of pass-through adjusted demand shifters,$\gamma_t^k \left(\frac{1-\widehat{\rho_{od}^k}}{\widehat{\rho_{od}^k}}\right)$ and $\gamma_d \left(\frac{1-\widehat{\rho_{od}^k}}{\widehat{\rho_{od}^k}}\right)$.[17] All specifications include product-time fixed effects. A consistent pattern emerges across these three columns, in both Ethiopia and Nigeria, that is consistent with our model. First, the estimated coefficient on the (log) distance separating the trading pairs at first rises (in column 2 relative to column 1) when only the adjusted price gap is used; but this coefficient then falls (in column 3 relative to column 2) when both corrections are applied. These results imply that the two biases discussed above are substantial in magnitude but, at least in the case of Nigeria and Ethiopia, cancel each other out to some extent.

Columns 4-6 of Tables 3, 4 and 5 allow for a more general specification of $\tau(\mathbf{X}_{odt}^k)$. We allow the marginal costs of trading $\tau(\mathbf{X}_{odt}^k)$ to be functions of both the (log) distance between the source and destination, the log weight of a unit of the good in question and the interactions of the two. In both Ethiopia and Nigeria, the marginal cots of distance is substantially larger for heavier goods.

The estimated coefficients in column (3) of each table correspond, according to our methodology, to the estimated marginal costs of distance (in travel time units) along the

[17] As we are dividing by $\widehat{\rho_{od}^k}$, results are very sensitive to estimated $\widehat{\rho_{od}^k}$s close to 1. Therefore, we winsorize all the pass-through rates estimates that fall below 0.2. Our results are robust to this procedure and the un-winsorized regressions are reported in tables 3 and 4.

mean journey length in each country (approximately 6 and 8 hours respectively). These numbers are substantially higher than the estimated total costs of distance. The estimated coefficients imply that the marginals costs of trade increase by 4.11 cents and 5.70 cents for each additional unit of log-distance in Ethiopia and Nigeria respectively (compared to 2.99 cents and 3.40 cents cents without the correction for spatial markup variation).

To interpret these estimates, consider the following. The least remote locations in our sample are approximately an hour of travel (ie 60 minutes or 4.1 log minutes) away from the source of production. (This travel time falls within the second percentile of the distribution of route lengths in both samples). The most remote locations in our sample are approximately twenty hours (ie 1200 minutes or 7.1 log minutes) of travel away from the source of production. (This travel time falls within the 99th percentile of route lengths in Ethiopia and the 97th percentile in Nigeria). Therefore, the additional trade costs incurred by transporting goods to the most remote compared to the least remote locations (a difference of 3 log minutes) is 12 cents in Ethiopia and 17 cents in Nigeria. The mean product observation in our Ethiopia sample costs just over 40 cents. So the *ad valorem* equivalent of this relative cost of remoteness is 30 percent. The equivalent calculation for our Nigeria sample (mean product cost of 1.17 dollars) suggests a relative cost of remoteness of 14 percent. These are considerable costs of intranational trade.

To obtain a better sense of the magnitude, we can make rough comparisons to estimates of the marginal costs of distance from other sources. In a widely cited paper, Hummels (2001) uses freight cost data included in some countries customs records to estimate the relationship between freight costs and distance for internationally traded goods. Table 3 of his paper reports estimates of the ad-valorem freight costs for imported goods at relatively proximate and relatively far distances from the origin port. Taking simple differences of these ad valorem costs and dividing through by the change in log distance provides estimates comparable to the ad valorem numbers given above.[18] The implied increase in ad valorem costs for an increase in distance of 3 log points are listed in the table below for the seven countries for which Hummels' could obtain data. The US customs data is particularly rich, and allows separate estimates by mode of transport.

[18] We take the difference between teh smallest and largest distance estimates reported by Hummels (2001). All of these estimates are for cargoes with the mean weight to value ratio.

Implied Δad-valorem transport cost for Δ lndistance of 3 units (percent) (by mode of transport for cargo of mean kg/$)	
US (Truck from CAN)	2.0
US (Rail from CAN)	2.7
US (Ocean)	4.9
US (Air)	14.6

Source: Authors' calculation based on Table 3 in Hummels (2001).

The increase in ad valorem trade costs associated with an increase in distance of 3 log points was 30 percent in Ethiopia and 14 percent in Nigeria. Since almost all this trade travels by road, the most easily comparable figures from Hummels are those for truck traffic from Canadian provinces to the US border.[19] The change in ad valorem trade costs with log distance in our two African samples is approximately 7 to 15 times larger than the change in ad valorem freight costs with log distance found for international trade shipments from Canada to the US. Therefore, the Ethiopian and Nigerian numbers imply extremely large costs of intranational trade relative to international trade costs along the same mode of transport linking two developed countries. Interestingly, the estimates for Nigeria are not too dissimilar to the estimates Hummels obtains for landlocked Paraguay, where imports must travel long distances over developing-country land routes prior to arriving at the dry port.

Figure 4 presents our nonparametric estimates of the effect of distance (again, in travel time units) on the marginal costs of trading. By and large these plots confirm the parametric (linear) regression estimates referred to above. Importantly, the ordering of slopes across three different methodologies (all pairs, trading pairs and markup-adjusted pairs) is the same nonparametrically (in these figures) as parametrically (in the regression coefficients reported above).

Tables 3 and 4 carry out a variety of important robustness checks. Columns 1-4 repeat the estimation of the main specification shown in the previous table but with the inclusion of destination or destination-time fixed-effects. This does not substantially affect the coefficient estimates. However, given the limited number of source locations, the destination fixed effects are highly correlated with distance and hence our preferred specification includes only product-time fixed effects. Columns 5-6 control for destination-specific demand shocks in a more parsimonious manner by including controls for the log population and log income per capita at the destination. Columns 7-8 do not winsorize the $\widehat{\rho_{od}^k}$ estimates that fall below 0.2 as we do for the main specification to avoid dividing price gaps by numbers close to zero. Columns 9-10 use exchange rates deflated by the local inflation

[19] The import data record the province of origin in Canada and the district of entry into the US.

rate to instrument for origin prices in the estimation of $\widehat{\rho^k_{od}}$ for the subsample of import goods where bilateral deflated exchange rates explain origin price movements. Columns 11-12 build on columns 9-10 but also include the deflated local currency oil price as an explanatory variable in the pass through regression. The inclusion of the oil price explicitly deals with the worry that shocks to oil prices (potentially due to exchange rate fluctuations) can alter both the origin prices and marginal costs of transport. Columns 13-14 remove goods which show strong evidence of producer price setting behavior: we remove the four goods from the two samples for which nominal prices remain fixed for long periods of time (24 months or more). Finally, Columns 15-16 remove price pairs where the destination location is less than 100 minutes from the source location in case demand shocks are spatially correlated biasing our pass through estimates towards one for nearby locations.

4.4 Implications for the share surplus accruing to consumers, to intermediaries, and to deadweight loss

Consider the following thought experiment. Due to tariff reductions or improvements in international transportation and logistics, events often termed 'globalization', the port price of a particular import falls by 20 percent. This price reduction creates an additional amount of social surplus that will in part: (1) accrue as consumer surplus to consumers located at various points within the country, (2) accrue as profits to the intermediaries who provide consumers with the import goods, and (3) end up as deadweight loss associated with intermediaries using their market power to restrict supply. The model in section 3 shows—in Result 4(c)—that under the assumption that demands are in the constant pass-through class, the pass through rate and the competitiveness index of any particular route provide sufficient statistics for estimating how the social surplus is distributed between consumers, intermediaries and deadweight loss.

But where can estimates of these parameters be obtained?

First, Result 2(b) above has already discussed a method for obtaining consistent estimates of ρ^k_d, namely equilibrium pass-through $\rho^k_{odt} = \left(1 + \frac{\delta^k_{dt}}{\phi^k_{odt}}\right)^{-1}$ under the additional assumption (Assumption 5) that pass-through is constant over time within a product-destination market (because δ^k_{dt} and ϕ^k_{odt} are constant).

Second, the formula

$$\rho^k_{od} = \left(1 + \frac{\delta^k_d}{\phi^k_{od}}\right)^{-1} \tag{21}$$

suggests how the pass-through rate ρ^k_{od} and the competitiveness index ϕ^k_{od} are connected to one another and hence how estimates of ρ^k_{od} could be used to estimate ϕ^k_{od}. Unfortunately, in general there is no unique mapping between ρ^k_{od} and ϕ^k_{od}. Indeed, as equation (21) above illustrates, in principle there are DT known values of ρ^k_{od}, but DT unknown values of δ^k_d and another DT unknown values of ϕ^k_{od} to be estimated. We therefore assume (in Assumption 8) that the variation in the demand-side determinants of pass-through (ie the parameters δ^k_d) and the supply-side determinants of pass-through (ie the parameters ϕ^k_{od}) are sufficiently orthogonal over destination markets d and products k as to allow data on the pass-through rate (ie an estimate of ρ^k_{od}) to identify ϕ^k_{od} which is all that is required to apply Result 4(b) and hence provide an answer to the question of how does the share of total surplus accruing to consumers vary with remoteness. However, as should be clear, the particular assumption made in Assumption 8 here is overly sufficient since it restricts there to be only $D+T$ unknown parameters to be estimated from DT pass-through ρ^k_{od} estimates.

Assumption 5. *The demand parameter δ^k_d is constant over destination locations d but can vary freely across products k; that is, δ^k_d=$\delta^k \forall d$. Similarly, the competitiveness index parameter ϕ^k_{od} is constant over products k but is free to vary across destinations d; that is, ϕ^k_{od}=$\phi_d \forall k$.*

This is a particularly stark assumption but one that is perhaps not an implausible first-pass. That is, because of possible economies of scale it seems plausible that the essential variation in the number of intermediaries and their competitive conduct (ie m^k_{od} and θ^k_d), and hence the overall competeviness index ϕ^k_{od}, across products and locations is primarily across locations. We have in mind here a notion that large locations have many intermediaries supplying any given good. Likewise, while we allow the additive and multiplicative shifters of demand (ie a^k_{dt} and b^k_{dt}) to vary across locations, products and time, it seems plausible that the second-order curvature parameter δ^k_{dt}, the unique demand-side parameter that governs pass-through, is constant across locations and time. That said, because Assumption 8 is overly sufficient for identification, it is testable, and we will explore this in future work.

We are finally ready to state the key result that describes an empirical procedure (and the assumptions required for it to be accurate) to Question 4:

Result 4(c): *Under Assumptions 1-5, a consistent estimator of the competitiveness index at a destination (ie ϕ_d), up to a scalar, can be obtained by estimating the following regression by OLS*

$$\Xi_{od}^k = \gamma_d + \gamma^k + \gamma^k \zeta_{od}^k + \varepsilon_{od}^k, \tag{22}$$

where $\Xi_{od}^k \doteq \ln(\frac{1}{\rho_{od}^k} - 1)$ *if* $\zeta_{od}^k = 1$ *and* $\Xi_{od}^k \doteq \ln(1 - \frac{1}{\rho_{od}^k})$ *if* $\zeta_{od}^k = 0$, $\widehat{\rho_{od}^k}$ *is a consistent estimator of the equilibrium pass-through rate obtained by applying Result 2(b),* γ_d *and* γ^k *are destination- and product-specific fixed effects respectively, and* ε_d^k *is an error term. Normalizing such that the lowest value of* $\phi_d = 1$*, a consistent estimator of* ϕ_d *is* $\widehat{\phi}_d \doteq e^{\widehat{\gamma_d}}$*. Further, an estimate of the ratio of intermediaries' surplus* $IS_d^k(Q_d^k)$ *to consumer surplus* $CS_d^k(Q_d^k)$ *in the market at destination location d for product k is given by*

$$\widehat{\frac{IS_d^k}{CS_d^k}(Q_d^k)} = \frac{1}{\widehat{\rho_{od}^k}} + e^{-\widehat{\gamma_d}} - 1. \tag{23}$$

Result 4(c) therefore describes a simple method for using estimated pass-through rates $\widehat{\rho_{od}^k}$, which we estimate separately by product k and destination location d, to infer how the distibution of suprlus varies with remoteness. That is, despite the lack of access to consumption quantity data in this setting, we can use estimated pass-through rates, guided by Result 4(c), to infer the share of total surplus—that is, the gains from trade—accruing to consumers, to intermediaries, and to deadweight loss in each market (ie product and location) in our sample.

Note also that, along the way to answering this question, Result 4(c) suggests a way in which the competitiveness index ϕ_d for each destination d can be identified. As outlined in Result 4(c), the good and origin-destination specific pass through rates ρ_{od}^k provide sufficient variation to estimate the unknown competitiveness indices for each destination location d. Various methods can be used to obtain estimates of the competitiveness index ϕ_d. Here, we follow Result 4(c) and transform the pass-through rates to linearize this relationship and then apply OLS to recover estimates of ϕ_d.

Figure 7 shows non-parametric plots of how the competitiveness index varies with (log) distance to the main commercial city (Addis Ababa or Lagos), with higher values of the index representing greater levels of competition. If intermediaries compete a la Cournot, the competitiveness index simply corresponds to the number of middlemen serving a particular location. Column (2) of Table 6 reports a descriptive regression of the competitiveness index at each location against the log distance to the main commercial city. The value of the competitiveness index clearly declines with distance form the capital in both Ethiopia and Nigeria. More remote locations have a less competitive intermediary sector serving them.

Result 4(c) above also described how estimates of the distribution of surplus follow simply from estimates of pass-through and competitiveness. Figure 8 presents non-parametric plots of the relationship between the ratio of intermediary profits to consumer surplus and distance for each good, as well as the ratio of deadweight loss to total social surplus. Columns (3) to (5) of Table 6 report descriptive regressions of these ratios and shares against the log source-to-destination distance. For both Ethiopia and Nigeria, the further a good must travel to reach the consumer, the smaller share of the (partial equilibrium) surplus that accrues to the consumer. The additional share of surplus going to consumers in the least remote locations (1 hour away) compared to the most remote locations (20 hours away) is 7 percent in Ethiopia and 19 percent in Nigeria.

The normalization that the least competitive locations were served by monopolist traders is not wholly innocuous (although necessary to avoid the dummy variable trap in our estimation strategy). Reassuringly, choosing other normalizations where the least competitive location is more competitive than under monopoly changes the share going to consumers but does not affect the slope of this share with respect to log distance (the key comparison of interest).

The fact that consumers accrue only a fraction of the surplus generated by the ability to purchase goods made in distant locations does not tell us how much surplus is created in total. Our finding that the marginal costs of intranational trade are extremely high clearly implies that the total quantity of surplus will be smaller in more remote locations. In the extreme case, high marginal costs of trade may prevent goods from even reaching remote locations. In this scenario, a tariff cut at the border will not increase the social surplus of interior consumers at all.

Consumer price index enumerators record as missing a good that is unavailable at a particular location during a particular month. This information on product availability provides suggestive evidence that internal trade costs substantially reduce the total quantity of social surplus generated by trade. If products cannot be found in locations far from the port or factory, neither consumers nor intermediaries in this location benefit from trade in this product. Figure 6 plots product availability (a binary variable) on the log source-to-destination distance for the subset of product-location pairs where product is observed at least once in the sample. As expected, in both countries product availability falls precipitously with distance from the factory or port.

5 Conclusion

This paper sets out to answer the question *how large are intranational trade costs in developing countries?* We find that the costs of distance appear to be under-estimated by standard spatial price gap methods used to infer trade costs. The costs of distance approximately double when we use discard uninformative price gaps, those price gaps for which neither of the pairs is a source location for the good in question. The costs of distance approximately double again when spatial variation in mark-ups accounted for by using a sufficient statistic (pass-through rates) to adjust price gaps**.**

Our finding that the costs of intranational trade are extremely high (approximately 7 to 15 times larger than the freight costs for road transport between Canada and the US), has obviously implications for consumer welfare. High intranational trade costs reduce the amount of potential surplus consumers can derive from purchasing goods made in distant locations. Of the surplus that remains once the costs of distance have been accounted for, it appears that a significant fraction does not actually accrue to consumers (and instead accrue to intermediaries and deadweight loss), and that this is especially true in the most remote locations.

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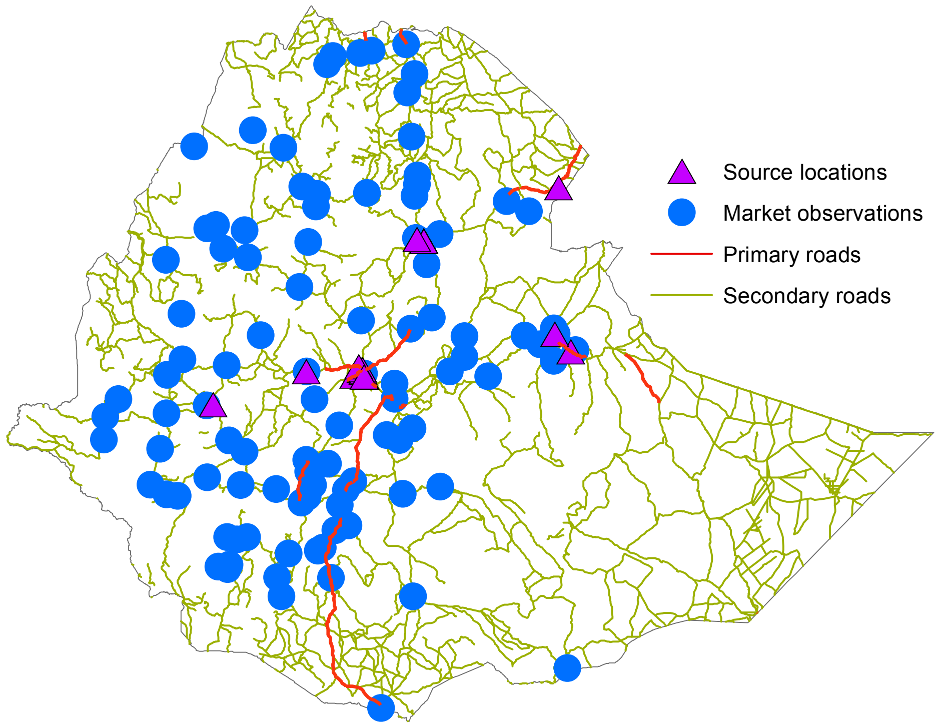
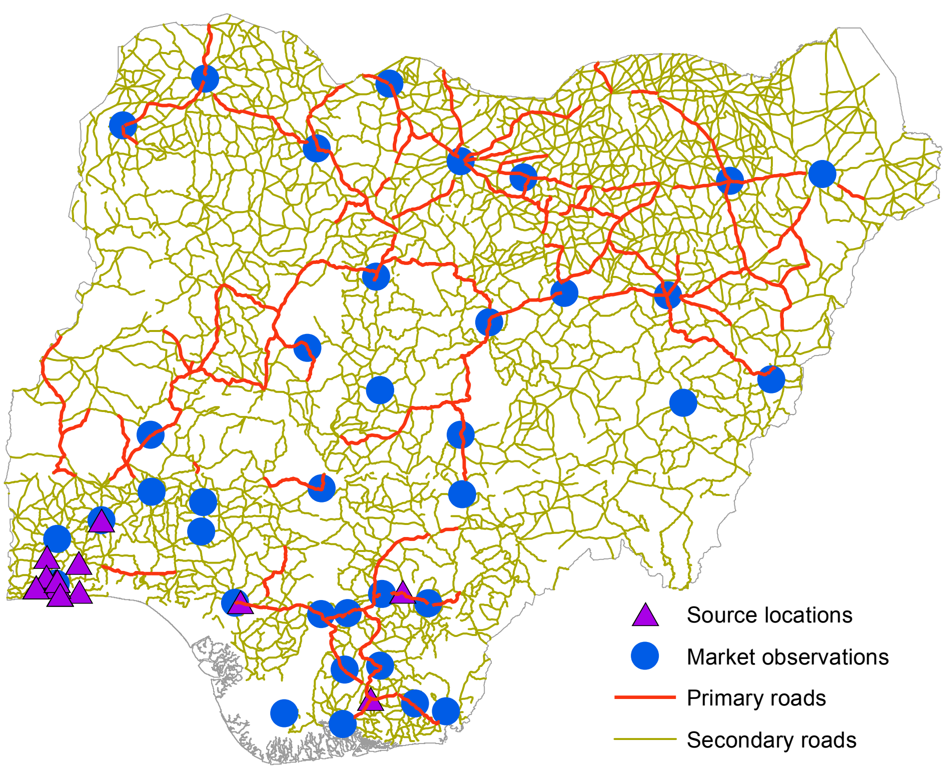
Figures

Figure 2: Maps of sample locations

Panel A: Ethiopia

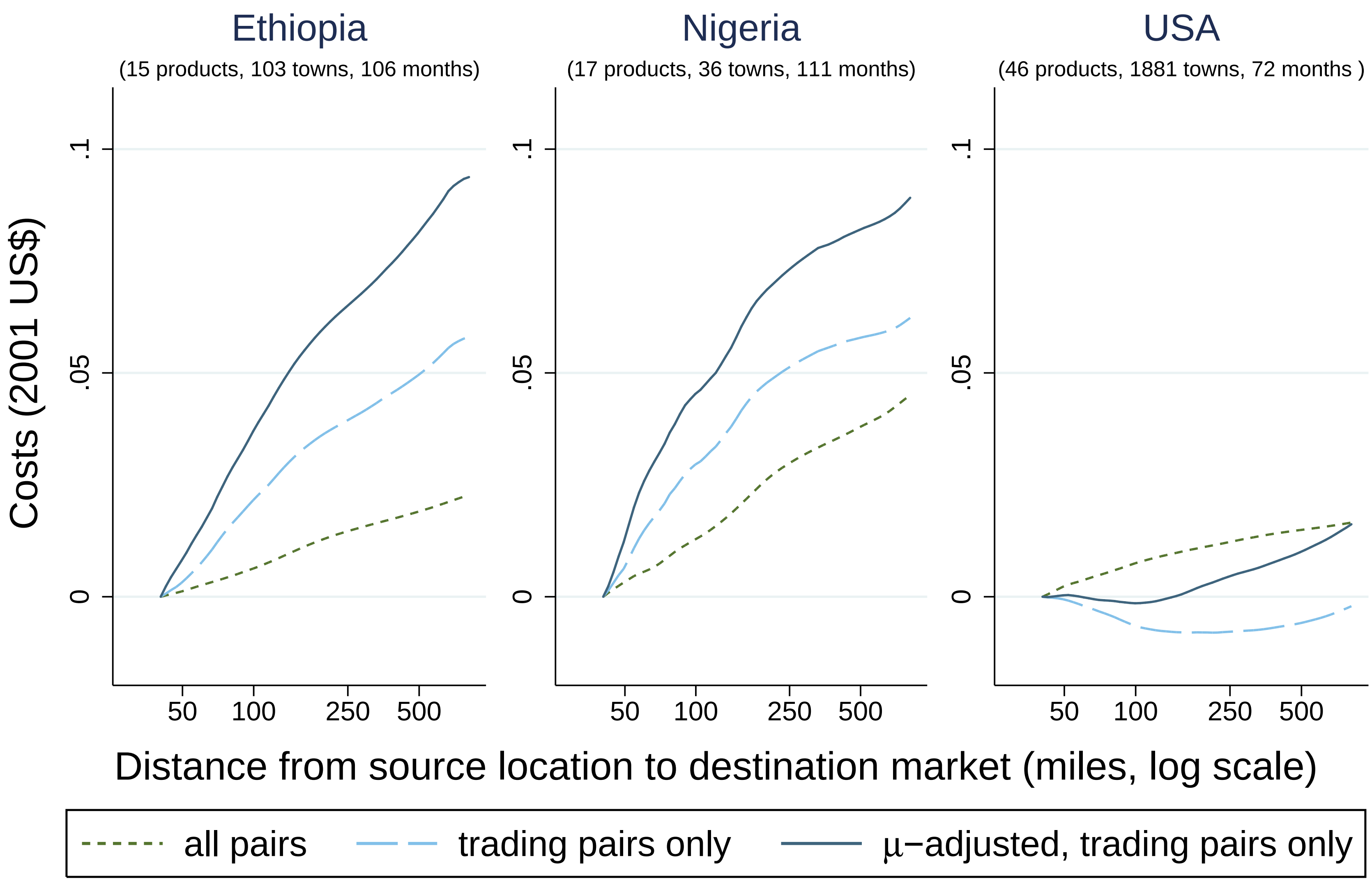


Panel B: Nigeria



Note: Red triangles denote market locations at which prices are observed and blue circles denote origin locations (factories in the case of domestically produced goods, ports-of-entry in the case of foreign goods).

Figure 1: Marginal costs of distance



Locally weighted polynomial (Epanechnikov kernel, bandwidth=0.5). All plots are semiparametric and include product−time fixed effects. μ−adjusted regression controls for interactions between pass−through and fixed effects as described in text.

Figure 3: Estimated pass-through rates for all goods and distance

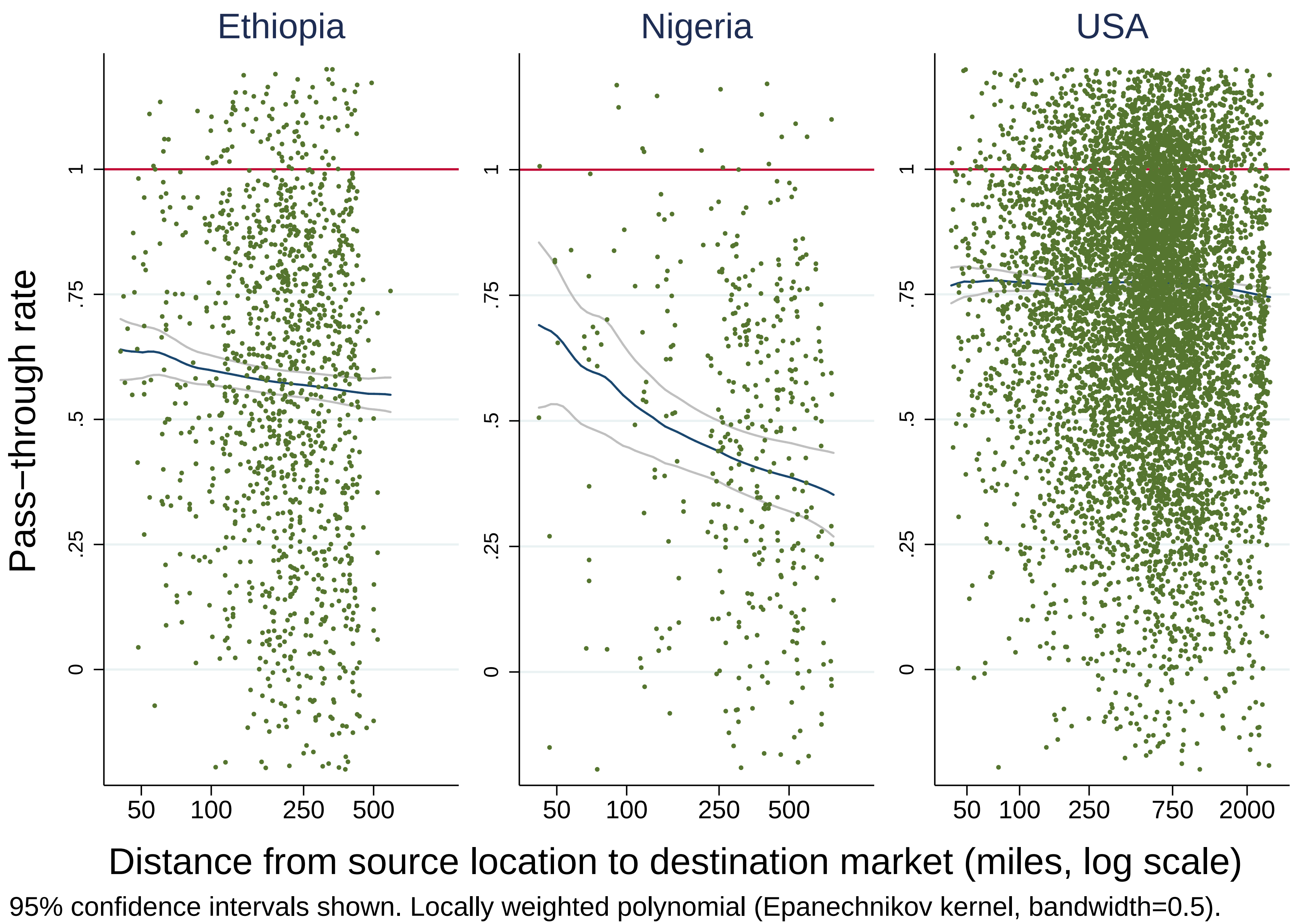
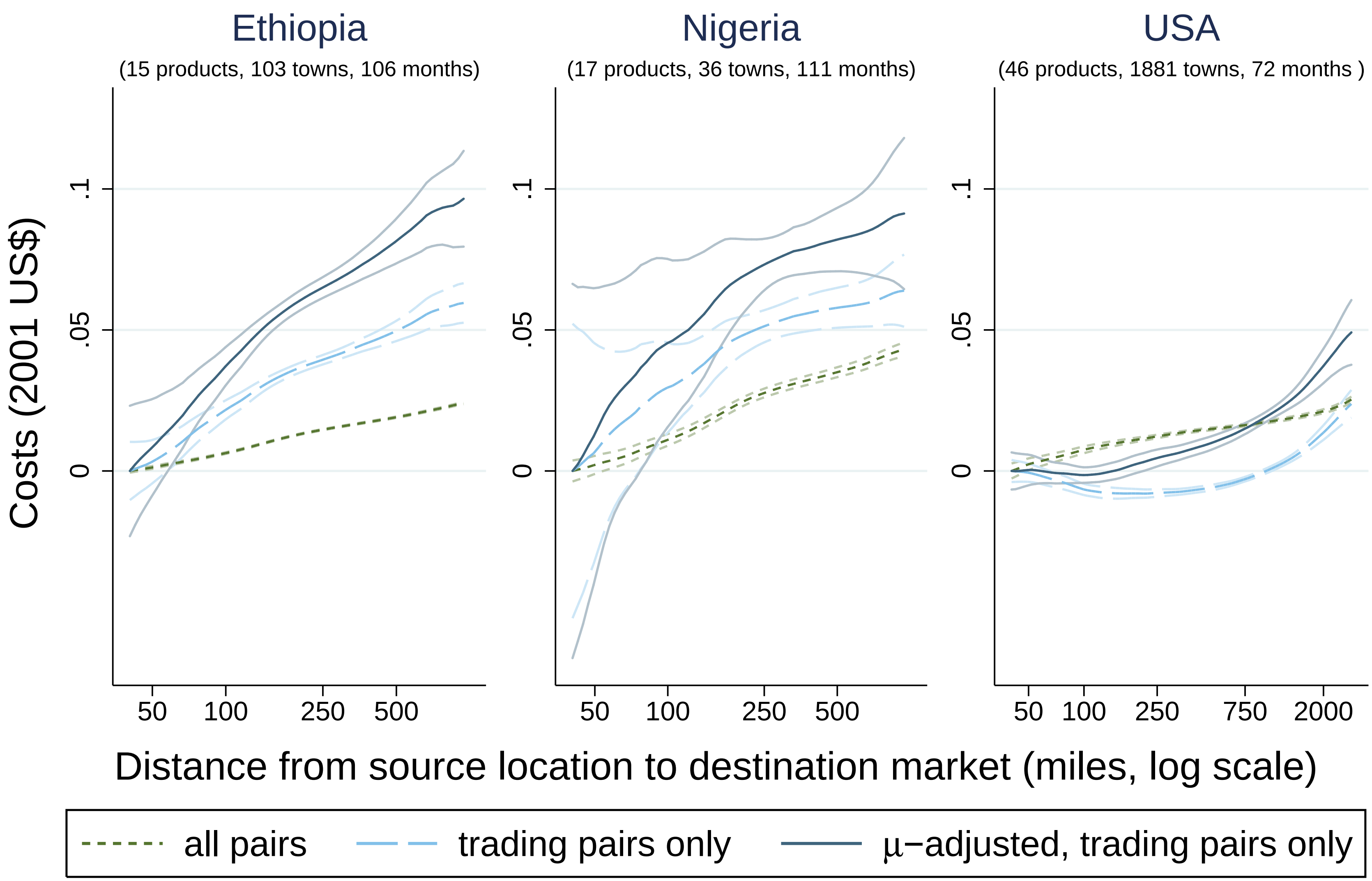
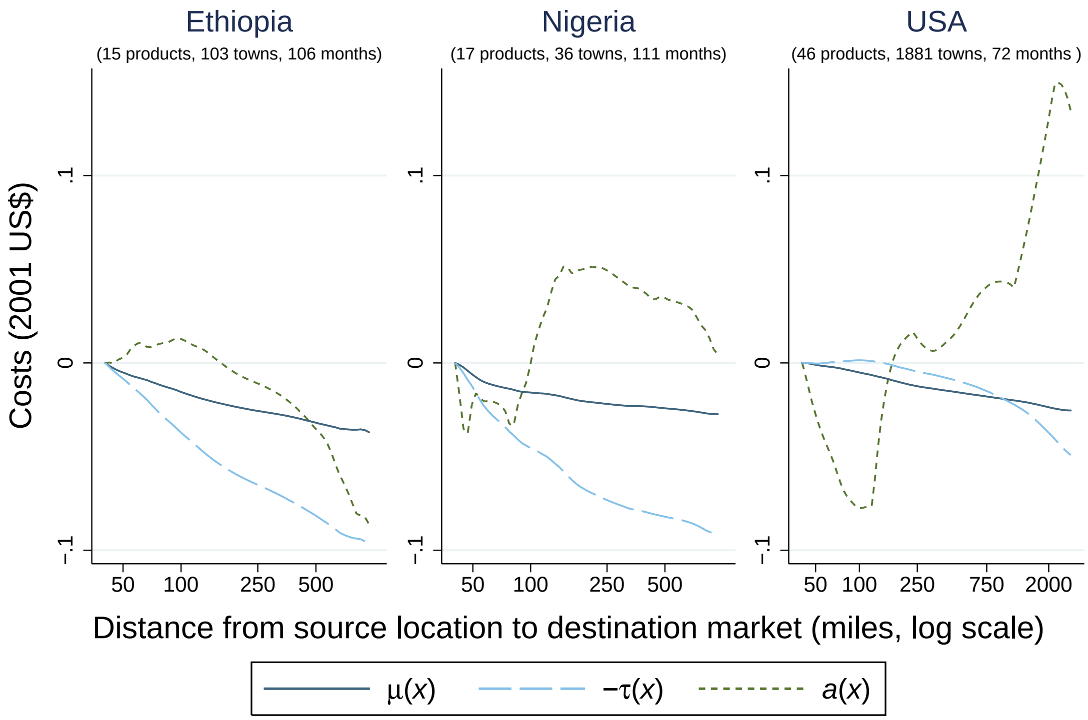


Figure 4: Marginal costs of distance



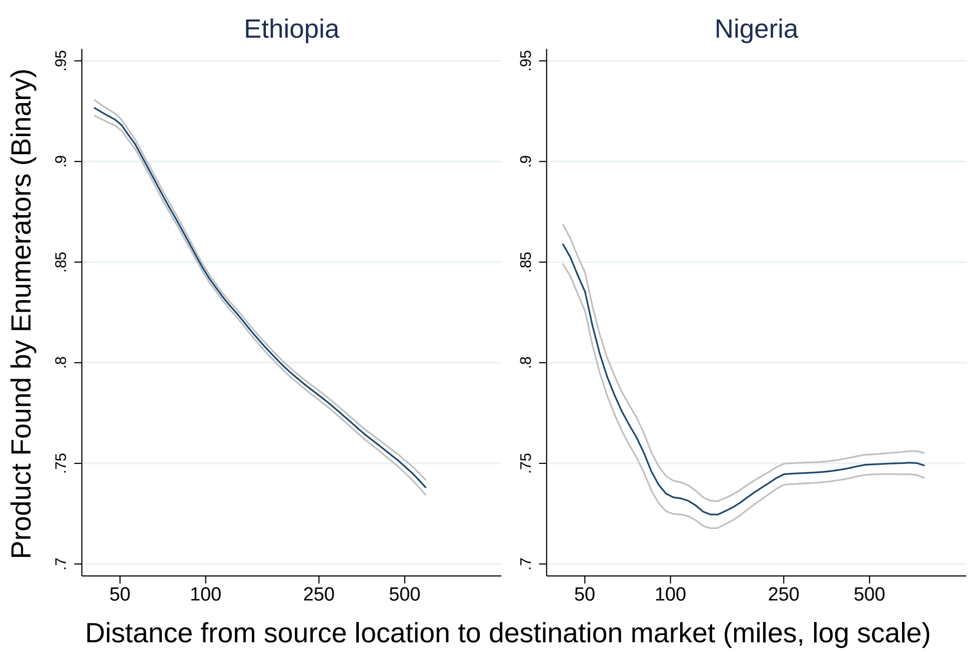
Bootstrapped 95% confidence intervals. Locally weighted polynomial (Epanechnikov kernel, bandwidth=0.5). All plots are semiparametric and include product−time fixed effects. μ−adjusted regression controls for interactions between pass−through and fixed effects as described in text.

Figure 5: Variation in markups across space



Locally weighted polynomial (Epanechnikov kernel, bandwidth=0.5).
Semiparametric plots of choke prices and trade costs from the adjusted price gap regression.

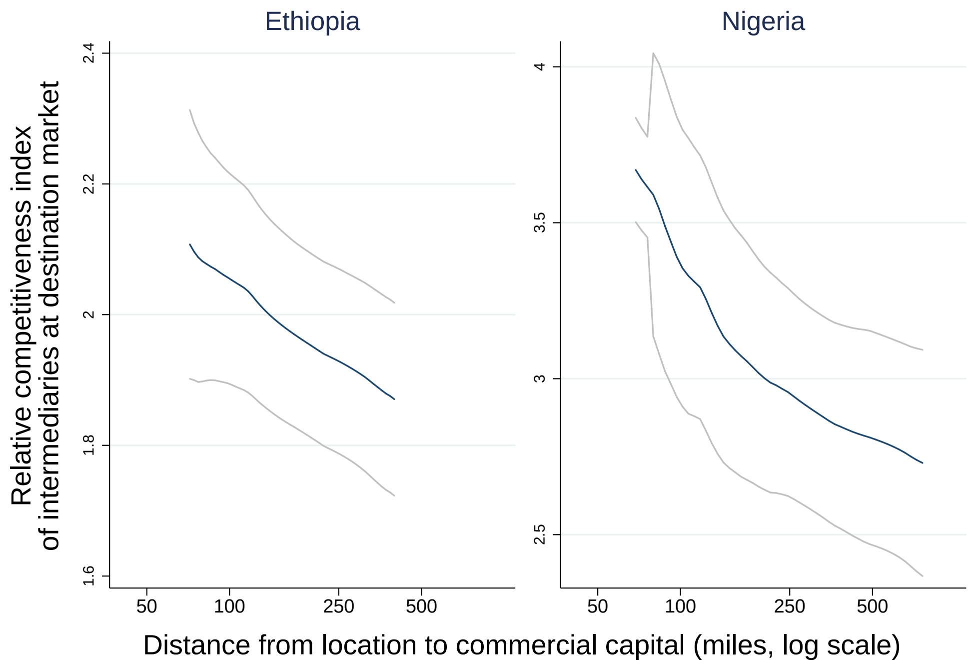
Figure 6: Product availability



95% confidence intervals shown. Locally weighted polynomial (Epanechnikov kernel, bandwidth=0.5).
Linear Probability Model.

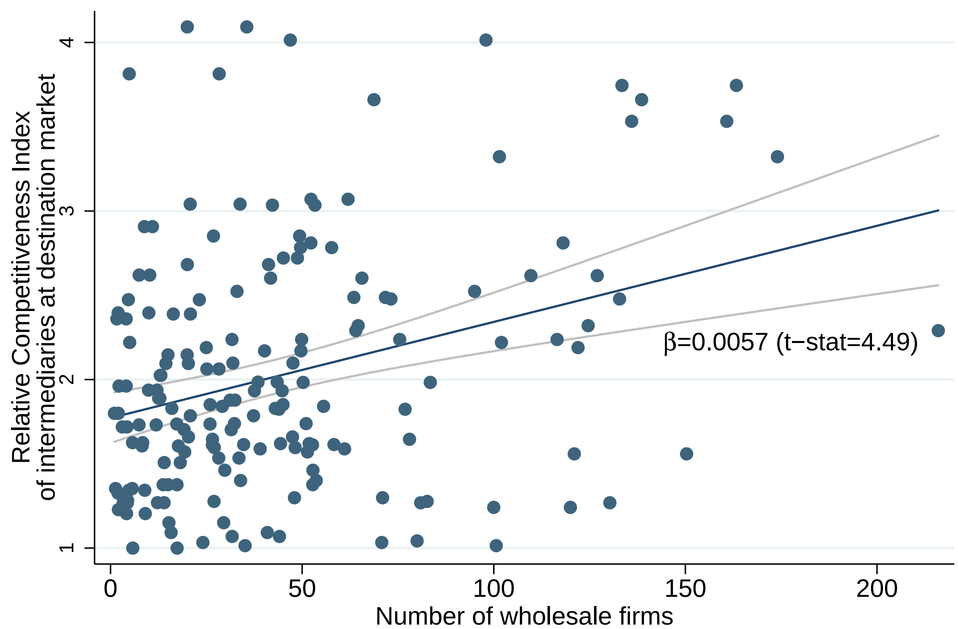
Figure 7: Competitiveness of intermediaries and distance

Panel A: Relative competitiveness index and distance



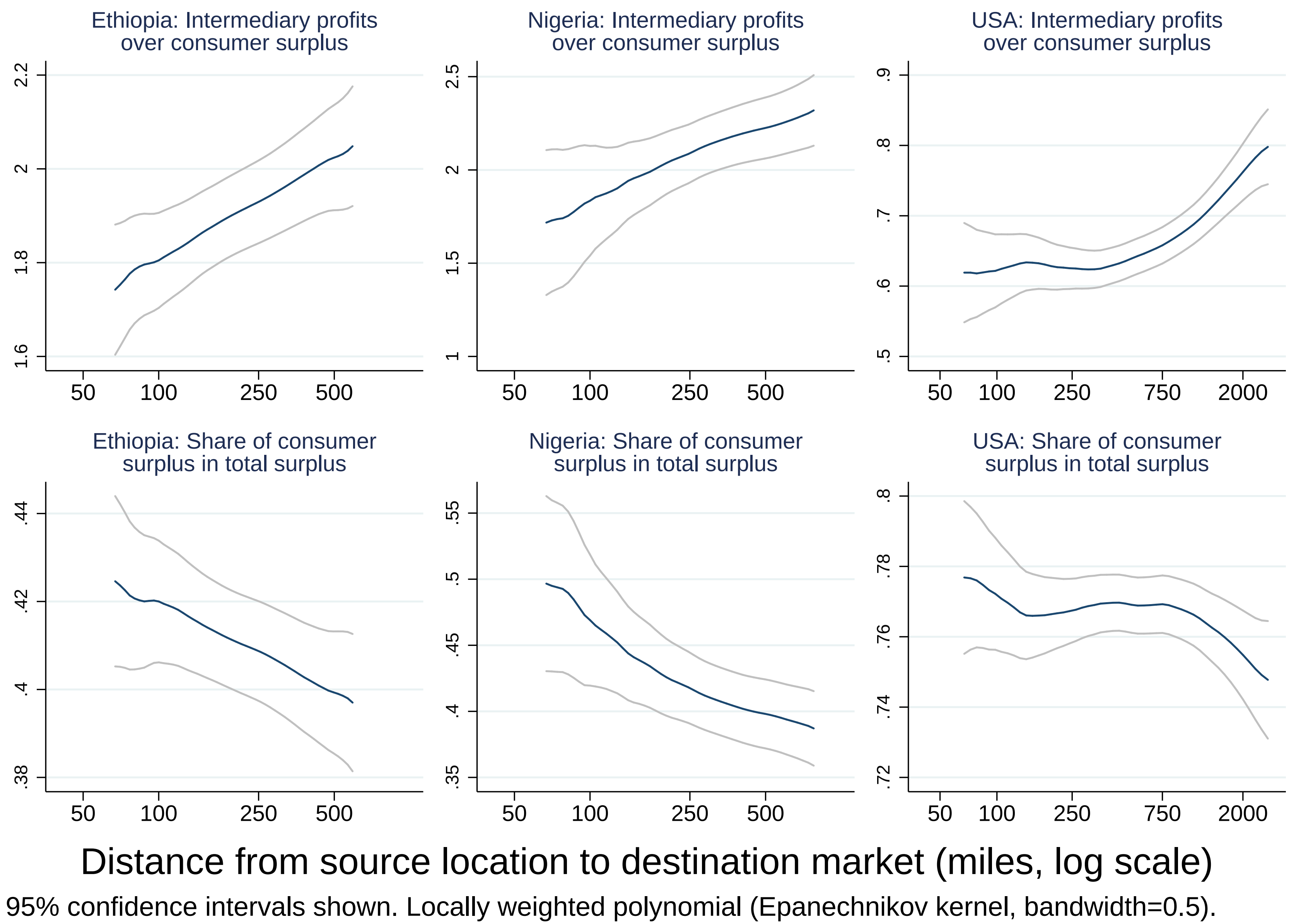
95% confidence intervals shown. Locally weighted polynomial (Epanechnikov kernel, bandwidth=0.5).

Panel B: Competitiveness index and Ethiopia Distributive Trade Surveys (2001 and 2008)



95% confidence intervals shown. Locally weighted polynomial (Epanechnikov kernel, optimal bandwidth).
Plot of competitiveness index against number of wholesalers from 2001 and 2008 Distributive Trade Survey.

Figure 8: Ratio of intermediary profit/deadweight loss to consumer surplus and distance



Tables

Table 1: Total intranational trade costs, on average

Ethiopia	(1) Electric Bulb Philips (40/60w)	(2) Wine Saris (750cc)	(3) Drink Meta Beer (330cc)	(4) Detergent Zahira (50Gm)	(5) Toilet Soap Lux (90Gm)	(6) Drink Coca Cola (300cc)	(7) Batteries Eveready Drycell	(8) Cigarettes Rothmans (pack)	(9) Water Ambo (500cc)	(10) Beer Harar (330cc)	(11) Hair Oil Zenith (330cc)	(12) Motor Oil Mobil (1Lt)	(13) Drink Pepsi (300cc)	(14) Pen Bic (Ball Point)	(15) Beer Bedele (330cc)
Absolute Price Gap	0.034	0.30	0.028	0.0056	0.018	0.035	0.031	0.11	0.040	0.029	0.066	0.13	0.030	0.011	0.030
(All Pairs)	(0.039)	(0.28)	(0.029)	(0.0053)	(0.019)	(0.035)	(0.048)	(0.24)	(0.045)	(0.041)	(0.064)	(0.20)	(0.027)	(0.012)	(0.031)
Price Gap	0.029	-0.034	0.027	0.0025	0.0051	0.057	0.00038	-0.019	0.070	0.038	0.042	0.022	0.034	0.0042	0.067
(Trading Pairs)	(0.040)	(0.32)	(0.034)	(0.0059)	(0.021)	(0.037)	(0.057)	(0.21)	(0.047)	(0.038)	(0.079)	(0.19)	(0.036)	(0.014)	(0.031)
Origin Price	0.16	1.05	0.28	0.055	0.18	0.15	0.17	0.89	0.13	0.26	0.60	1.86	0.15	0.095	0.24
	(0.038)	(0.11)	(0.021)	(0.0036)	(0.012)	(0.020)	(0.049)	(0.12)	(0.017)	(0.031)	(0.061)	(0.22)	(0.023)	(0.014)	(0.026)
Distance to	251.9	193.8	196.3	248.1	251.4	187.0	244.3	245.8	199.5	288.3	205.8	198.8	156.8	249.5	193.1
Source (miles)	(114.4)	(83.8)	(89.5)	(111.4)	(115.1)	(92.8)	(116.9)	(115.6)	(82.7)	(121.5)	(83.6)	(85.8)	(80.1)	(114.7)	(95.4)
Unit Weight (Gm)	20	850	400	50	90	350	40	30	500	400	350	1200	320	20	400
Observations	445,402	243,409	252,238	123,442	464,758	463,043	319,126	255,296	418,829	246,591	429,193	221,671	484,802	470,266	246,239

Nigeria	(1) Drink Bournvita (450Gm)	(2) Cement Elephant (50Kg)	(3) Baby Food Cerelac (400Gm)	(4) Detergent Omo (pack)	(5) Tea Lipton (small box)	(6) Margarine Blue Band (250Gm)	(7) Sardines Titus (125Gm)	(8) Beer Guiness (300cc)	(9) Cement Nigercem (50Kg)	(10) Drink Coke Btl. (350cc)	(11) Drink Coke Can (350cc)	(12) Drink Milo (450Gm)	(13) Sugar St Louis (900Gm)	(14) Powder. Milk Peak (400Gm)	(15) Evap. Milk Peak (170Gm)	(16) Evap. Milk Carnation (170Gm)	(17) Cigarettes B&H (pack)
Absolute Price Gap	0.10	0.58	0.14	0.052	0.039	0.12	0.039	0.069	0.68	0.0084	0.020	0.10	0.046	0.087	0.020	0.038	0.037
(All Pairs)	(0.12)	(0.53)	(0.14)	(0.071)	(0.12)	(0.11)	(0.036)	(0.10)	(0.98)	(0.0080)	(0.029)	(0.089)	(0.049)	(0.084)	(0.020)	(0.097)	(0.035)
Price Gap	0.038	0.47	0.037	-0.020	0.00029	0.045	-0.0069	0.030	0.34	-0.0020	-0.0021	0.0066	0.0094	0.0092	-0.022	-0.0030	0.027
(Trading Pairs)	(0.11)	(0.64)	(0.15)	(0.070)	(0.036)	(0.15)	(0.045)	(0.099)	(0.89)	(0.012)	(0.026)	(0.12)	(0.054)	(0.11)	(0.028)	(0.055)	(0.037)
Origin Price	1.18	4.35	1.21	0.34	0.26	0.80	0.35	0.41	3.81	0.12	0.24	1.32	0.37	1.31	0.31	0.20	0.42
	(0.046)	(0.85)	(0.13)	(0.069)	(0.020)	(0.17)	(0.073)	(0.040)	(0.23)	(0.011)	(0.011)	(0.056)	(0.044)	(0.078)	(0.062)	(0.011)	(0.018)
Distance to	367.5	344.9	350.0	341.0	384.7	336.7	350.4	226.2	272.8	373.9	377.3	374.0	349.5	373.0	350.3	394.6	326.8
Source (miles)	(177.2)	(169.4)	(170.7)	(161.6)	(177.2)	(166.5)	(166.8)	(181.3)	(159.5)	(179.5)	(183.3)	(178.2)	(178.0)	(179.7)	(166.4)	(168.1)	(172.3)
Unit Weight (Gm)	450	50000	400	100	226	250	125	300	50000	400	350	450	900	400	170	170	30
Observations	16,852	46,563	48,191	30,668	12,182	53,384	53,498	5,876	1,071	8,348	7,178	8,053	23,260	8,378	53,830	4,452	8,194

Notes: Row 1 uses data from all location pairs. Row 3 only uses data from "trading pairs", eg pairs where one of the locations is either the factory location for that product or the port of entry. Prices are deflated by the average of the proportional price change for each good at its origin location. Real prices are converted into US Dollars using the prevailing exchange rate during the base period (January 2001). Standard errors in parentheses.

Table 2: Estimating the Marginal Cost of Distance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Ethiopia			Nigeria			USA	
Dependent variable:	Absolute Price Gap (All Pairs)	Price Gap (Trading Pairs)	Adjusted Price Gap (Trading Pairs)	Absolute Price Gap (All Pairs)	Price Gap (Trading Pairs)	Adjusted Price Gap (Trading Pairs)	Absolute Price Gap (All Pairs)	Price Gap (Trading Pairs)	Adjusted Price Gap (Trading Pairs)
Log distance to source (miles)	0.0115***	0.0248***	0.0374***	0.0234***	0.0305***	0.0469***	0.00686***	0.00502***	0.0119***
	(0.000439)	(0.00125)	(0.00223)	(0.00268)	(0.00478)	(0.00749)	(0.000680)	(0.000771)	(0.00105)
			{0.00370}			{0.0121}			{.}
			[0.00594]			[0.0175]			[0.00130]
Time-Product FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-Product $\times \frac{1-\hat{\rho}}{\hat{\rho}}$	No	No	Yes	No	No	Yes	No	No	Yes
Destination $\times \frac{1-\hat{\rho}}{\hat{\rho}}$	No	No	Yes	No	No	Yes	No	No	Yes
Observations	4,130,923	100,761	100,761	348,131	23,089	23,089	1,275,363	167,551	167,551
R-squared	0.356	0.252	0.932	0.501	0.502	0.969	0.438	0.410	0.929

Notes: Columns 1, 4 and 7 use data on the absolute price gap between all location pairs. Columns 2, 5 and 8 use data on the actual price gap between "trading pairs", eg destination price minus origin price for pairs where one of the locations is either the factory location for that product or the port of entry. Columns 3, 6 and 9use the transformed price gap $(1-\widehat{\rho^k_{od}})/\widehat{\rho^k_{od}}$ and additionally includes time-product and destination fixed effects multiplied by $(1-\widehat{\rho^k_{od}})/\widehat{\rho^k_{od}}$ in order to control for omitted variable bias due to the level of market power covarying with distance. Prices are deflated by the average of the proportional price change for each good at its origin location. Real prices are converted into US Dollars using the prevailing exchange rate during the base period (January 2001). All regressions include time-product fixed effects. Time-product clustered standard errors in round parentheses. Time-product block bootstrapped standard errors in curly parentheses, product-destination block bootstrapped standard errors in square parentheses. * significant at 10 percent level, ** at 5 percent and *** at 1 percent.

Table 3: Estimating the Marginal Cost of Distance: Robustness Checks Ethiopia

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Destination-Year Fixed Effects		Destination-Time Fixed Effects		Not Winsorizing Pass Through Rates		ρ Estimated Every 5 Years	
Dependent variable:	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap
Log distance to source (miles)	0.0249***	0.0438***	0.0249***		0.0248***	0.0321***	0.0247***	0.0329***
	(0.000466)	(0.00138)	(0.000466)		(0.000465)	(0.00891)	(0.000464)	(0.00152)
Observations	100,876	100,876	100,876		100,761	100,761	100,453	100,453
R-squared	0.251	0.930	0.251		0.252	0.996	0.256	0.935

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	ρ Estimated Every 2.5 Years		ρ Estimated Using 3 Lags		Removing Locations <100 Miles Away		Controls For Oil Price in ρ	
Dependent variable:	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap
Log distance to source (miles)	0.0250***	0.0394***	0.0246***	0.0322***	0.0402***	0.0668***	0.0248***	0.0389***
	(0.000467)	(0.00171)	(0.000464)	(0.00115)	(0.00112)	(0.00257)	(0.000465)	(0.00137)
Observations	98,295	98,295	100,053	100,053	88,437	88,437	100,761	100,761
R-squared	0.258	0.945	0.257	0.943	0.231	0.933	0.252	0.931

	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
	Using Exchange Rates as IVs in ρ		Normalizing Prices Using CPI		Not Cleaning Price Data		Interaction with Weight	
Dependent variable:	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap
Log distance to source (miles)	0.0248***	0.0358***	0.0252***	0.0334***	0.0258***	0.0349***	-0.0446***	-0.0769***
	(0.000465)	(0.00131)	(0.000471)	(0.00133)	(0.000447)	(0.00155)	(0.00169)	(0.00466)
Log distance × Log weight							0.0143***	0.0221***
							(0.000386)	(0.000863)
Observations	100,761	100,761	100,761	100,761	116,710	116,710	100,761	100,761
R-squared	0.252	0.934	0.260	0.916	0.219	0.920	0.265	0.933

	(25)	(26)	(27)	(28)
	Actual Road Distance (miles)		Travel Time (minutes)	
Dependent variable:	Price Gap	Adj. Gap	Price Gap	Adj. Gap
Log distance to source	0.0271***	0.0383***	0.0289***	0.0411***
	(0.000483)	(0.00128)	(0.000513)	(0.00135)
Observations	100,761	100,761	100,762	100,762
R-squared	0.257	0.932	0.258	0.933

Notes: For each specification pair, the first column regresses log distance on the price gap between trading pairs and the second column regresses the transformed price gap $(P^k_{ds} - \widehat{\rho^k_{od}} P^k_{os}) / \widehat{\rho^k_{od}}$ on log distance and additionally includes time-product and destination fixed effects multiplied by $(1 - \widehat{\rho^k_{od}}) / \widehat{\rho^k_{od}}$ in order to control for omitted variable bias due to the level of market power covarying with distance. All regressions include time-product fixed effects. Columns 1 to 2 include destination-year fixed effects in both the pass through and price gap regressions. Columns 3-4 replace the destination-year fixed effects with destination-time fixed effects. Columns 5-6 utilize raw $\widehat{\rho^k_{od}}$ estimates that have not been winsorized below 0.2. Columns 7-8 use pass through rates estimated over 5 year subsamples and columns 9-10 use pass through rates estimated over 2.5 year susbsamples. Columns 11-12 include three lag terms in the pass through regression and use the sum of the coefficients on the main effect and lagged terms as the pass through rate. Columns 13-14 remove price pairs where the destination location is less than 100 miles from the source location. Columns 15-16 include the deflated local currency oil price as an explanatory variable in the pass through regression. Columns 17-18 also include oil prices but in addition use deflated exchange rates to instrument for origin prices in the estimation of $\widehat{\rho^k_{od}}$ for the subsample of import goods where bilateral deflated exchange rates explain origin price movements. Columns 19-20 use the national CPI to normalize prices rather than an inflation rate generated from the subset of products in our data set. Columns 21 to 22 do not remove outliers from the price data. Columns 23-24 include an interaction with weight. Columns 25-26 use actual road distance instead of great circle distance. Columns 27-28 use travel time instead of great circle distance. Time-product clustered standard errors in parentheses. * significant at 10 percent level, ** at 5 percent and *** at 1 percent.

Table 4: Estimating the Marginal Cost of Distance: Robustness Checks Nigeria

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Destination-Year Fixed Effects		Destination-Time Fixed Effects		Not Winsorizing Pass Through Rates		ρ Estimated Every 5 Years	
Dependent variable:	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap
Log distance to	0.0310***	0.0530***	0.0310***	0.0820***	0.0305***	0.0442***	0.0305***	0.0854***
source (miles)	(0.00226)	(0.00543)	(0.00226)	(0.00645)	(0.00225)	(0.00545)	(0.00225)	(0.00621)
Observations	23,497	23,497	23,497	23,497	23,089	23,089	23,089	23,089
R-squared	0.489	0.969	0.489	0.969	0.502	0.999	0.502	0.970

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	ρ Estimated Every 2.5 Years		ρ Estimated Using 3 Lags		Removing Locations <100 Miles Away		Controls For Oil Price in ρ	
Dependent variable:	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap
Log distance to	0.0317***	0.0564***	0.0323***	0.0411***	0.0305***	0.0469***	0.0305***	0.0511***
source (miles)	(0.00228)	(0.00958)	(0.00248)	(0.00401)	(0.00319)	(0.00719)	(0.00225)	(0.00456)
Observations	22,334	22,334	20,445	20,445	21,300	21,300	23,089	23,089
R-squared	0.504	0.974	0.503	0.946	0.522	0.969	0.502	0.973

	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
	Using Exchange Rates as IVs in ρ		Normalizing Prices Using CPI		Not Cleaning Price Data		Interaction with Weight	
Dependent variable:	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap
Log distance to			0.0357***	0.0594***	0.0336***	0.0734***	-0.244***	-0.326***
source (miles)			(0.00265)	(0.00602)	(0.00289)	(0.00849)	(0.0115)	(0.0130)
Log distance ×							0.0436***	0.0563***
Log weight							(0.00208)	(0.00185)
Observations			23,089	23,089	23,334	23,334	23,089	23,089
R-squared			0.500	0.967	0.396	0.914	0.540	0.970

	(25)	(26)	(27)	(28)
	Actual Road Distance (miles)		Travel Time (minutes)	
Dependent variable:	Price Gap	Adj. Gap	Price Gap	Adj. Gap
Log distance to	0.0337***	0.0553***	0.0343***	0.0570***
source	(0.00234)	(0.00473)	(0.00238)	(0.00489)
Observations	23,084	23,084	23,084	23,084
R-squared	0.504	0.964	0.504	0.964

Notes: For each specification pair, the first column regresses log distance on the price gap between trading pairs and the second column regresses the transformed price gap $(P^k_{ds} - \widehat{\rho^k_{od}} P^k_{os}) / \widehat{\rho^k_{od}}$ on log distance and additionally includes time-product and destination fixed effects multiplied by $(1 - \widehat{\rho^k_{od}}) / \widehat{\rho^k_{od}}$ in order to control for omitted variable bias due to the level of market power covarying with distance. All regressions include time-product fixed effects. Columns 1 to 2 include destination-year fixed effects in both the pass through and price gap regressions. Columns 3-4 replace the destination-year fixed effects with destination-time fixed effects. Columns 5-6 utilize raw $\widehat{\rho^k_{od}}$ estimates that have not been winsorized below 0.2. Columns 7-8 use pass through rates estimated over 5 year subsamples and columns 9-10 use pass through rates estimated over 2.5 year susbsamples. Columns 11-12 include three lag terms in the pass through regression and use the sum of the coefficients on the main effect and lagged terms as the pass through rate. Columns 13-14 remove price pairs where the destination location is less than 100 miles from the source location. Columns 15-16 include the deflated local currency oil price as an explanatory variable in the pass through regression. Columns 17-18 also include oil prices but in addition use deflated exchange rates to instrument for origin prices in the estimation of $\widehat{\rho^k_{od}}$ for the subsample of import goods where bilateral deflated exchange rates explain origin price movements. Columns 19-20 use the national CPI to normalize prices rather than an inflation rate generated from the subset of products in our data set. Columns 21 to 22 do not remove outliers from the price data. Columns 23-24 include an interaction with weight. Columns 25-26 use actual road distance instead of great circle distance. Columns 27-28 use travel time instead of great circle distance. Time-product clustered standard errors in parentheses. * significant at 10 percent level, ** at 5 percent and *** at 1 percent.

Table 5: Estimating the Marginal Cost of Distance: Robustness Checks USA

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Destination-Year Fixed Effects		Destination-Time Fixed Effects		Not Winsorizing Pass Through Rates		ρ Estimated Every 5 Years	
Dependent variable:	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap
Log distance to source (miles)					0.00502***	0.0112***	0.00414***	0.0103***
					(0.000460)	(0.00193)	(0.000480)	(0.000985)
Observations					167,551	167,551	132,338	132,338
R-squared					0.410	0.999	0.393	0.939

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	ρ Estimated Every 2.5 Years		ρ Estimated Using 3 Lags		Removing Locations <100 Miles Away		Controls For Oil Price in ρ	
Dependent variable:	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap
Log distance to source (miles)	0.00370***	0.0169***	0.00510***	0.00781***	0.0116***	0.0186***	0.00502***	0.0239***
	(0.000550)	(0.00158)	(0.000597)	(0.00111)	(0.000629)	(0.00128)	(0.000460)	(0.00215)
Observations	84,523	84,523	70,463	70,463	156,081	156,081	167,551	167,551
R-squared	0.336	0.944	0.311	0.922	0.421	0.931	0.410	0.954

	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
	Using Exchange Rates as IVs in ρ		Normalizing Prices Using CPI		Not Cleaning Price Data		Interaction with Weight	
Dependent variable:	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap	Price Gap	Adj. Gap
Log distance to source (miles)			0.0102***	0.0477***	0.00569***	0.0130***		
			(0.00103)	(0.00474)	(0.000509)	(0.000886)		
Log distance × Log weight								
Observations			167,551	167,551	167,551	167,551		
R-squared			0.488	0.932	0.412	0.922		

	(25)	(26)	(27)	(28)
	Actual Road Distance (miles)		Travel Time (minutes)	
Dependent variable:	Price Gap	Adj. Gap	Price Gap	Adj. Gap
Log distance to source	0.00563***	0.0133***	0.00730***	0.0167***
	(0.000499)	(0.00102)	(0.000581)	(0.00125)
Observations	166,368	166,368	165,616	165,616
R-squared	0.429	0.934	0.425	0.940

Notes: For each specification pair, the first column regresses log distance on the price gap between trading pairs and the second column regresses the transformed price gap $(P^k_{ds} - \widehat{\rho^k_{od}} P^k_{os})/\widehat{\rho^k_{od}}$ on log distance and additionally includes time-product and destination fixed effects multiplied by $(1 - \widehat{\rho^k_{od}})/\widehat{\rho^k_{od}}$ in order to control for omitted variable bias due to the level of market power covarying with distance. All regressions include time-product fixed effects. Columns 1 to 2 include destination-year fixed effects in both the pass through and price gap regressions. Columns 3-4 replace the destination-year fixed effects with destination-time fixed effects. Columns 5-6 utilize raw $\widehat{\rho^k_{od}}$ estimates that have not been winsorized below 0.2. Columns 7-8 use pass through rates estimated over 5 year subsamples and columns 9-10 use pass through rates estimated over 2.5 year susbsamples. Columns 11-12 include three lag terms in the pass through regression and use the sum of the coefficients on the main effect and lagged terms as the pass through rate. Columns 13-14 remove price pairs where the destination location is less than 100 miles from the source location. Columns 15-16 include the deflated local currency oil price as an explanatory variable in the pass through regression. Columns 17-18 also include oil prices but in addition use deflated exchange rates to instrument for origin prices in the estimation of $\widehat{\rho^k_{od}}$ for the subsample of import goods where bilateral deflated exchange rates explain origin price movements. Columns 19-20 use the national CPI to normalize prices rather than an inflation rate generated from the subset of products in our data set. Columns 21 to 22 do not remove outliers from the price data. Columns 23-24 include an interaction with weight. Columns 25-26 use actual road distance instead of great circle distance. Columns 27-28 use travel time instead of great circle distance. Time-product clustered standard errors in parentheses. * significant at 10 percent level, ** at 5 percent and *** at 1 percent.

Table 6: Regressing Pass-Through Rates, Competitiveness and Surplus Measures on Distance

	(1)	(2)	(3)	(4)	(5)	(6)
	Ethiopia					
Dependent variable:	Pass-Through Rates (Good-Location)	Competitiveness Index of Intermediaries (All Locations)	Ratio of Intermediary Profits to Consumer Surplus (Good-Location)	Ratio of Deadweight Loss to Consumer Surplus (Good-Location)	Consumer's Share of Total Surplus (Good-Location)	Product Availability 1=Price Record, 0=No Price Record (Time-Prod-Loc)
Log distance between source and destination	-0.0449***		0.229***	0.0368***	-0.0185**	-0.0959***
	(0.0152)		(0.0598)	(0.00908)	(0.00763)	(0.00309)
Log distance between location and Addis Ababa		-0.344***				
		(0.127)				
Constant	0.814***	3.766***	0.683**	0.120**	0.509***	1.308***
	(0.0797)	(0.668)	(0.312)	(0.0475)	(0.0403)	(0.0163)
Observations	1,418	100	1,418	1,418	1,418	145,682
R-squared	0.004	0.059	0.009	0.009	0.004	0.14

	(7)	(8)	(9)	(10)	(11)	(12)
	Nigeria					
Dependent variable:	Pass-Through Rates (Good-Location)	Competitiveness Index of Intermediaries (All Locations)	Ratio of Intermediary Profits to Consumer Surplus (Good-Location)	Ratio of Deadweight Loss to Consumer Surplus (Good-Location)	Consumer's Share of Total Surplus (Good-Location)	Product Availability 1=Price Record, 0=No Price Record (Time-Prod-Loc)
Log distance between source and destination	-0.101*		0.342***	0.0749***	-0.0593***	-0.0444***
	(0.0537)		(0.115)	(0.0126)	(0.0174)	(0.00431)
Log distance between location and Lagos		-0.594***				
		(0.149)				
Constant	0.997***	6.359***	0.173	-0.173**	0.755***	0.999***
	(0.307)	(0.836)	(0.660)	(0.0706)	(0.101)	(0.0245)
Observations	490	36	490	490	490	31,914
R-squared	0.01	0.168	0.02	0.065	0.023	0.299

	(13)	(14)	(15)	(16)	(17)	(18)
	USA					
Dependent variable:	Pass-Through Rates (Good-Location)	Competitiveness Index of Intermediaries (All Locations)	Ratio of Intermediary Profits to Consumer Surplus (Good-Location)	Ratio of Deadweight Loss to Consumer Surplus (Good-Location)	Consumer's Share of Total Surplus (Good-Location)	Product Availability 1=Price Record, 0=No Price Record (Time-Prod-Loc)
Log distance between source and destination	-0.0117***		0.0644***	-0.000576*	-0.00483	
	(0.00393)		(0.0112)	(0.000321)	(0.00385)	
Log distance between location and Chicago		-51.28				
		(54.40)				
Constant	0.842***	461.3	0.260***	0.0138***	0.796***	
	(0.0243)	(366.5)	(0.0689)	(0.00211)	(0.0238)	
Observations	9059	2865	9059	9011	9011	
R-squared	0.001	0.001	0.003	0.000	0.000	

Notes: Column 1 to 5, 7 to 11 and 13 to 17 regress log distance on estimates of pass-through rates, competitiveness, the ratio of intermediary profit to consumer surplus, the ratio of deadweight loss to consumer surplus and the share of consumer surplus in total surplus. Since the competitiveness index is location not location-product specific, distance to the commercial capital is used in columns 2, 8 and 14 rather than source-destination distance. Standard errors in parentheses. Columns 6 and 12 regress log distance on product availability at the monthly Time Period-Product-Location level by ordinary least squares. Sample restricted to product-location pairs for which the product is observed in at least one month. Columns 6 and 12 both include Time-product fixed effects and Time-product clustered standard errors in parentheses. * significant at 10 percent level, ** at 5 percent and *** at 1 percent.