

# Trade Policy and the Structure of Supply Chains<sup>\*</sup>

Sebastian Heise<sup>†</sup>

*Yale Department of Economics*

Justin R. Pierce<sup>‡</sup>

*Board of Governors of the Federal Reserve System*

Georg Schaur<sup>§</sup>

*University of Tennessee, Knoxville*

Peter K. Schott<sup>¶</sup>

*Yale School of Management & NBER*

PRELIMINARY and INCOMPLETE

September 2015

## Abstract

We model the impact of trade policy on supply chains and show that reducing the likelihood of a trade war can lead to the adoption of “Japanese”-style just-in-time procurement practices, in which domestic buyers ensure the provision of high-quality inputs from foreign suppliers via long-term relationships. Empirically, we find that a change in U.S. trade policy that eliminated uncertainty over a U.S.-China trade war coincides with a relative shift towards smaller and more frequent shipments between U.S. importers and Chinese exporters. (JEL F13, F14, F15, F23) (Keywords: Supply Chain, Uncertainty, Trade War, Procurement)

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<sup>\*</sup>Schott and Heise thank the National Science Foundation (SES-1427027) for research support. We thank [*your name here*] for helpful comments. Any opinions and conclusions expressed herein are those of the authors and do not necessarily represent the views of the U.S. Census Bureau, the Board of Governors or its research staff. All results have been reviewed to ensure that no confidential information is disclosed.

<sup>†</sup>28 Hillhouse Avenue, New Haven, CT 06511, email: sebastian.heise@yale.edu.

<sup>‡</sup>20th & C Streets NW, Washington, DC 20551, tel: (202) 452-2980, email: justin.r.pierce@frb.gov.

<sup>§</sup>519 Stokely Management Center, Knoxville, TN tel: (865) 974-1710, email: gschaur@utk.edu.

<sup>¶</sup>135 Prospect Street, New Haven, CT 06520, tel: (203) 436-4260, email: peter.schott@yale.edu.

# 1 Introduction

Motivated by the success of Japanese manufacturers such as Toyota, many firms have introduced “Japanese”-style procurement practices in an effort to boost operational efficiency.<sup>1</sup> Under the Japanese system, buyer-seller relationships are characterized by joint learning and information sharing, and buyers motivate sellers to maintain product quality by committing to long-run purchases at a price above sellers’ costs. Under the opposing “American” system, by contrast, buyers choose the lowest-cost seller for each order via competitive bidding, and low quality is deterred via costly inspection.

Given the increasingly global nature of firms’ supply chains (Baldwin and Lopez-Gonzalez 2013), trade barriers represent a potentially important – yet under-studied – consideration in the formation of buyer-seller relationships. Indeed, if buyer and seller are located in different countries, the possibility of a trade war may prevent foreign sellers from entering into the sort of long-term relationships with domestic buyers that characterize the Japanese system. To the extent that this disincentive to adopting the Japanese system prevents reductions in buyers’ inventory and procurement costs, efficiency may suffer.

In this paper, we examine the role of trade policy in firms’ selection of procurement systems. We propose a theoretical model in which reductions in the probability of a trade war increase firms’ incentives to switch from American- to Japanese-style procurement. Empirically, we show that a shift in U.S. trade policy that permanently normalized trade relations between the United States and China coincides with changes in the pattern of U.S. firms’ imports from Chinese suppliers along the lines suggested by the model.

Our theoretical analysis is built around the framework introduced by Taylor and Wiggins (1997), who demonstrate that because of the fixed cost of inspection in the American system and the need for repeated payment of premia in the Japanese system, shipments between seller and buyer are optimally smaller and more frequent – i.e., more “just-in-time” – under the Japanese model. We extend Taylor and Wiggins (1997) to a setting in which a buyer purchases inputs from a foreign supplier. We assign exogenous beliefs about the probability of a prohibitive increase in import tariffs (i.e., a trade war as in Ossa 2014) to both parties, and demonstrate that the lower the probability

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<sup>1</sup>This movement is documented in a series of studies. See, for example, O’Neal (1989), Heide and John (1990), Lyons et al. (1990), Dyer and Ouchi (1993), Han et al. (1993), Helper and Sako (1995) and Liker and Choi (2004). We follow Taylor and Wiggins (1997) in using the term procurement to refer to the structuring of purchases – in our case, imports – over time.

assigned by the seller to a trade war, the more likely Japanese- versus American-style procurement is to be adopted. The intuition for this result is straightforward: the lower the probability of a trade war, the greater the seller's confidence that a long-term relationship with a buyer can be sustained. This increased confidence lengthens the time horizon over which the seller expects to collect price premia in a long-term relationship with the buyer, driving down the premium needed on each shipment to enforce honesty and thereby the relative cost of the Japanese system compared to the American system.

The model guides our empirical analysis of the impact of the United States' October 2000 granting of permanent Normal Trade Relations (PNTR) to China on U.S.-China trade. Conferral of PNTR was a non-traditional trade liberalization in that it did not change the actual import tariffs the United States applied to Chinese goods. Instead, it ruled out the possibility of tariff increases to potentially prohibitive levels. Specifically, while U.S. imports from China had been subject to the relatively low NTR tariff rates reserved for WTO members since 1980, continued access to these low rates required annual renewals that were uncertain and politically contentious. Absent these renewals, U.S. import tariffs on Chinese goods would jump to the non-NTR tariff rates assigned to non-market economies originally established under the Smoot-Hawley Tariff Act of 1930. By permanently setting U.S. duties on Chinese imports to NTR levels, PNTR may have encouraged U.S. importers and Chinese exporters to adopt Japanese-style procurement, particularly for products with high gaps between non-NTR and NTR tariff rates.<sup>2</sup>

Our empirical analysis uses transaction-level U.S. import data to estimate the effect of PNTR on several measures of procurement that capture differences between the American and Japanese systems, including average shipment size, frequency and price. We employ a triple difference-in-differences identification strategy that exploits variation in the gap between non-NTR and NTR rates to assess whether U.S.-China importer-exporter-product procurement patterns change relative to imports from exporters in other countries (first difference) after the change in U.S. policy is implemented (second difference) in products with higher NTR gaps (third difference).<sup>3</sup> For

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<sup>2</sup>Pierce and Schott (2015) show that PNTR coincided with sharp increases in U.S. imports from China, as well as the number of U.S. and Chinese firms engaged in U.S.-China trade.

<sup>3</sup>In our model, seller and buyer trade a single product, so the probability of a trade war and the probability the seller-buyer relationship ends are the same. Our empirical analysis, on the other hand, examines firms trading a wide range of products subject to varying increases in tariffs in the event of a failed annual renewal prior to PNTR.

each procurement measure, we compare outcomes within a series of increasingly broad bins: within importer-exporter-product triplets, within importer-product pairs, and within products.

Consistent with the model’s predictions, we find that PNTR is associated with a shift towards Japanese-style procurement for U.S.-China relationships, and that this shift is more pronounced for products where the change in policy is more binding, namely those with larger NTR gaps. In the preferred, within importer-exporter-product specification, our results suggest that a one standard deviation increase in the gap between non-NTR and NTR tariff rates is associated with a relative decline in average shipment quantity of 13 percent and an increase in average shipment price of 4 percent. Via the lens of the model, the estimated reduction in average shipment size implies a commensurate reduction in inventory costs.

To our knowledge this is the first paper to model how trade policy affects procurement patterns.<sup>4</sup> The model we develop also provides an alternate perspective on the large literature examining contractual frictions in international trade (see the survey by Antras and Helpman 2008). A recent working paper Pflueger and Kukharsky (2010), for example, suggests the problem of hold-up on the decision to outsource may be solved by relationship formation, i.e., the sharing of long-term gains in a repeated game from a sustained relationship. Here, we examine how long-term, “Japanese” relationships can overcome frictions associated with guaranteeing the provision of high-quality inputs. One attractive feature of our approach is that it yields predictions regarding shipment patterns that can be tested using transaction-level trade data.

More broadly, our analysis contributes to several literatures in economics and operations research. Our linking of a change in trade policy to firm import patterns joins a growing number of papers examining the various impacts of specific trade policies on firm and aggregate outcomes (see the survey by Goldberg and Pavcnik 2015). We also contribute to research examining the behavior of importers (e.g., Blaum et al. 2015), the implications of trade wars (e.g. Ossa 2014), information frictions in international trade (e.g., Cristea 2011) and trade policy uncertainty (e.g., Handley 2014, Handley and Limao).

The remainder of this paper proceeds as follows. Section 2 outlines our theoretical model. Section 3 describes the data used in our empirical analysis. Sections 3.2 and 4 contain our empirical analysis. Section 5 concludes. An online appendix contains

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<sup>4</sup>Procurement within countries is a subject of considerable research in the industrial organization literature. See, for example, Tadelis and Zettelmeyer (2015), Cicala (2015) and Bajari et al. (2014).

additional results.

## 2 Theoretical Model

This section develops a model of optimal procurement when buyer and seller are located in different countries. We start with the framework developed by Taylor and Wiggins (1997) – hereafter TW – in which buyers solve a quality control problem with respect to their inputs using one of two procurement strategies. Under the “American” system, buyers use competitive bidding to select the lowest-cost supplier for each shipment, and use the threat of inspection to deter provision of low quality goods. Under the “Japanese” system, buyers incentivize honesty by purchasing exclusively from a single seller and indefinitely paying this seller a premium over her fixed and variable costs.

TW consider a setup in which a buyer has a fixed procurement need for a single good, and faces the problem of determining the optimal procurement pattern. They demonstrate that shipments under the American system are larger and less frequent than under the Japanese system for two reasons. First, the fixed costs associated with inspection under the American System encourage buyers to minimize the number of orders. Second, sellers under the Japanese system have an incentive to order more frequently as a way of minimizing the payoff to a deviating seller.

Given these distortions, both the Japanese and American systems are more costly than the first best, where sellers supply high-quality inputs without need for threat or incentive. TW show that while American and Japanese procurement may co-exist as local solutions to the buyer’s quality-control problem, the global optimum depends on the ratio of the seller’s fixed cost of producing each shipment to the buyer’s fixed cost of inspecting each shipment. Intuitively, the lower the ratio of these fixed costs, the cheaper the Japanese system and the more likely it is to be embraced.

We generalize TW to allow for exogenous beliefs about changes in the expected level of buyer-country import tariffs as well as explicit inventory costs. We then demonstrate that eliminating the possibility of a trade war provides a seller with a greater incentive to adopt Japanese-style procurement by reducing her effective discount rate. This in turn reduces inventory costs. The model yields empirical predictions that we examine in Section 4.

## 2.1 The Setting

Over time interval  $\Delta t$  a “buyer” ( $B$ ) uses total inputs  $q$  purchased from a “seller” ( $S$ ). Without loss of generality, we normalize  $\Delta t = 1$ , e.g., 1 year. The buyer receives his inputs in a series of symmetric shipments of size  $x$ . As a result, there are  $q/x$  shipments during each time interval, each arriving  $\Delta t/(q/x) = x/q$  time intervals apart. During the “order cycle” between each shipment, the buyer’s inventory falls from  $x$  to 0. This setting is described visually in Figure 1, where  $s = 1, 2, \dots, q/x$  indexes the shipments during each time interval  $\Delta t$  and  $t = \{1, 2, \dots\}$  indexes time intervals.

The exogenous interest rate over time interval  $\Delta t$  is  $r$ , so that the discount rate between orders is  $rx/q$ . Let  $h = r/q$ . With continuous discounting, the discount rate between shipments is  $\delta(x) = (e^{-hx})$ . If  $w(x)$  denotes the cost of each *shipment* (i.e., each batch  $x$ ), the present value of an order placed  $T = ts + s$  shipments in the future is  $\delta(x)^T w(x) = (e^{-hx})^T w(x)$ .

Let  $\theta \in \{\underline{\theta}, \bar{\theta}\}$  index the low or high quality of the input produced by the seller. The buyer requires high quality, e.g., an acceptably low defect rate among the units shipped.<sup>5</sup> The seller’s problem is to determine whether to provide high- or low-quality goods for each shipment sent to the buyer.

The buyer can inspect each shipment at cost  $m$  per shipment before accepting and paying for it. Let  $\alpha$  be the probability that such an inspection occurs. If the buyer chooses to inspect and the quality is low, the relationship is terminated and the seller receives no payment from the buyer. We assume that goods are specific to the buyer, so that the seller cannot sell them to an alternative partner. Furthermore, if the seller ships low-quality goods her reputation is harmed and she is excluded from the market forever. If the buyer does not inspect, the order is accepted and the seller is paid. If the order subsequently turns out to be of low quality, the relationship is terminated. In that case, the buyer cannot recover payment from the seller but can substitute contemporaneous and future orders from an alternate seller. Here, too, a seller found shipping low quality is excluded from the market forever.<sup>6</sup>

TW do not consider inventory costs explicitly. Here, we assume that the instanta-

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<sup>5</sup>In an extension of their basic setup, TW consider the output market into which buyers sell and have buyers choose the optimal level of  $\theta$ . They show that for  $h$  sufficiently small, the optimal level of quality under both the Japanese and American systems is arbitrarily close to the first best optimal level of quality.

<sup>6</sup>This assumption is a simplification. In practice, practitioners of Japanese procurement tend to reduce orders to suppliers that ship sub-standard goods but do not eliminate them unless violations are egregious or not corrected. See, for example, Liker and Choi (2004).

neous inventory cost increases with quality  $\theta$  and that it is proportional to the inventory utilization rate,

$$v\theta \frac{(x - qz)}{x}, \quad (1)$$

where  $v$  is an exogenous constant and  $z \in [0, x/q]$  denotes a time within an order cycle. With this formulation, total inventory costs over an order cycle are

$$\int_0^{x/q} v\theta \frac{(x - qz)}{x} dz = \frac{v\theta x}{2q}. \quad (2)$$

These costs increase with order size  $x$  because larger, less frequent orders increase the amount of time inventories remain closer to capacity. Smaller, more frequent shipments, by contrast, reduce inventory costs by increasing the speed of inventory throughput relative to capacity. We assume inventory costs for a given order are paid upon acceptance of an order, so the net present cost of storing an order purchased  $T$  shipments in the future is

$$\delta(x)^T \frac{v\theta x}{2q}. \quad (3)$$

As inventory costs over an order cycle are a function of the time between shipments ( $x/q$ ), changes in that interval are directly proportional to changes in inventory costs if inventory holding costs and the cost of producing quality remain constant.

## 2.2 The Seller's Problem

A seller produces batches of quantity  $x$  with variable cost  $\theta$  and fixed cost  $f$  per batch, where  $f$  encompasses the fixed cost of both setting up and delivering a production run.<sup>7</sup> The seller receives order value  $w_i(x, \theta)$  per *shipment*, where  $i$  indicates whether the payment is under an American or Japanese system. We assume the seller does not have any bargaining power and fills an order only if she at least breaks even,

$$w_i(x, \theta) \geq f + \theta x. \quad (4)$$

We assume free trade between the buyer's and seller's countries, but that a trade war is possible. In the event of a trade war, the import tariff on the input rises enough

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<sup>7</sup>Thus, we ignore any transportation costs which depend on shipment size or value. We note that uncertainty over these costs may also inhibit the formation of long-term relationships.

to sever existing buyer-seller relationships between the affected countries.<sup>8</sup> The seller's exogenous belief about the probability of continued *peaceful* trade, and therefore that the relationship will continue, is  $0 < \rho_S < 1$ .<sup>9</sup> The seller's discount factor for an order placed  $T$  time intervals in the future is  $\delta_S(x)^T$ , where the subscript indicates that this is potentially specific to the seller. Given that the stationary environment described above (and summarized in Figure 1) implies a continuous repetition of order cycles over time, the net present value to the seller of supplying shipments of  $x$  to the buyer as  $T \rightarrow \infty$  is

$$\frac{w_i(x, \theta) - f - x\theta}{1 - \delta_S(x)\rho_S}. \quad (5)$$

As a result, the seller ships high quality ( $\theta = \bar{\theta}$ ) if and only if expression 5 is at least as great as the one-time profit from cheating by supplying low quality ( $\theta = \underline{\theta}$ ), i.e.,

$$\frac{w_i(x, \bar{\theta}) - f - x\bar{\theta}}{1 - \delta_S(x)\rho_S} \geq (1 - \alpha)w(x, \bar{\theta}) - f - x\underline{\theta}. \quad (6)$$

As this expression makes clear, decreases in shipment size  $x$ , as well as increases in the seller's belief about continued trade peace,  $\rho_S$ , raise the seller's discount factor,  $\delta_S(x)\rho_S$ , thereby strengthening the seller's incentive to provide high-quality shipments.<sup>10</sup>

### 2.3 The Buyer's Problem

The buyer chooses to conduct procurement either under the American ( $A$ ) or the Japanese ( $J$ ) system. Under the American system, buyers select the lowest cost supplier and use inspections to deter cheating. To simplify the problem we assume buyers under the American system always inspect while buyers in the Japanese system never inspect, so that  $\alpha_A = 1$  and  $\alpha_J = 0$ .<sup>11</sup> In that case, under the American system, the seller just

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<sup>8</sup>We provide a micro-foundation for this belief in Section A of the online appendix. Recent research (Ossa 2014) indicates that the optimal tariffs countries might set in the event of a trade war are substantial, averaging 63 percent worldwide.

<sup>9</sup>The model considers trade in a single product. An alternate interpretation of  $\rho_S$  that brings the model closer to our data analysis below is that it reflects both the probability of a trade war (which is the same for all products) and the subsequent rise in tariffs (which might vary across products) for the particular good being traded. The probability of breakup is rising in the latter.

<sup>10</sup>An alternative approach to incorporating trade policy uncertainty would be to include exogenous parameter  $k_S$  as part of the discount rate, e.g.,  $\delta_S(x) = e^{-hx+k_S}$ .

<sup>11</sup>TW show that optimal inspection under the American system is a function of shipment size and quality,  $\alpha_A^* = \bar{\alpha}(x, \theta) > 0$ , while under the Japanese system inspections do not occur,  $\alpha_J^* = 0$ .



breaks even on each shipment,

$$w_A(x, \bar{\theta}) = f + \bar{\theta}x. \quad (7)$$

As there is no expectation of a long-term relationship under the American system, this shipment value satisfies the seller's incentive compatibility constraint (equation 6).

Under the Japanese system, buyers obtain seller honesty through repeat purchases and by paying sellers a premium over their costs. The shipment value under the Japanese system is

$$w_J(x, \bar{\theta}) = f + \bar{\theta}x + \left( \frac{1}{\delta_S(x)\rho_S} - 1 \right) (\bar{\theta} - \underline{\theta})x. \quad (8)$$

This equation holds with strict equality given the assumption that the buyer holds all the bargaining power, but is still incentive compatible for the seller. The third term on the right hand side reflects the premium over the shipment value paid under the American system,  $w_A(x)$ , that a buyer under the Japanese system pays to incentivize the seller to sustain high quality over a long-term relationship. Intuitively, this premium rises as the buyer's belief in trade peace,  $\rho_S$ , falls.

The buyer discounts future payments with discount factor  $\delta_B(x)$  and assigns a probability (potentially different from the seller),  $\rho_B$ , to the continuation of the relationship. To simplify the analysis, we set  $\rho_B = 1$  under the assumption that the buyer is able to replace a lost relationship with an approximately equal relationship by switching to a different country. Alternatively, U.S. buyers may be more confident about avoiding trade wars because they have more information about existing lobbying efforts and policy practices compared to foreign partners.

Including inventory costs, the net present cost to the  $i = A, J$  buyer of continual ordering under the two systems is then

$$C_i = \frac{w_i(x, \bar{\theta}) + \alpha_i m}{1 - \delta_B(x)\rho_B} + \frac{v\bar{\theta}x}{2q(1 - \delta_B(x)\rho_B)}, \quad (9)$$

where  $m$  is the fixed cost of inspecting a shipment and  $\alpha_i$  is the probability of inspection.

The buyer under each procurement system chooses the optimal order size  $x_i^*$  to minimize equation (9),

$$x_i^* = \operatorname{argmin} \left( \frac{w_i(x, \bar{\theta}) + \alpha_i m}{1 - \delta_B(x)\rho_B} + \frac{v\bar{\theta}x}{2q(1 - \delta_B(x)\rho_B)} \right). \quad (10)$$

The tradeoff associated with choosing lower- versus higher-frequency procurement can be seen by setting the first order condition for this problem to zero, yielding

$$\frac{1}{1 - \delta_B(x)\rho_B} \left( w'_i(x, \bar{\theta}) + \frac{v\bar{\theta}}{2q} \right) = \frac{-\delta'_B(x)k_B}{(1 - \delta_B(x)\rho_B)^2} \left( w_i(x, \bar{\theta}) + \alpha_i m + \frac{v\bar{\theta}x}{2q} \right). \quad (11)$$

where,

$$w'_i(x, \bar{\theta}) = \begin{cases} \bar{\theta} & \text{if } i = A \\ \bar{\theta} + \left( \frac{1}{\delta_S(x)\rho_S} - 1 \right) (\bar{\theta} - \underline{\theta}) - \frac{\delta'_S(x)}{\delta_S(x)^2\rho_S} (\bar{\theta} - \underline{\theta})x & \text{if } i = J \end{cases} \quad (12)$$

The left hand side of equation (11) represents the discounted value of higher costs associated with a small increase in order size (i.e., a small decrease in order frequency). The right hand side measures the savings from an increased discount factor due to spacing orders further apart in time. Note that fixed order costs,  $f$  – a parameter of  $w_i(x, \bar{\theta})$  – and  $m$ , appear only on the right hand side of the expression: the higher these costs, the greater the benefit of raising order size (i.e., a small decrease in order frequency).

## 2.4 Numerical Solutions

In this section we report numerical solutions of the model to provide intuition for its key relationships and to motivate the empirical analysis in Section 4. We provide analytic solutions for some of these relationships in the next section. Unless otherwise noted, numerical solutions assume the baseline parameters listed in Table 1.

Figure 2 shows that the overall cost of the Japanese system falls with the seller's probability of trade peace ( $\rho_S$ ). The intuition for this relationship is straightforward: as  $\rho_S$  rises, Japanese sellers require less compensation to refrain from providing low quality goods, driving overall costs lower. Two other features of Figure 2 are worth noting. First, it shows that even if  $\rho_S = 1$  the cost of the Japanese system does not drop to that of the first-best (FB) scenario, where neither inspection nor payment premia are required to deter provision of low-quality goods.<sup>12</sup> The reason for this outcome is that even when trade peace is assured, the seller must be compensated for discounting if, as is the case here,  $r > 0$ . Second, Figure 2 reveals that beyond some threshold level

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<sup>12</sup>Optimal order size is independent of  $k$  under both the American system and the first-best scenario. We solve for the  $x^{FB}$  as  $x_A^*$  conditional on the fixed inspection cost ( $m$ ) being zero.

for  $\rho_S$ , which we denote  $\rho_S^{Switch}$  (arbitrarily equal to 0.91 in the figure), the cost of the Japanese system drops below that of the American system. At that point, buyer and seller switch from the American to the Japanese system.

The left and right panels of Figure 3 demonstrate that the optimal shipment size under the Japanese system rises with the seller’s probability of trade peace ( $\rho_S$ ), while the optimal shipment price,  $w_J(x, \bar{\theta})/x_J^*$ , falls. The decline in order price as  $\rho_S$  rises reflects the just-noted drop in the seller’s rent. Given that decline, the buyer shifts towards larger and less frequent shipments to reduce payment of fixed costs.

The key relationships for our empirical analysis, however, come from joint consideration of Figures 2 and 3. Together, they reveal that if an increase in the probability of trade peace causes  $\rho_S$  to jump from below  $\rho_S^{Switch}$  to above this level, observed order size *falls* and observed order price *rises* as buyer and seller switch from the American to the Japanese system, i.e., from the solid black lines in the figure to the dashed blue lines. This implication of the model allows us to distinguish empirically between a change within a given procurement system and a switch of systems. The empirical results reported in Section 4 are consistent with PNTR leading to a switch to the Japanese system in U.S.-China procurement.

Figure 4 reveals that the optimal order size under both systems increases with the seller’s fixed cost  $f$ , while the optimal order size in the American system increases with per-shipment inspection cost  $m$ . In both cases, buyers seek to minimize incurring larger fixed costs by reducing shipments, thereby increasing order size.

Finally, Figure 5 shows that optimal order size under both the American and Japanese systems declines with the marginal costs of high quality ( $\bar{\theta}$ ) and inventory ( $v$ ). As the cost to produce high quality rises, buyers have an incentive to push purchases further into the future via more frequent, smaller orders. When inventory costs are high, buyers economize on inventory costs by ordering more frequently.

## 2.5 Analytic Solutions

This section makes use of additional simplifying assumptions to derive a series of analytical implications from the model. In particular, we seek to relate reductions in the probability of a trade war – i.e., U.S. conferral of PNTR on China – to a switch from American- to Japanese-style procurement.

We shut down the channel by which changes in shipment size (and therefore frequency) affect sellers’ incentives to cheat by assuming *for the seller* that  $hx \rightarrow 0$ , so

that  $\delta_S(x) = e^{-hx} \rightarrow 1$ .<sup>13</sup> Our interpretation of this assumption is that sellers care more about the likelihood that their relationship with the buyer might be broken by trade policy than they do about the interest rate.<sup>14</sup> As in our numerical solutions, we set  $\underline{\theta} = 0$ .

With these assumptions, we solve for  $x_i^*$  using the same Padé approximation of  $\delta_B(x)$  employed by TW, i.e.,  $\delta_B(x) = \frac{2-hx}{2+hx}$ .<sup>15</sup> Substituting equations (7) and (8) into equation (11), we find optimal order sizes

$$x_i^* = \begin{cases} \sqrt{\frac{2q(f+m)}{\gamma r \theta}} & \text{if } i = A \\ \sqrt{\frac{2qf}{\lambda r \theta}} & \text{if } i = J \end{cases} \quad (13)$$

where  $\gamma \equiv 1 + \frac{v}{2q} < \frac{1}{\rho_S} + \frac{v}{2q} \equiv \lambda$ .

This result yields two propositions which highlight the key differences between the two systems.

**Proposition 1.** *In the Japanese system order sizes are smaller (and therefore more frequent) than in the American system.*

*Proof.* This result follows directly from equation (13). □

With the optimal order sizes in hand, it is easy to order compare shipment unit values,  $w_i(x)/x$ , under the two systems.

**Proposition 2.** *All else equal, shipment unit values are greater under the Japanese system than under the American system,  $w_J^*(x, \bar{\theta})/x_J^* > w_A^*(x, \bar{\theta})/x_A^*$ .*

*Proof.* From Proposition 1 we have  $x_J^* < x_A^*$ . Therefore, because  $0 < \rho < 1$ ,  $w_J^*(x, \bar{\theta})/x_J^* = \frac{1}{\rho} \bar{\theta} + \frac{f}{x_J^*} > \bar{\theta} + \frac{f}{x_A^*} = w_A^*(x, \bar{\theta})/x_A^*$ . □

Buyers under the Japanese system pay a premium for smaller, more frequent orders compared to the American system in order to incentivize the provision of high quality inputs.

In our empirical analysis, we are able to compare the procurement patterns of buyers and sellers trading at arm's length versus those of related parties.<sup>16</sup> We conjecture that

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<sup>13</sup>TW assume  $\delta(x) \rightarrow 1$  for both buyer and seller for much of their analysis.

<sup>14</sup>The interest rate becomes more important as  $k_S \rightarrow 1$ , i.e., as our model converges to that of TW.

<sup>15</sup>As noted in TW footnote 17 (and Judd 1997), the Padé expansion is more convenient and often more accurate for obtaining closed-form solutions than a Taylor-series expansion.

<sup>16</sup>By law, U.S. import transactions are defined to be between related parties if either party owns, controls or holds voting power equivalent to 6 percent of the outstanding voting stock or shares of the other organization (see Section 402(e) of the Tariff Act of 1930).

the latter require neither inspections nor order value premia to solve the quality-control problem. As a result, related parties' procurement patterns may correspond to those of the first-best.

**Proposition 3.** *The first-best order size is  $x^{FB} = \sqrt{\frac{2qf}{\gamma r \theta}}$ .*

*Proof.* Intuitively, as is evident from examination of equation (13), this is tantamount to  $\rho_S \rightarrow 1$  under the Japanese system and  $m = 0$  under the American system.<sup>17</sup> For  $\rho_S < 1$ ,  $x_J^* < x^{FB}$  because smaller orders reduce the gain to the seller from cheating on a particular order.<sup>18</sup> Here, as in TW,  $x_A^* > x^{FB} > x_J^*$  if  $\rho_S < 1$ .  $\square$

We now turn to a key result of the model, the extent to which the probability of trade peace influences adoption of the American versus Japanese systems. The buyer adopts the system that minimizes the costs of procurement. For the Japanese system, we substitute the optimal order size  $x_J^*$  into the cost function from equation (9) to obtain the net present value,  $C_J$ ,

$$C_J = \frac{\left(\sqrt{2r\lambda\bar{\theta}f/q} + rf/q\right) \left(\sqrt{2r\lambda\bar{\theta}f/q} + 2\lambda\bar{\theta}\right) \sqrt{2}}{4(r/q)\sqrt{r\lambda\theta f/q}}. \quad (14)$$

**Lemma 1.** *The cost of the Japanese system strictly decreases as  $\rho_S$  rises and approaches infinity as  $\rho_S \rightarrow 0$ .*

*Proof.* Substitute  $\lambda = \frac{1}{\rho_S} + \frac{1}{2} \frac{v}{q}$  and take the derivative with respect to  $\rho_S$  to obtain

$$\frac{\partial C_J}{\partial \rho_S} = - \left( \frac{\left( fh\rho_S q + \sqrt{\rho_S v + 2q} \sqrt{\bar{\theta} f \rho_S q h} \right) \sqrt{\bar{\theta}}}{h^{3/2} \sqrt{\rho_S v + 2q} \sqrt{f} \rho_S^{5/2} \sqrt{q}} \right) < 0 \quad (15)$$

$$\lim_{\rho_S \rightarrow 0} \text{Costs Japanese System} = \infty \quad (16)$$

$\square$

For the American system, substitute the optimal order size  $x_A^*$  into the cost function to obtain the long run expected costs

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<sup>17</sup>As  $k_S \rightarrow 1$ , the discount rate becomes more important than the probability of trade peace, which is more consistent with the closed-economy version of the model developed by TW. In our setup, it is plausible to think that  $k_S$  can never actually equal 1, i.e., there is always some possibility of a trade war occurring, however small it is.

<sup>18</sup>To the extent the seller cares about discounting,  $x_J^*$  also is below  $x^{FB}$  because smaller orders raise the net present value of future orders via the discount rate.

$$C_A = \frac{\left(\sqrt{2}\sqrt{h\gamma\bar{\theta}(f+m)} + hf + mh\right) \left(\sqrt{2}\sqrt{h\bar{\theta}\gamma(f+m)} + 2\gamma\bar{\theta}\right) \sqrt{2}}{4h\sqrt{\gamma h\bar{\theta}(f+m)}}. \quad (17)$$

**Lemma 2.** *The cost of the American system increases in the fixed inspection cost  $m$ .*

*Proof.* Take the derivative of the cost with respect to  $m$  to obtain

$$\frac{\partial C_A}{\partial m} = \frac{1}{2} \left( \frac{\gamma\sqrt{2\bar{\theta}} + \sqrt{\gamma h\bar{\theta}(f+m)}}{\sqrt{h\bar{\theta}\gamma(f+m)}} \right) > 0. \quad (18)$$

□

**Proposition 4.** *For a finite  $m > 0$ , there exists a unique  $\rho_S^{Switch}$  such that if  $\rho_S < \rho_S^{Switch}$  the buyer adopts the American system and if  $\rho_S > \rho_S^{Switch}$  the buyer adopts the Japanese system. Furthermore, as suggested by Proposition 3, if  $\rho_S \rightarrow 1$  and  $m = 0$ , then the firm is indifferent between the two systems.*

*Proof.* Let  $\Delta C(k_S, m) = C_A - C_J$ . Substitute  $m = 0$  and  $\rho_S = 1$  to show that  $\Delta C(1, 0) = 0$ . Given Lemma 2 this means that  $\Delta C(1, m > 0) > 0$ . By Lemma 1 we have that  $\frac{\partial \Delta C(1, m > 0)}{\partial \rho_S} < 0$  and  $\lim_{\rho \rightarrow 0} \Delta C(1, m > 0) = -\infty$ . Therefore, for any finite  $m > 0$ , there must be a unique  $\rho_S^{Switch}$  such that  $\Delta C(\rho_S < \rho_S^{Switch}, m) < 0$  and  $\Delta C(\rho_S > \rho_S^{Switch}, m) > 0$ . □

With an increase in  $\rho_S$ , the seller is more confident about the relationship continuing, so adoption of the Japanese system becomes more likely. In the extreme, if  $\rho_S = 1$  and  $m > 0$ , all firms adopt the Japanese system. This result mirrors the numerical solution displayed in Figure 3.

As noted in the previous section, we use this implication of the model to motivate an empirical analysis of whether a substantial, exogenous shock to the continuation probability  $\rho_S$  (i.e., PNTR) can cause a shift to Japanese procurement (i.e., increased order frequency and price, smaller order size). We expect these changes to be larger for relationships encompassing goods where the change in the continuation probability is the most pronounced.

## 3 Transaction-Level U.S. Import Data

### 3.1 Description

We use transaction-level U.S. import data from the U.S. Census Bureau to identify the international procurement patterns of U.S.-based importing firms. The Bureau’s Longitudinal Foreign Trade Transaction Database (LFTTD) tracks every U.S. import transaction from 1992 to 2011. Data available include the dates the shipment left the exporting country and arrived in the United States, identifiers for the U.S. and foreign firm conducting the trade and whether they are related or at arm’s length, the transaction value and quantity, a ten-digit Harmonized System (HS) code classifying the product traded, and the country of origin of the exporter.<sup>19</sup>

We refine the data as follows. First, we drop all transactions that are warehouse entries, so that our dataset represents all imports used for consumption. Second, we remove all transactions that do not include an importer identifier, an exporter identifier, an HS code, a value, a quantity or a valid transaction date. Third, we use the procedure suggested by Pierce and Schott (2012) to create time-consistent HS codes, and correct an inconsistency in U.S. importing firms’ identification codes over time by mapping firms in the LFTTD into the Longitudinal Business Database (LBD) and using the identifiers in the latter.<sup>20</sup> Fourth, we deflate transaction values using the quarterly GDP deflator from the FRED database maintained by the Federal Reserve Bank of Saint Louis. Finally, we collapse the refined version of the data by U.S. importer ( $m$ ), foreign exporter ( $x$ ), origin country ( $c$ ), week the export left the foreign country ( $w$ ) and ten-digit Harmonized System product category.

### 3.2 Arm’s-Length versus Related-Party Shipments

We summarize the importer-exporter-product relationships observed in the data along several dimensions relevant to the model presented in the previous section. After excluding triplets with just a single shipment, we compute the total shipment value

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<sup>19</sup>As noted above, import transactions are defined to be between related parties if either party owns, controls or holds voting power equivalent to 6 percent of the outstanding voting stock or shares of the other organization. We classify observations with a missing related party identifier as related. For further information on the LFTTD, see Bernard, Jensen and Schott (2009) and Kamal, Krizan and Monarch (2015).

<sup>20</sup>The inconsistency arises due to a change in single-unit firms’ identification codes in 2002. We drop observations for invalid exporter identifiers, e.g., those that do not begin with a letter (it should start with the country name) or that have fewer than the requisite number of characters.

across the relationship ( $Value_{mxh}$ ), the total length of the relationship in terms of the number of weeks between the first and last observed shipment ( $Length_{mxh}$ ) and the total number of weeks in which a shipment occurs ( $Shipments_{mxh}$ ) during the length of the relationship. We note that  $length_{mxh}$  is potentially subject to both left and right censoring.

The averages and standard deviations of these attributes are reported in Table 2, where the left panel contains results for arm’s-length (AL) relationships and the right panel shows results for related-party (RP) relationships.<sup>21</sup> These unconditional comparisons reveal three trends. First, AL relationships are smaller in terms of overall value traded and number of shipments received, and more short-lived in terms of their overall length compared to related-party relationships. Second, individual shipments within AL relationships also appear smaller and more frequent than RP shipments in terms of average value per shipment and length per shipment. Finally, the large standard deviations reported in the table indicate that attributes of both arm’s-length and related-party relationships exhibit substantial variation across all dimensions of activity.

A more formal comparison of AL and RP that controls for variation in the variation in the types of products and relationships they encompass is achieved via the following OLS specification,

$$\ln(\bar{Y}_{mxhct}) = \beta_0 + \beta_1 1\{RP_{mxhc} = 1\} + \beta_2 \ln(Total Value_{mxct}) + \delta_{mch} + \delta_t + \delta_l + \epsilon_{mxhct} \quad (19)$$

where  $m$ ,  $x$ ,  $c$ ,  $h$  and  $t$  index U.S. importers, foreign exporters, origin country, ten-digit HS products and years. The regression sample is restricted to importer-exporter-product triplets that have at least two transactions in each  $mxhct$  bin and that engage solely in arm’s length or solely in related-party ( $RP$ ) transactions over the full 1992 to 2011 sample period.  $\bar{Y}_{mxhct}$  represents one of three attributes:  $VPS_{mxct}$ , the average value per shipment in the bin;  $QPS_{mxct}$ , the average quantity per shipment in the bin; and  $WBS_{mxct}$ , the average weeks between shipments in the bin. The indicator variable  $1\{RP_{mxhc} = 1\}$  distinguishes arm’s-length from related parties, and  $TotalValue_{mxct}$

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<sup>21</sup>Results for AL relationships are restricted to relationships that never report an RP shipment. Results for RP relationships encompass all other relationships. We do not summarize the prices of AL vs RP relationships due to the potential influence of transfer pricing (see Bernard et al. 2006).



accounts for the total value of shipments in the bin. By including this variable we compare AL relationships with RP relationships importing the same total value in the same year. Importer-product-country, year and relationship-length fixed effects are represented by  $\delta_{mhc}$ ,  $\delta_t$  and  $\delta_l$ , where  $\delta_l$  categorizes relationships with lengths from 1 to 6 years plus a final category of 7-or-more years. The coefficient of interest is  $\beta_1$ , which estimates the relative difference between related and arm’s-length procurement in log points.

Results for  $\beta_1$  and  $\beta_2$  are reported in Table 3, where each column contains the regression for a different relationship attribute. As indicated by the negative and statistically significant point estimates in the first two columns of the table, conditional on procuring the same total value, related parties use smaller shipments and order more frequently than arm’s-length parties within the noted fixed-effect dimensions. The -0.04 and -0.18 point estimates for  $\beta_1$  reported in the first two columns of the table indicate that average shipment size in terms of value and quantity for related parties are approximately 4 and 18 percent lower compared to an arm’s-length relationship of the same size. Results in the final column of the table indicate that related-party shipments arrive approximately 4 percent more frequently than arm’s length shipments.

One explanation for the more just-in-time nature of RP transactions is that RP relationships approximate the first best scenario discussed in Section 2, i.e., that they reflect the fact that AL relationships are predominantly American. This explanation is consistent with the fact that AL relationships tend to be short-lived *vis a vis* RP relationships.

## 4 Procurement and PNTR

The numerical and analytic results in Section 2 indicate that an increase in the seller’s belief in peaceful trade can induce buyer and seller to switch from the American to the Japanese system. In this section, we examine the relationship between the U.S. granting of PNTR to China in October 2000 – which substantially reduced the possibility of a trade-war-like hike in U.S. import tariffs on Chinese goods – and several outcome variables that capture procurement differences between American and Japanese procurement. We first explain our identification strategy and then present the results.

## 4.1 Empirical Strategy

U.S. imports from non-market economies such as China are subject to non-NTR tariff rates originally set under the Smoot-Hawley Tariff Act of 1930. These rates are often substantially larger than the NTR rates the U.S. offers fellow members of the World Trade Organization (WTO). The U.S. Trade Act of 1974 allows the President to grant NTR tariff rates to non-market economies on an annually renewable basis subject to Congressional approval, and U.S. Presidents began granting such a waiver to China in 1980. While these waivers kept the actual tariff rates applied to Chinese goods low, the need for annual approval by Congress created uncertainty about whether the low tariffs would continue, particularly during the 1990s.

The U.S. Congress passed a bill granting China permanent NTR (PNTR) status in October 2000, which was implemented on January 1, 2002 as part of China's entry into the WTO in December 2001. By eliminating the threat of sudden spikes in U.S. import tariffs on Chinese goods, this change in U.S. policy likely encouraged greater adoption of Japanese-style procurement between U.S. importers and Chinese exporters. Via the lens of the model developed in Section 2, this encouragement was stronger for firms trading products with relatively large NTR gaps, as the probability that a U.S. buyer would abandon a Chinese seller in the event of a failed annual renewal would be higher in these products.

We define the NTR gap for eight-digit HS import product  $h$  as the difference between non-NTR and NTR rates,

$$NTR\ Gap_h = Non\ NTR\ Rate_h - NTR\ Rate_h, \quad (20)$$

using *ad valorem* tariff rates provided by Feenstra, Romalis and Schott (2002) for 1999, the year before passage of PNTR in the United States.<sup>22</sup> As indicated in Figure 6, these gaps vary widely across products, and have a mean and standard deviation of 0.32 and 0.23. Our identification strategy exploits this variation in the NTR gap to determine whether U.S.-China procurement patterns change relative to procurement patterns with exporters from other source countries (first difference) after the change in U.S. policy is implemented (second difference) in industries with higher NTR gaps (third difference). The last difference captures the fact that industries with larger

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<sup>22</sup>While U.S. tariffs are set at the level of eight-digit HS products, we observe trade at the ten-digit HS level. In our empirical work, we therefore match each ten-digit HS product with the tariff associated with its first eight digits.

NTR gaps experience a larger increase in the relationship continuation probability than industries with smaller gaps. We expect the largest shifts toward Japanese-style procurement after PNTR to occur in U.S. imports of high-gap products from China.

## 4.2 Estimation Results

We analyze the relationship between PNTR and procurement patterns within increasingly broad bins across three specifications.

Our first, preferred specification compares shipments within importer-exporter-product triplets across two symmetric time intervals around the change in U.S. trade policy,  $p \in \{Pre, Post\}$ ,

$$\ln(\bar{Y}_{mxhcp}) = \beta_0 + \beta_1 1\{p = Post\} * 1\{c = China\} * NTRGap_p + \gamma \chi_{mxhcp} \quad (21)$$

$$+ \beta_2 \ln(Total Value_{mxhcp}) + \lambda_{mxh} + \lambda_c + \lambda_p + \epsilon_{mxhcp}$$

where subscripts  $m$ ,  $x$ ,  $h$  and  $p$  index U.S. importers, exporters from country  $c$ , ten-digit HS products and time period. The regression sample consists of all shipments by “always-arm’s-length” parties, i.e., parties that engage solely in arm’s length transactions over the entire 1992 to 2011 sample period, so long as there is at least one shipment in each period. Periods are one of two distinct five-year windows around 2001, either 1995 to 2000 (pre period) or 2002 to 2007 (post period).

$\bar{Y}_{mxhcp}$  represents one of several attributes of shipment patterns within an  $mxhcp$  bin deemed relevant by the model developed in Section 2:  $WBS_{mxhcp}$  is the average number of weeks between shipments,  $VPS_{mxhcp}$  is the average value per shipment,  $QPS_{mxhcp}$  is the average quantity per shipment,  $Price_{mxhcp}$  is the average unit value per shipment, and  $Length_{mxhcp}$  is the average length in weeks of the importer-exporter-product relationships appearing within the  $mxhcp$  bin.<sup>23</sup> The matrix  $\chi_{mxhcp}$  represents the full set of interactions of the NTR gap, the post dummy variable ( $1\{p = Post\}$ ) and the China dummy variable ( $1\{c = China\}$ ) required to identify  $\beta_1$ .  $Total Value_{mxhcp}$  is the total value of all shipments occurring within the  $mxhcp$  bin; its inclusion accounts for the varying scale of imports across bins. Relationship ( $mxh$ ), country and period fixed effects are represented by  $\delta_h$ ,  $\delta_c$  and  $\delta_p$ . The difference-in-differences coefficient

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<sup>23</sup>The length of each relationship is defined as the number of weeks between the first observed transaction during the period and the last observed transaction during the period.

of interest,  $\beta_1$ , measures the log difference in activity for shipments from China versus other countries after the change in U.S. policy versus before for products with higher versus lower NTR gaps. From the model presented in Section 2, we expect  $\beta_1 < 0$  for  $VPS_{mxhcp}$ ,  $QPS_{mxhcp}$  and  $WBS_{mxhcp}$ , and  $\beta_1 > 0$  for  $Price_{mxhcp}$  and  $Length_{mxhcp}$  if PNTR induced a switch from the American to the Japanese system.

The second specification ignores exporter identity and analyzes shipments within importer-products across periods,

$$\begin{aligned} \ln(\bar{Y}_{mhcp}) = & \beta_0 + \beta_1 1\{p = Post\} * 1\{c = China\} * NTRGap_p + \gamma\chi_{mhcp} \\ & + \beta_2 \ln(Total Value_{mhcp}) + \delta_{mh} + \delta_c + \delta_p + \epsilon_{mhcp} \end{aligned} \quad (22)$$

Here, too, the regression sample includes all shipments by “always-arm’s-length” parties so long as there is at least one shipment for each  $mhcp$  bin. After the procurement attributes are computed, the  $mxhcp$  data are collapsed to the  $mhcp$  level so that there is one observation – the average – in the regression for each  $mhcp$  bin.

Our final specification ignores both importer and exporter identity and analyzes shipments within products across periods,

$$\begin{aligned} \ln(\bar{Y}_{hcp}) = & \beta_0 + \beta_1 1\{p = Post\} * 1\{c = China\} * NTRGap_h + \gamma\chi_{hcp} \\ & + \beta_2 \ln(Total Value_{hcp}) + \delta_h + \delta_c + \delta_p + \epsilon_{hcp} \end{aligned} \quad (23)$$

As above, we require at least one shipment within each  $hcp$  bin, and the data are collapsed to the  $hcp$  level after the procurement attributes are computed.

Results for the first, second and third specifications are reported in the corresponding three columns of Table 4, where each row reports the estimated DID term coefficient and standard error for a different relationship attribute. Starting with the preferred, within- $mxh$  results reported in column 1, we find that all estimates of  $\beta_1$  are consistent with a switch towards Japanese procurement: point estimates for value per shipment, quantity per shipment and weeks between shipments are all negative, though statistically significant only for the first two, while they are positive and statistically significant for shipment price and overall length. In terms of economic significance, these results imply that a one standard deviation increase in the NTR gap (0.23) is associated with relative declines in shipment value and shipment quantity of 1.6 and 3.0 percent after

the change in U.S. policy. Shipment price and relationship length, by contrast, rise by 0.9 and 2.3 percent, respectively. Through the lens of our model, the decline in shipment quantity implies a commensurate drop in inventory costs.

Comparison of the within-relationship results in column 1 with the within-product results in column 3 provides further intuition for our theoretical framework. For example, the relatively large (in absolute terms) DID point estimates for  $VPS_{hcp}$ ,  $WBS_{hcp}$  and  $Length_{hcp}$  reflects the fact that the change in U.S. policy gave rise to many new relationships. Since many of these relationships involved firms that had not imported from China before (see Pierce and Schott 2015), it is unsurprising that they were short-lived and perhaps encompass smaller, trial-size shipments.

## 5 Conclusion

This paper analyzes the impact of trade policy on firms' procurement patterns. We develop a theoretical model in which firms' choice of how to structure shipments along a supply chain responds to their beliefs regarding the probability of continued peaceful trade. This model reveals that reductions in the likelihood of a trade war can allow domestic buyers to reduce inventory costs by forming long-term, just-in-time relationships with foreign sellers.

We examine the model's implications empirically by estimating the effect of the U.S. granting of Permanent Normal Trade Relations – which substantially reduced the possibility of a U.S.-China trade war – on the procurement patterns of U.S.-based firms. Using transaction-level U.S. import data and a triple difference-in-differences specification, we show that PNTR is associated with a movement toward more Japanese-style procurement along the lines suggested by the model.

The results suggest that an important but under-examined aspect of trade agreements in a world with already low tariffs may be their affect on relationship formation. That is, trade agreements promoting institutions which allow firms to develop more stable relationships may give rise to an additional source of welfare gains from trade associated with reducing inventory and monitoring costs.<sup>24</sup> The extent to which such gains are smaller or larger than those that allow firms better access to contract enforcement or dispute resolution is an interesting area for further research.

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<sup>24</sup>Indeed, improving the efficiency of trade relationships is a goal of the recent WTO agreement on trade facilitation. See [https://www.wto.org/english/thewto\\_e/minist\\_e/mc9\\_e/desci36\\_e.htm](https://www.wto.org/english/thewto_e/minist_e/mc9_e/desci36_e.htm).

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Table 1: Default Parameters for Numerical Solutions

	Baseline
Buyer, Seller Continuation Probability ( $k_B, k_S$ )	(1, 0.99)
Inventory Cost ( $v$ )	0.02
Order Quantity ( $q$ )	0.02
Interest Rate ( $r$ )	0.02
Low, High Quality ( $\underline{\theta}, \bar{\theta}$ )	(0, 0.02)
Seller Fixed Cost ( $f$ )	0.01
Buyer Inspection Cost ( $m$ )	0.02

	Relationship Type	
	Arm's-Length	Related-Party
Total Value Traded	228,874 11,720,829	1,757,764 79,918,870
Overall Length (Months)	32 77	66 130
Total Number of Shipments	4 11	10 34
Value/Shipment (VPS)	43,257 601,379	65,379 1,091,935
Length/Shipment (LPS)	6 15	10 22
Number of Relationships	24,138,500	7,523,500

Notes: Table reports the mean and standard deviation of each attribute across relationships, which are defined as importer by exporter by ten-digit Harmonized System category triplets observed across the 1992 to 2011 sample period. First column summarizes arm's-length relationships and second column summarizes related-party relationships (see text). Observations are restricted to relationships with more than one transaction. Value, Length and Shipments refer to the total real value of imports observed over the relationship, the duration of the relationship in weeks, and the the total number of shipments observed during the relationship. Number of observations has been rounded to the nearest 100 as per U.S. Census Bureau Disclosure Guidelines.

Table 2: Relationship Summary Statistics

	ln(Value / Shipment <sub>mxhct</sub> )	ln(Quantity/ Shipment <sub>mxhct</sub> )	ln(Weeks Between Shipments <sub>mxhct</sub> )
1{RP <sub>mxhct</sub> =1}	-0.04 *** 0.001	-0.18 *** 0.002	-0.04 *** 0.001
ln(Total Value <sub>mxch</sub> )	0.580 *** 0.0001	0.550 *** 0.0002	-0.2 *** 0.0001
Observations	16,491,300	16,491,300	16,491,300
R-Squared	0.93	0.93	0.50
Fixed Effects	mch,t,l	mch,t,l	mch,t,l

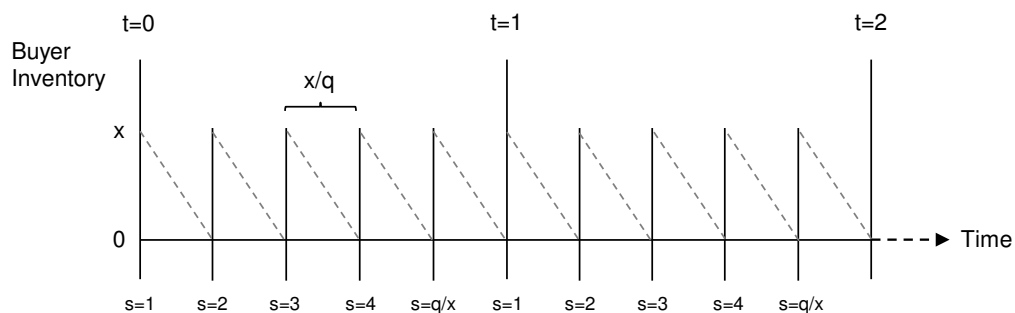
Notes: Table presents results of importer-exporter-product-country-year (*mxhct*) level OLS regressions of relationship attributes on a dummy variable indicating related-party status (RP) and a covariate (Total Value) indicating the size of the relationship in terms of value shipped. Regression sample restricted to relationships with at least two observations per *mxhct* bin that engage solely in arm's length or solely in related-party (RP) transactions over the sample period. WBS is the average number of weeks between shipments. VPS and QPS are the average value and quantity per shipment. Results for fixed effects are suppressed. Superscripts \*, \*\* and \*\*\* indicate statistical significance at the 10, 5 and 1 percent levels, respectively. Number of observations has been rounded to the nearest 100 as per U.S. Census Bureau Disclosure Guidelines.

Table 3: Related-Party versus Arm's Length Transactions

Dependent Variable	Within	Within	Within
	Importer- Exporter- Product	Importer- Product	Product
In(Value per Shipment)	-0.07 *** 0.01	-0.05 *** 0.01	-0.18 *** 0.05
In(Quantity per Shipment)	-0.13 *** 0.02	-0.04 ** 0.02	-0.04 0.10
In(Price per Shipment)	0.04 ** 0.02	-0.04 ** 0.02	-0.11 0.09
In(Weeks Between Shipments)	-0.04 0.03	-0.06 *** 0.02	-0.36 *** 0.07
In(Overall Relationship Length)	0.10 *** 0.04	0.00 0.03	-0.34 *** 0.08
Observations	752,600	1,011,700	324,300
Sample	mxhcp	mhcp	hcp
Fixed Effects	mxh,c,p	mh,c,p	h,c,p

Notes: Table summarizes the results of generalized difference-in-differences regressions of relationship attributes on a DID coefficient representing the interaction of the NTR gap and dummy variables representing the post-PNTR period and trade with China (see text). Each cell in the table represents the result of a different regression. Data are collapsed to the importer-exporter-product-country-period (mxhcp) level in column 1, the importer-product-country-period (mhcp) in column 2, and the product-country-period (hcp) level in column 3. Sample is restricted to bins with at least two observations for the pre- and post period. Dependent variables are computed with respect to noted sample bins. Results for fixed effects and other covariates needed to identify the DID coefficient of interest are suppressed. Superscripts \*, \*\* and \*\*\* indicate statistical significance at the 10, 5 and 1 percent levels, respectively. Number of observations has been rounded to the nearest 100 as per U.S. Census Bureau Disclosure Guidelines.

Table 4: PNTR and Procurement



Notes: Buyer uses inputs purchased from a seller at rate  $q$  over each time interval, e.g.,  $t=0$  to  $t=1$ . There are  $s=\{1,2,\dots,q/x\}$  shipments of size  $x$  per time interval, each arriving  $x/q$  time intervals apart. Between each shipment, the buyer's inventory falls from  $x$  to 0.

Figure 1: Model Setup

Figure 2: Overall Cost vs Continuation Probability ( $k$ )

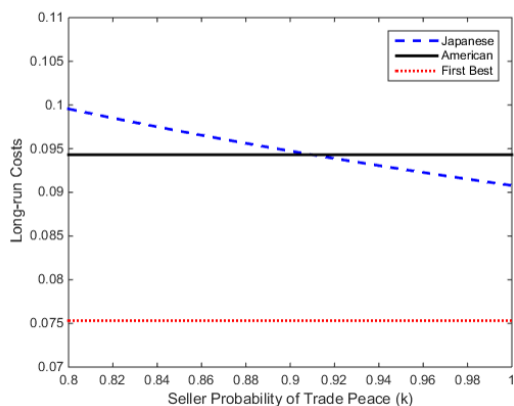


Figure 3: Order Size and Price vs Continuation Probability ( $k$ )

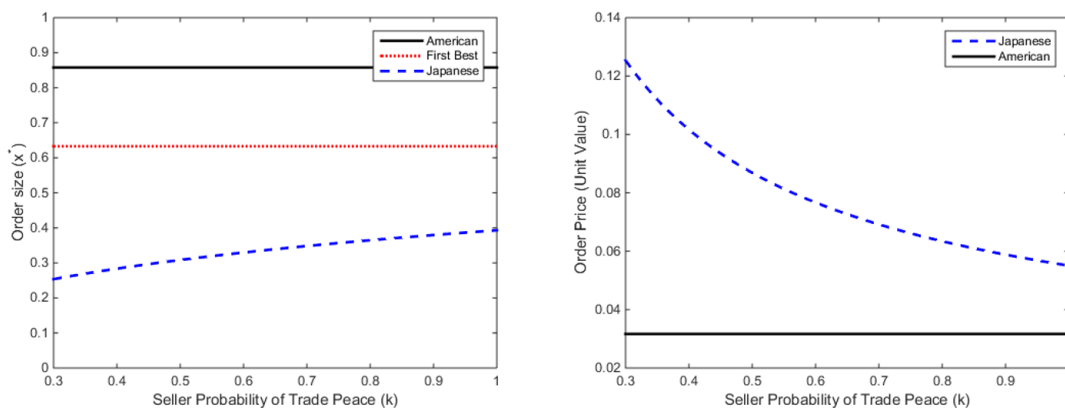


Figure 4: Order Size vs Fixed Costs ( $f, m$ )

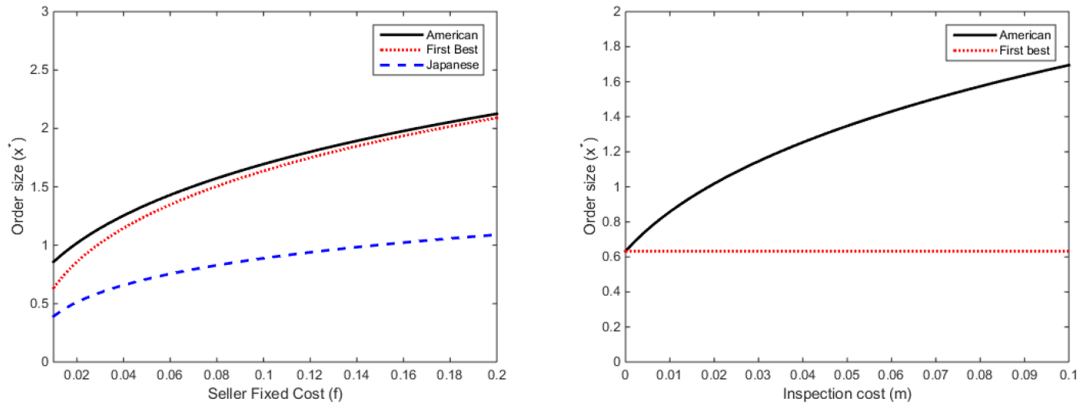
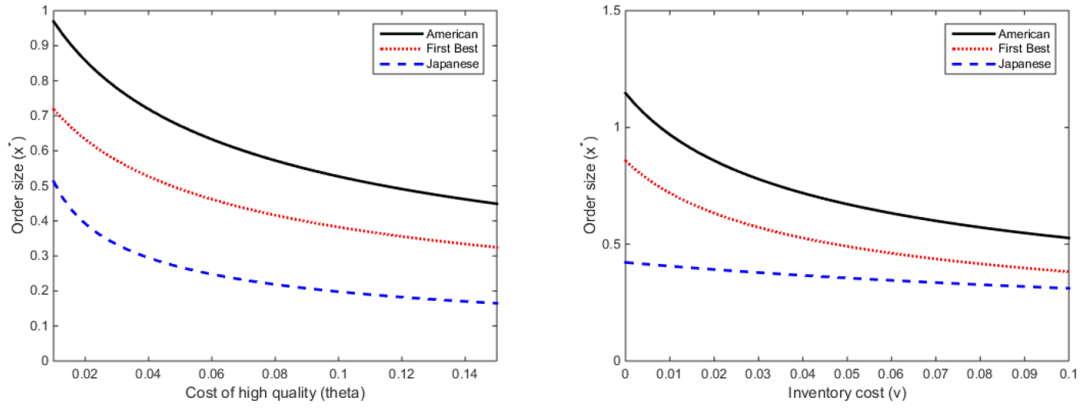


Figure 5: Order Size vs Variable Costs ( $\bar{\theta}, v$ )



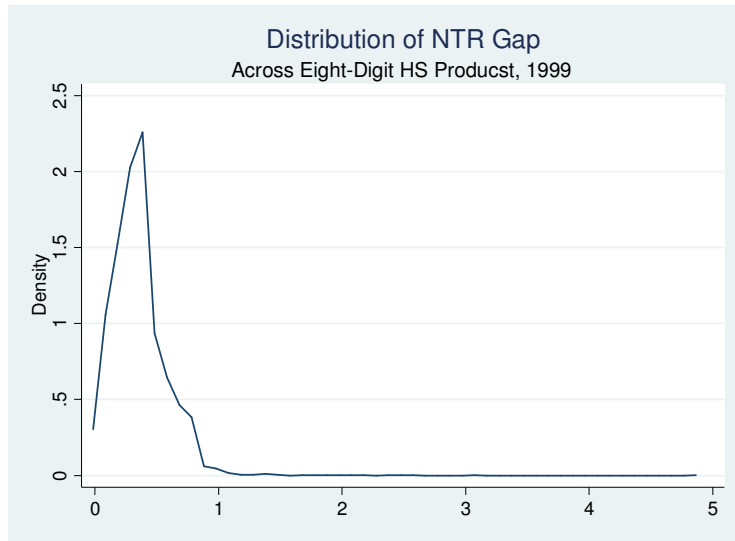


Figure 6: Distribution of the NTR Gap Across Products

# Appendix

## A Micro-foundation for $\rho_S$

In Section 2.2 of the main text, we assume that in the event of a trade war, the import tariff on the product the buyer imports from the seller rises to a prohibitive level, with the result that the buyer-seller relationship is severed. In this section, to provide a closer link between the model and our empirical analysis, we offer a short micro-foundation for the seller's belief  $k_S$  about the probability that the relationship will continue that is a function of the change in tariffs and therefore product-specific.

Assume that the initial *ad valorem* import tariff on the traded input,  $\tau_0$ , is equal to zero, but rises to  $\tau_{TW} > 0$  in the event of a trade war. In that case, the buyer may seek an alternate seller from another country. Let the difference in the net present value for the buyer thereafter sourcing  $q$  from this alternate seller be

$$NPV(q)_{Seller} - NPV(q)_{Alternative}. \quad (\text{A.1})$$

We assume the seller does not know the value of the second term and therefore treats it as a random variable  $\epsilon$ , where  $\epsilon$  is independent of the true probability of a trade war,  $(1-\pi)$ . The seller's probability that the relationship with the buyer continues in any period,  $\rho_S$ , is then

$$\rho_S = (1 - \pi)P(\epsilon > (1 + \tau_{TW})NPV(q)_{Alternate}) + \pi P(\epsilon > NPV(q)_{Alternate}). \quad (\text{A.2})$$

Given that  $P(\epsilon > (1 + \tau_{TW})NPV(q)_{Alternate}) < P(\epsilon > NPV(q)_{Alternate})$ ,  $\rho_S$  decreases with the true probability of a trade war,  $1 - \pi$ , as well as the trade-war tariff,  $\tau_{TW}$ . In our empirical analysis, we interpret  $\tau_{TW}$  as the NTR gap. In that case, in the event of a trade war, buyer-seller relationships oriented around a particular product are less likely to survive the higher that product's spike in tariffs. We note that in this setup, the the continuation probability,  $\rho_S$ , is independent of the buyer's choice of optimal order size, consistent with the idea that the buyer is true to his commitment.

## B Additional Analytic Propositions

This section highlights additional implications of the simplified model discussed in Section 2.5.

**Proposition 5.** *Under both the American and Japanese procurement systems, optimal order size rises (optimal frequency falls) with an increase in fixed production cost  $f$  and decreases in variable cost  $\bar{\theta}$  or inventory cost  $v$ . Under the Japanese system, optimal order size rises (optimal frequency falls) with an increase in the continuation probability  $k_S$ . Under the American system, optimal order size rises (optimal frequency falls) with an increase in order inspection costs  $m$ .*

*Proof.* It is straightforward to show that  $\frac{\partial x_J^*}{\partial \lambda} < 0$ ,  $\frac{\partial \lambda}{\partial \rho} < 0$  and  $\frac{x_J^*}{x_A^*} = \sqrt{\frac{\gamma f}{\lambda(f+m)}} < 1$   $\square$

In order to see the intuition behind this, hold the discount rate fixed, and assume that the variable cost to produce high quality  $\bar{\theta}$  or inventory variable cost  $v$  falls. This lowers the present value of variable order costs relative to fixed order costs. In that case, buyers reduce order frequency to raise variable order costs at the expense of costs of lower discounted future order costs. Likewise, holding the discount rate fixed, an increase in the fixed order cost  $f$  raises discounted future fixed order costs. The buyer therefore balances the increase in fixed order costs by increasing lowering order frequency. The continuation probability  $k_S$  affects order size only under the Japanese system. An increase in  $k_S$  lowers the incentive premium the buyer pays the seller in each order cycle. At a given discount rate, this reduces the variable discounted order costs and buyers increase shipment sizes and reduce order frequencies to re-optimize on order costs.

**Proposition 6.** *(i) An increase in the probability of peaceful trade  $\rho_S$  raises order size (lowers order frequency) in the Japanese system relative to the American System; (ii) the greater the inventory cost  $v$  the less elastic are relative order size (and relative order frequency) with respect to a change in  $\rho_S$ ; and (iii) variable and fixed production and delivery costs do not affect the elasticity of relative order size (or shipping frequency) with respect to  $\rho_S$ .*

*Proof.* The elasticity of relative order size with respect to  $k_S$ ,  $\frac{d(x_J^*/x_A^*)/\rho_S}{d\rho_S/(x_J^*/x_A^*)}$  is  $\epsilon \equiv \frac{q}{(\rho_S v + 2q)\rho_S} > 0$ .  $\square$



This proposition summarizes the impact of a switch from the American to the Japanese system due to an exogenous decline in the seller's perceived probability of a trade war . As a result of such a switch, order size falls and shipping frequency rises, with the magnitude of these changes falling in the inventory cost  $v$ . Combined with proposition 1 this implies that those firms that had the lowest order frequencies before the increase in the continuation will switch to the Japanese system and see an increase in order frequencies, while those firms with the highest order frequencies and are already in a Japanese style contract will see a decrease in the order frequency.

**Proposition 7.** *Under both the American system and the Japanese system, order unit values increase in fixed cost  $f$ , variable production cost  $\bar{\theta}$ , and variable inventory cost  $v$ . Under the American system, they also increase in the fixed inspection cost  $m$ . In the Japanese system, they decrease as the probability of trade peace  $\rho_S$  increases.*

*Proof.* Substitute the optimal shipping quantities  $x_J^*$  and  $x_A^*$  into the order unit values and take the derivatives with respect to the appropriate parameters.  $\square$

Within relationships already organized according to the Japanese system, a rise in the probability of peaceful trade induces a decline in order unit value. Within relationships previously organized according to the American system, however, a rise in the probability of peaceful trade induces a rise in the order unit value if the relationship switches to the Japanese system. Again, this is similar as above. It suggests a non-linearity in the dependent variable. The higher order values see a decrease (those are Japanese before the liberalization) and the lowest unit values see an increase (those are american but may switch to Japanese.)

**Proposition 8.** *An increase in the inspection cost  $m$  will lower the cutoff  $\rho_S^*$  at which point the buyer switches from the American to the Japanese system.*

*Proof.* For any given value of  $m$ ,  $\rho_S^*$  is the cutoff such that  $\Delta C(\rho_S^*, m) = 0$ , where the buyer is just indifferent between the two systems. Apply the implicit function theorem to consider only arm's length transactions. show that

$$\frac{\partial \rho(m)^*}{\partial m} = -\frac{\frac{\partial \Delta(\rho_S, m)}{\partial m}}{\frac{\partial \Delta(\rho_S, m)}{\partial \rho_S}} = -\frac{1}{2} \left( \frac{\left( \sqrt{(2q+v)(f+m)r\bar{\theta}} + 2q\bar{\theta} + \bar{\theta}v \right) r \rho_S^{5/2} \sqrt{(\rho_S v + 2q)f}}{q\sqrt{(f+m)(2q+v)} \left( fr\rho_S + \sqrt{(\rho_S v + 2q)f\rho_S r\bar{\theta}} \right) \bar{\theta}} \right) < 0 \quad (\text{A.3})$$

$\square$

For a given increase in the probability of trade peace  $\rho_S$ , a buyer under the American procurement system with a high  $m$  is more likely to switch to the Japanese system.