

Trade Policy in the Presence of a Discriminating Foreign Monopolist

Phillip McCalman
Department of Economics
University of California-Santa Cruz
mccalman@ucsc.edu

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Abstract

When a foreign monopolist sets a single market clearing price for its product, the sign of the optimal tariff is determined by the extent of pass through (also known as the terms of trade effect). However, when a foreign monopolist uses a non-linear price schedule to discriminate between domestic consumers the calculus of welfare maximization is very different. While there are still terms of trade effects from the imposition of a tariff, the existence of such effects are neither necessary nor sufficient to determine the sign of the optimal tariff. Instead the distribution of valuations within the population is the key determinant of the nature of policy intervention. This result differs substantially from the uniform price case and is driven by the incentive compatibility constraint which places the distribution of types at the center of the analysis. If there is a relatively large fraction of high types in the population, then domestic information rents can be increased substantially by subsidizing imports thereby increasing the consumption of the low valuation types and moving the incentive constraint in favor of the high valuation types. However, if the share of high types in the population is relatively small then the increase in information rents will also be small but the fiscal implications of a subsidy will be large. Consequently, the optimal policy will be to impose a trade tax.

Key Words: Trade Policy, Discrimination, Monopoly, Non-linear Pricing

JEL Classifications: F12, F13

1 Introduction

Firms use a wide variety of techniques to sell their products. The diversity of methods extends far beyond the simple notion that a lower price will attract more consumers. Indeed the whole idea that firms rely on linear prices is challenged by the contracts offered for not only telecommunication services but also by the discounts for volume available in almost all retail outlets (e.g. 500ml of soft drink is more than half the price of 1000ml). The literature analyzing these techniques is vast but all studies have one feature in common, they all focus exclusively on a closed economy setting. The focus on closed economy models seems natural, especially since the working assumption regarding international trade is that it is motivated, at least in part, by differences in price. Such a motivation naturally lends itself to a relatively competitive view of international markets. However, recent empirical work challenges the idea that international trade is conducted in environments characterized by well organized exchange with high quality information about prices. Indeed, Rauch (1999) finds that between 60-70% of international trade occurs outside of organized exchanges or institutions that disseminate price information. This implies that the majority of international trade occurs in settings where basic information about the identity of buyers and sellers requires some effort to collect and that one or potentially both sides of an exchange have market power. At the very least this suggests there is scope for some of the vast array of selling techniques observed in the closed economy to also be applied to international transactions.

This paper considers one such technique. Specifically a foreign monopolist is assumed to serve a heterogeneous group of domestic consumers. Unfortunately for the monopolist there is no obvious way of distinguishing between the different types of customers. Instead the foreign monopolist offers the domestic consumers a menu to pick from, each option differing in terms of the quantity and total payment required. By choosing among the different options the consumers are implicitly generating a distribution of prices for the product sold by the monopolist. How is a domestic government's view of the world is altered by such behavior? More specifically, is the operation of trade policy likely to be affected by the non-linear pricing structure of the foreign monopolist?¹

This question is interesting since an important consideration in assessing the implications of trade policy is the terms of trade effect. This effect is central to arguments about optimal trade policy since it provides a motivation for intervention by the domestic government. However, if there

¹Another possibility in non-competitive markets is that relationship specific investment maybe undertaken. For an analysis of trade policy and the hold-up problem see Antras and Staiger (2008).

is not a single market clearing price, but instead a distribution of prices it is not immediately obvious whether or how a domestic government should intervene in international trade.

This paper shows that the optimal trade policy in the presence of non-linear pricing has a very different motivation than when the foreign monopolist charges a uniform price (see Brander and Spencer (1984)).² In particular a terms of trade effect is neither necessary nor sufficient for intervention to occur by a national welfare maximizing government.³ This stands in direct contrast to a uniform price monopolist where the terms of trade effect not only serves as the basis for intervention but also determines whether the trade tax is positive or negative. For the uniform price case, if pass through is less than complete (i.e. a \$1 trade tax raises the domestic price by less than a dollar), then it is optimal to impose a positive trade tax since the foreign firm pays part of the tax. However, if pass through is more than complete then the optimal policy is a subsidy to imports. In this instance a \$1 subsidy will lower the domestic price by more than a dollar, with the terms of trade benefit once again the mechanism that motivates intervention. Finally, if pass through is complete then the optimal tariff is zero. Such logic no longer applies when the foreign firm uses non-linear prices.

Given that the linear and non-linear price scenarios share many common features, such as total output below the efficient level, why is there a difference in the operation of optimal trade policy? The crucial difference relates to the information rents captured by a consumer under non-linear pricing. These rents are derived from the ability of high valuation types to claim to be low valuation types and the need for the monopolist to set an incentive compatible price schedule to avoid this outcome. As a result the information rents that a high type earns are a function of the bundle designed for the low types, which creates an incentive for the monopolist to reduce the bundle below the efficient level for all types except the highest type. By offering a subsidy on all imports the government moves production closer to the first best for the low valuation types. The beneficial impact of the subsidy for the low valuation types also translates into greater information rents for the high valuation types due to a change in the incentive compatibility constraint. Will a government choose a subsidy? Clearly, more than complete pass through lowers the fiscal cost of the subsidy. However, the degree of heterogeneity among consumers is also important. If the fraction of high

²Krishna (1990) examines the implications of exogenous trade frictions for the quality composition of imports when the foreign monopolist chooses the quality of its product line. However, she does not characterize the optimal policy. For other work that considers optimal trade policy under asymmetric information see Bagwell and Staiger (1989) and Kolev and Prusa (1999).

³For a more general discussion of the role of the terms of trade effect in trade policy and international agreements see Bagwell and Staiger (2002).

types is relatively large, then the optimal policy is more likely to be a subsidy since the gain in information rents is more than sufficient to offset the fiscal cost of the subsidy. This effect can be so strong that a subsidy is optimal even when pass through is less than complete. Conversely, when pass through is more than complete, the optimal trade tax can still be positive under non-linear pricing, with this more likely the higher the fraction of low types in the population. Hence, the incentive compatibility constraint introduces a role for consumer heterogeneity into the welfare calculus that implies the optimal policy is now determined by the interaction of the change in the terms of trade for each type and the distribution of valuations. It is this interaction that generates the results that stand in stark contrast to those derived under the assumption of a uniform price monopolist. This difference raises intriguing questions about the broader implications of the design of trade policy and the location of production, especially FDI, that will be pursued in future research.

The paper is structured as follows. To provide some evidence for the operation of non-linear pricing of international transactions, the next section considers whether all imports of a given product from a particular source country enter the US for the same price or whether there is a distribution of prices. There does indeed seem to be a distribution of prices, which persists despite controlling for a number of factors including economies of scale and distance. One possible explanation of the residual variation is non-linear pricing. Section 3 then presents a standard model of non-linear pricing by a monopolist, the main difference being that a border separates the producer from the consumers. In this context the optimal trade tax is derived and characterized in section 4. Section 5 considers the trade tax choice under two standard demand specifications, while section 6 examines quality choice and ad valorem tariffs. Finally, 7 concludes and discusses avenues of potential research.

2 Variation in Unit Values and US Import Volumes

Import data for the US is available at a very disaggregated level. Not only does the data record imports by source country for each of the 10 digit Harmonized System (HS10) products, but information is additionally broken down by month and US customs district.⁴ An important feature of this data is that it contains information on both f.o.b. value and quantity, therefore unit values for a product can be computed by exporter, month and customs district. Data of this degree of disaggregation make it possible to explore whether or not imports of a product from a country tend

⁴There are approximately 15,000 products at the 10 digit level and 44 customs districts. This data is made available by the U.S. Census Bureau.

to enter the US for approximately the same price or whether there is a distribution of prices.

Table 1: Coefficient of Variation for Unit Values, 1994

Sample Definition	CRT Monitors	White Shirts	Fuel Oil
Whole	2.32	1.21	0.28
Monthly FE	2.15	1.19	0.26
Exporter FE	1.29	0.47	0.23
# obs	(3677)	(5381)	(670)

Since our goal is descriptive we will focus on three products that have previously been the subject of analysis.⁵ These products are CRT monitors, men’s white cotton shirts and fuel oil.⁶ Based on the most disaggregated breakdown of the data, Table 1 reports the coefficient of variation for unit values for each product in 1994. The first row considers the degree of variation in unit values for the entire sample for each product. As previous studies have noted, even for narrowly defined products there is a large degree of variation in unit values, with the coefficient of variation ranging from a high of 2.32 for CRT monitors to a low of 0.28 for fuel oil. The ordering of these statistics also aligns with priors since CRT monitors are a relatively differentiated good while men’s white shirts are somewhat standardized and fuel oil represents a commodity. The second row considers one possible source of variation, month to month fluctuations. As can be seen, this returns values very similar to the first row, and therefore the explanation of the variation must lie elsewhere.

Following the previous literature the third row includes exporter fixed effects. Once again the results are relatively intuitive with the exporter effects accounting for half the variation in unit values for CRT monitors and very little for fuel oil. However, a notable feature not identified by previous work is that there still exists a large amount of variation in unit values for both CRT monitors (1.29) and white shirts (0.47) that is unaccounted for by exporter fixed effects. This implies that these products sell for a wide range of prices, even controlling for the country of origin (i.e. the unit values vary widely and products from a particular country are not sold for the same price). In fact for both CRT monitors and men’s white shirts, the variation in unit values within countries is roughly the same order of magnitude as the variation in unit values across countries.

A natural question to ask is where this variation comes from? There are a number of possible explanations including economies of scale, within exporter firm heterogeneity⁷, variation in product

⁵See Schott (2004).

⁶The HS10 codes are 8471923200, 6205202065 and 2710000530, respectively.

⁷See Melitz (2003).

quality across US customs districts (Alchian-Allen effects)⁸ or some form of price discrimination such as non-linear pricing.⁹ The objective here is not to attempt to test each possibility to see which explanation fits the data the best (since all are likely to play some role), but rather to see if non-linear pricing can be ruled out by controlling for the other main sources of variation. If there is residual variation, then non-linear pricing is a potential explanation. In particular, a specific form of non-linear pricing is considered: quantity discounts. If quantity discounts are responsible for the variation in unit values, then shipments with larger quantities should be associated with lower unit values. However, it is also possible that larger shipments are associated with economies of scale and therefore result in lower unit values. To control for this and other possibilities the following specification is estimated:

$$\ln(UV_{spm}) = \alpha_s + \alpha_m + \beta_1 \ln(\text{dist}_{sp}) + \beta_2 \ln(Q_{spm}) + \beta_3 \ln(Q_{sm}) + \epsilon_{spm} \quad (1)$$

where $\ln(UV_{spm})$ is the log of unit value for product i , from source country s to customs district p in month m , α_s is a vector of exporter fixed effects and α_m is a vector of month fixed effects, $\ln(\text{dist}_{sp})$ log of the distance between a source country and a customs district, $\ln(Q_{spm})$ is the log of quantity of i shipped from s to p in m , $\ln(Q_{sm})$ is the log of total quantity shipped by s to the US in month m , and ϵ_{spm} is the error term.

Table 2 reports the OLS regression results. Since (1) contains exporter and month fixed effects, the coefficient on $\ln(Q_{spm})$ is based on the variation in unit values of an exporter across customs districts within a month. The use of $\ln(Q_{sm})$ controls for influence of economies of scale on unit values. This interpretation assumes that the benefits of economies of scale are generated within a month and reflected uniformly in the price for that month. After controlling for economies of scale in this way, the quantity discount for CRT monitors is relatively large with each 10% increase in volume leading to a 1.3 % decline in price. White shirts show a more modest, yet statistically significant, quantity discount. In contrast, fuel oil records no economically or statistically significant association between unit value and volume.¹⁰

Note that controlling for economies of scale with $\ln(Q_{sm})$ implicitly assumes that there is either

⁸See Hummels and Skiba (2004).

⁹Another option is that the variation is driven by errors in filling out customs forms, see GOA, 1995. See the appendix for results based on robust regression techniques. These results are consistent with those reported in the text below.

¹⁰Note that the coefficient on distance is estimated to be both large and significant for CRT monitors. This result is sensitive to the specification employed and disappears in the robust regression analysis (see appendix A).

Table 2: OLS estimates of the association between $\ln(UV_{spm})$ and $\ln(Q_{spm})$

	CRT Monitors	White Shirts	Fuel Oil
$\ln(Q_{spm})$	-0.13*** (0.007)	-0.054*** (0.009)	-0.012 (0.01)
$\ln(Q_{sm})$	-0.037 (0.03)	-0.058** (0.02)	0.0016 (0.01)
$\ln(\text{distance})$	-0.22*** (0.05)	-0.019 (0.05)	-0.035*** (0.01)
Observations	3677	5381	670
R ²	0.68	0.64	0.36

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Estimates include separate Exporter and Month fixed effects

a sole exporter or that exporters within a country are homogeneous. However, if exporters within a country differ in productivity, then more assumptions are required for this specification to adequately control for economies of scale. If we follow the firm heterogeneity literature and assume that there are only country level fixed costs of exporting, then every exporter that pays the fixed fee can potentially serve all customs districts. If this is the case, then the standard model predicts that all economies of scale will be reflected in the firm specific price, and $\ln(Q_{sm})$ is sufficient to control for firm level economies of scale. However, if there are sub-national fixed costs or if more general demand structures are invoked then $\ln(Q_{sm})$ may not be adequate to control for economies of scale.¹¹

Aside from economies of scale another possibility is that the quality composition of within product bundles differ across US customs districts. One explanation of this difference is the Alchian-Allen effect. This says that per unit transport costs will induce changes in relative prices, with the total per unit cost higher for markets further away from the products country of origin. If higher quality versions of a product receive a higher price, then adding a common transport cost to all versions will move relative prices in favor of high quality goods, with this effect most pronounced for customs districts further away from the products origin. This changes the quality composition of the product bundle that arrives at each customs district (i.e. the shipping the good apples out phenomena). To

¹¹If there are sub-national fixed costs that vary in such a way that more varieties are supplied to larger markets, then the prediction from the standard heterogeneous firm model is that unit values should be increasing in volume. That is, the lowest productivity exporters only find it profitable to serve the largest sub-national markets. For models that augment the standard heterogeneous firm framework to include quality, and hence generate potentially different prediction on pricing, see Johnson (2008) and Baldwin and Harrigan (2007).

Table 3: OLS estimates of the association between $\ln(UV_{spm})$ and $\ln(Q_{spm})$

	CRT Monitors	White Shirts	Fuel Oil
$\ln(Q_{spm})$	-0.12*** (0.007)	-0.058*** (0.008)	-0.0041 (0.007)
$\ln(Q_{sm})$	-0.048* (0.03)	-0.024 (0.02)	0.0029 (0.01)
Observations	3677	5381	670
R ²	0.79	0.79	0.83

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Estimates include Month and Exporter*(Customs District) fixed effects

control for this possibility the following specification is estimated:

$$\ln(UV_{spm}) = \alpha_{sp} + \alpha_m + \beta_2 \ln(Q_{spm}) + \beta_3 \ln(Q_{sm}) + \epsilon_{spm} \quad (2)$$

where α_{sp} is a vector of exporter/customs district fixed effects. Table 3 reports results. Since this specification includes exporter/customs district effect the coefficient on $\ln(Q_{spm})$ reflects variation in unit values of an exporter within a customs district over time. Thus it is implicitly assumed that transport costs do not change over the 12 month period considered. Once again the coefficients on $\ln(Q_{spm})$ represent a sensible ordering in terms of magnitude and statistical significance. Note also that economies of scale are also accounted for by the inclusion of $\ln(Q_{sm})$. After controlling for both of these sources of variation, there still remains significant variation in unit values which is associated with larger shipments. Therefore, the evidence offered in the two tables does not rule out non-linear pricing as a potential explanation of the variation in unit values and therefore the next section considers the implications of this behavior.

3 Non-linear Pricing by a Foreign Monopolist

Quantity discounts can result from second degree price discrimination, a price strategy that has not been extensively analyzed in the international economics literature. To determine the implications of this selling mechanism consider the standard monopoly model of non-linear pricing.¹² The model

¹²See Maskin and Riley (1984) and Tirole (1988).

assumes that a monopolist sells a single good to a heterogeneous set of consumers at a constant marginal cost, c .¹³ At this point the only departure from the standard framework is that the consumers are assumed to be located in the home country while the monopolist is located in the foreign country. Since a border separates the two sets of agents, it is natural to consider that there is some trade policy instrument that is applied at the border to imports. This policy is assumed to be a per unit trade tax, t .¹⁴ While more complicated policies can be implemented, this simple policy has the feature that it both enables a direct comparison to the previous trade policy literature as well as capturing the actual structure of observed trade policy.¹⁵

The game is assumed to have four stages. In the first stage the domestic government sets trade policy. In the second stage the monopolist announces its schedule of prices and quantities, while in stage 3 consumers receive their preference draw from a common knowledge distribution, though the draw itself is private information. Finally, in stage 4 trade occurs. To solve this game we begin in stage 4 and work backwards.

3.1 Preferences

A consumer receives utility according to a quasi-linear utility function and faces a problem of maximizing utility given a pricing menu that specifies a total payment, $T(q)$, for any given quantity, q . Therefore the objective function has the following form

$$\theta_i u(q) - T(q) \quad i = L, H$$

where $\theta_i u(q)$ is the utility function and $T(q)$ is the monetary transfer from the consumer to the monopolist. Assume that $u(q)$ is increasing in q , $u' > 0$, and strictly concave, $u'' < 0$. The parameter θ indexes a consumer's willingness to pay and is assumed to be only known by the individual consumer. For expositional simplicity, assume that there are only two types of consumers,

¹³The presentation here will treat the output produced by the monopolist as homogeneous. However, the model can also be given a quality interpretation with each consumer type buying one unit of a good where the quality of that good is endogenous. However, this changes the interpretation of the trade tax, and the implications of this perspective will be discussed in more detail in section 6.

¹⁴As under a uniform price monopoly the first best policy is a price ceiling at marginal cost. However, if there are fixed costs of production this policy needs to be augmented. The augmentation becomes more difficult to implement if unobservable fixed costs exist. Likewise lump-sum taxation may suffer from the same difficulty. Furthermore, if there is quality differences then a price ceiling is no longer optimal.

¹⁵More specifically single rate ad valorem trade taxes are the norm (which is true for the commodities discussed in section 2) and the extension of the model to such policies is straight forward and discussed in section 6. The motivation for considering a per unit tax is that this policy is associated with the greatest variation in policy choice in the previous literature (see Brander and Spencer (1984)).

high valuation types (θ_H) and low valuation types (θ_L), where $\theta_H > \theta_L$.

3.2 The Monopolist's Problem

Assume that the monopolist believes that the high valuation type occurs in the population with probability β . However, to keep the problem interesting we will place some restriction on the distribution of types in the population. In particular, we will concentrate on circumstances where both types always participate in the market under *free trade*. To ensure that this is the case we assume that $(\theta_L - \beta\theta_H)u'(0) > (1 - \beta)c$ or $\beta < \frac{\theta_L u'(0) - c}{\theta_H u'(0) - c}$. Note in particular that this does not preclude the option of imposing a tariff that causes the low value type not to be served in equilibrium.

In this case the monopolist chooses $\{(q_L, T_L), (q_H, T_H)\}$ to maximize

$$\Pi = \beta(T_H - (c + t)q_H) + (1 - \beta)(T_L - (c + t)q_L)$$

subject to

$$\theta_L u(q_L) - T_L \geq \theta_L u(q_H) - T_H \tag{3}$$

$$\theta_H u(q_H) - T_H \geq \theta_H u(q_L) - T_L \tag{4}$$

$$\theta_L u(q_L) - T_L \geq 0 \tag{5}$$

$$\theta_H u(q_H) - T_H \geq 0 \tag{6}$$

where (3) and (4) are the incentive compatibility constraints for the low and high types, respectively, while (5) and (6) are the corresponding participation constraints. Given our assumptions, it is well known from the mechanism design literature that only two of these constraints bind, the incentive constraint for the high type, (4), and the participation constraint for the low type, (5). Therefore the relevant constraints can be rewritten as:

$$T_H = \theta_H u(q_H) - \theta_H u(q_L) + \theta_L u(q_L) \tag{7}$$

$$T_L = \theta_L u(q_L) \tag{8}$$

This allows the profit maximization problem to be simplified to become:

$$\max_{q_L, q_H} \Pi = \beta (\theta_H u(q_H) - \theta_H u(q_L) + \theta_L u(q_L) - (c+t)q_H) + (1-\beta)(\theta_L u(q_L) - (c+t)q_L) \quad (9)$$

Taking first order conditions gives:

$$\frac{\partial \Pi}{\partial q_L} = \beta(\theta_H - \theta_L)u'(q_L) - (\theta_L u'(q_L) - (c+t))(1-\beta) = 0 \quad (10)$$

$$\Rightarrow (\theta_L - \beta\theta_H)u'(q_L) - (1-\beta)(c+t) = 0 \quad (11)$$

$$\frac{\partial \Pi}{\partial q_H} = \theta_H u'(q_H) - (c+t) = 0 \quad (12)$$

These conditions imply the standard result that the high types are offered an efficient quantity, while the low types are offered and accept a bundle with an inefficiently low quantity. These results are illustrated in figure 1.

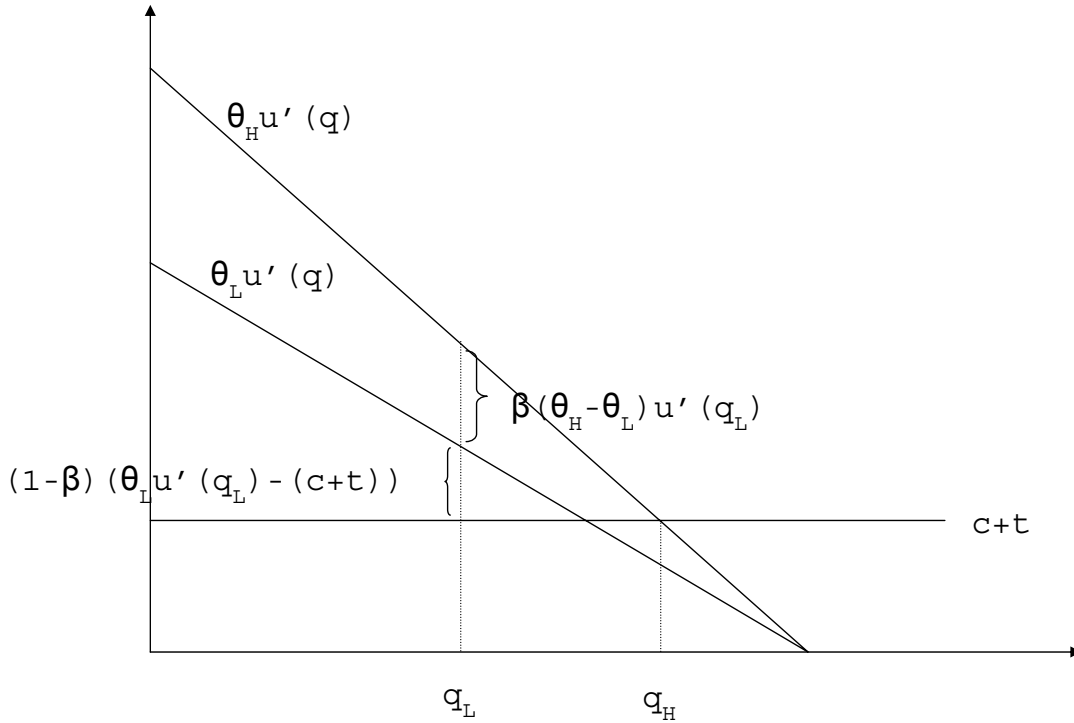


Figure 1: Optimal Quantities

Two useful comparative static results are that the optimal quantity offered to a low valuation

type is decreasing in the probability of being a high type:

$$\frac{dq_L}{d\beta} = \frac{\theta_H u'(q_L) - (c + t)}{(\theta_L - \beta\theta_H)u''(q_L)} < 0 \quad (13)$$

and that the quantity offered to each type is decreasing in the trade tax:

$$\frac{dq_L}{dt} = \frac{(1 - \beta)}{(\theta_L - \beta\theta_H)u''(q_L)} < 0 \quad (14)$$

$$\frac{dq_H}{dt} = \frac{1}{\theta_H u''(q_H)} < 0 \quad (15)$$

4 Optimal Trade Tax

Faced with a discriminating foreign monopolist the question arises as to whether trade policy is any more or less effective than under conventional uniform pricing. If a firm implements a more sophisticated pricing structure, does this mitigate or enhance the argument for intervention? Indeed the case for an optimal tariff in the presence of a foreign monopoly is already relatively qualified (see Brander and Spencer (1984)). Nevertheless, if intervention is warranted, what form will it take and what factors will it be conditional on? To address these questions, begin by defining the welfare of the importing country as the sum of net consumer surplus (CS) and tariff revenue (TR). In the current setting net consumer surplus is equal to the information rents captured by the domestic consumers. Therefore domestic welfare is represented as:

$$\begin{aligned} W &= CS + TR \\ &= (1 - \beta)(\theta_L u(q_L) - T_L) + \beta(\theta_H u(q_H) - T_H) + TR \\ &= \beta(\theta_H - \theta_L)u(q_L) + TR \end{aligned} \quad (16)$$

where the last line is derived using (4) and (5). This objective function differs from the standard one for two reasons; not only does the foreign monopolist use non-linear prices but it does so in the presence of incomplete information. Since both of these features are new to the analysis of optimal trade taxes its worthwhile considering decomposing their influences on the optimal policy. This is most easily achieved by assuming that the foreign monopolist has complete information, and consequently it uses non-linear prices to extract all consumer surplus. To be consistent with our previous assumption that both types are served under free trade, we start by considering what

happens as $\beta \rightarrow 0$.

4.1 Optimal tariffs when the foreign monopolist has complete information

If the foreign monopolist has complete information, then it can extract all of the domestic surplus by offering to sell a quantity given by $\theta_L u'(q_L) = c + t$ for a payment of $T_L = \theta_L u(q_L)$ (these results follow from (8) and (11)). In this case, domestic welfare is given by the tariff revenue: $W = tq_L$. Since tariff revenue is the only source of domestic welfare, the optimal tariff is given by:

$$\frac{\partial W}{\partial t} = q_L + t \frac{\partial q_L}{\partial t} = 0 \quad (17)$$

$$\rightarrow t^* = -\frac{q_L}{\partial q_L / \partial t} > 0 \quad (18)$$

which is the revenue maximizing tariff. A couple of observations are in order. First, the optimal tariff is always positive regardless of the shape of the demand function (this is in contrast to the usual uniform price monopoly result). Of course, this is subject to the second order conditions for a maximum for the domestic government. This condition requires $2 + q_L \frac{u'''(q_L)}{u''(q_L)} > 0$, which is the standard condition required for a uniform price monopolist to maximize profits. In a sense the ability of the monopolist to extract all the rents reverses the usual roles, with the domestic government now the monopoly supplier of market access, with the price of market access given by the tariff. By restricting market access the domestic government is able to increase domestic surplus. Finally, note that the terms of trade effect plays no role in determining the sign of the optimal tax; regardless of the extent of pass through the optimal policy is a tax. This is a direct consequence of the ability of the foreign monopolist to extract all consumer surplus through non-linear pricing, which decouples the link between distortions in quantity consumed and domestic welfare. These results are summarized in the following proposition:

PROPOSITION 1 *If the foreign monopolist has complete information about the preferences of domestic consumers and uses optimal non-linear prices, then the optimal tariff is the revenue maximizing tariff. Moreover, the sign of the optimal tariff is independent of the degree of pass through of the tariff.*

4.2 Optimal tariff when foreign monopolist has incomplete information

The previous subsection considered the operation of trade policy when the foreign monopolist uses non-linear prices under complete information. We now examine the optimal policy when the foreign monopolist is incompletely informed. To help gain insight into the mechanics of the process, we start with a setting where the government can make trade taxes contingent on the volume shipped.

4.3 Quantity dependent trade policy

A feature of the incomplete information pricing policies is that they induce the different types to purchase bundles of different sizes. While it may not be practical to set different rates for the different quantities imported, the consideration of the optimal tax for the high and low quantity is nevertheless revealing since it provides insight into the mechanics of optimal policy choice. In this case the welfare function becomes:

$$W = \beta(\theta_H - \theta_L)u(q_L) + (1 - \beta)t_L q_L + \beta t_H q_H \quad (19)$$

The associated first order conditions are:

$$\frac{\partial W}{\partial t_H} = q_H + t_H \frac{\partial q_H}{\partial t_H} = 0 \quad (20)$$

$$\frac{\partial W}{\partial t_L} = \beta(\theta_H - \theta_L)u'(q_L) \frac{\partial q_L}{\partial t_L} + (1 - \beta) \left(q_L + t_L \frac{\partial q_L}{\partial t_L} \right) = 0 \quad (21)$$

These conditions reveal a number of interesting features. First, despite the presence of incomplete information the first order condition for the optimal tariff on the high quantity is of the same form as (17). In this case, regardless of the distribution of types, the government will always seek to impose the revenue maximizing tariff on the high quantity shipments. This may seem somewhat surprising since the foreign monopolist doesn't capture all the surplus from the high type. On the contrary, the high type is able to capture some of the surplus due to its ability to imitate the low type. It is exactly this aspect that decouples the surplus of a high type from the quantity they consume; an attribute shared with the complete information case. Instead the surplus that a high type captures is a function of the quantity consumed by the low type. Hence, a tariff on the quantity consumed by the high type reduces the quantity they consume but not the surplus they capture, implying that the domestic government should set the revenue maximizing tariff for the high type quantity.

Second, the first order condition for the optimal tariff on the low quantity reflects the same revenue considerations as (17) but also incorporates an addition term reflecting the change in consumer surplus. In this case the government now trades-off the net fiscal implications of a trade tax $(1 - \beta)(q_L + t \frac{\partial q_L}{\partial t_L})$ against the negative consumption distortion associated with a positive tariff $(\beta(\theta_H - \theta_L)u'(q_L) \frac{\partial q_L}{\partial t_L})$. Note in particular that the consumption distortion is experienced by the high valuation type but its magnitude is determined by the quantity response of the low type to a tariff. This is a direct consequence of the incentive compatibility constraint which links the information rents of the high type to the surplus that they can gain from imitating a low type.

The optimal tariffs with incomplete information can be expressed as:

$$t_L^* = \frac{-q_L}{dq_L/dt_L} \left(1 + \frac{\beta(\theta_H - \theta_L)u'(q_L) \frac{dq_L}{dt_L}}{(1 - \beta)q_L} \right) \quad (22)$$

$$t_H^* = \frac{-q_H}{dq_H/dt_H} \quad (23)$$

Unlike the revenue maximizing tariff imposed on the high quantities, the sign of the optimal tariff on the low quantities is no longer unambiguous. In particular, whether it is optimal to tax or subsidize imports depends on the sign of $\left(1 + \frac{\beta(\theta_H - \theta_L)u'(q_L) \frac{dq_L}{dt_L}}{(1 - \beta)q_L} \right)$, which depends directly on the distribution of types. The numerator of the second term reflects the government's desire to move the consumption levels for the low type closer to the efficient level since by doing so it increases the surplus captured by the high types. The denominator reflects the fiscal implications of this policy. It follows directly that the smaller the probability of a low value type (the larger is β), the more likely a subsidy is to be implemented; the cost of a subsidy is diminished while the benefit increases as β increases. The intuition for this connection follows from the impact of a subsidy on the incentive compatibility constraint. A subsidy increases q_L which makes high types more likely to claim to be low types. To counter this the foreign monopolist must allow the high types to capture more surplus. This increase in information rents tends to be relatively big if the probability of a low type is small (which implies that q_L is relatively small and far from the first best quantity).

While these mechanics differ from the standard case with uniform prices, it is of interest to determine whether, nevertheless, the standard logic applies; the sign of the optimal policy can be predicted by the extent of pass through. This is clearly not the case for the optimal policy on the high quantity where there is no role for the terms of trade. To determine whether this result carries over to the optimal policy associated with the low quantity define the average per unit price paid

by the low valuation type as $p_L \equiv \frac{T_L}{q_L}$. Differentiating the average price with respect to the trade tax, t_L gives:

$$\frac{dp_L}{dt_L} = \frac{dT_L}{dt_L} \frac{1}{q_L} - \frac{dq_L}{dt_L} \frac{T_L}{(q_L)^2} \quad (24)$$

Totally differentiating (5) with respect to t_L , gives $\frac{dT_L}{dt_L} = \theta_L u'(q_L) \frac{dq_L}{dt_L}$. Substituting this quantity into (24) and using (5) yields:

$$\frac{dp_L}{dt_L} = \frac{dq_L}{dt_L} \left(u'(q_L) - \frac{u(q_L)}{q_L} \right) \frac{\theta_L}{q_L} \quad (25)$$

This represents the equivalent of the standard terms of trade effect for the low valuation type consumer. Note that as with the standard terms of trade effect, there is a terms of trade benefit if $\frac{dp_L}{dt} < 1$ and a terms of trade loss if $\frac{dp_L}{dt} > 1$. Combining (25) and (31) implies that the optimal tariff can be expressed as:

$$t_L^* = \frac{-q_L}{dq_L/dt} \left(1 - \frac{\beta(\theta_H - \theta_L)}{(1 - \beta)\theta_L} \left(\frac{u'(q_L)}{\frac{u(q_L)}{q_L} - u'(q_L)} \right) \frac{dp_L}{dt_L} \right) \quad (26)$$

Since the coefficient on $\frac{dp_L}{dt_L}$ can be either greater than or less than one, it is possible that the terms of trade effect can be either magnified or muted depending on parameter values. To see this consider the benchmark of the optimal tariff if instead the foreign monopolist uses a uniform price, p^U , to sell an equilibrium quantity, Q^U :

$$t^U = \frac{-Q^U}{dQ^U/dt} \left(1 - \frac{dp^U}{dt} \right) \quad (27)$$

These two expressions ((26) and (27)) share some common features. In both cases the sign of the optimal tariff is determined by the sign of the term in parentheses. However, under a uniform price monopoly the degree of pass through ($\frac{dp^U}{dt} \geq 1$) completely determines whether a subsidy or a tax is imposed at the border. While the extent of pass through also plays a role in determining the optimal policy under non-linear pricing, the impact of a terms of trade effect is now more difficult isolate. A key difference between equations (26) and (27) is the critical role played by the distribution of types in determining the sign of the optimal policy under non-linear pricing. This is highlighted by using

(14) and writing the optimal tariff for the low quantity in the following form:

$$t_L^* = \frac{-q_L}{dq_L/dt_L} \left(1 - \frac{\beta(\theta_H - \theta_L)}{(\theta_L - \beta\theta_H)} \epsilon(q_L) \right) \quad (28)$$

where $\epsilon(q_L) = -\left(\frac{u''(q_L)q_L}{u'(q_L)}\right)$, the elasticity of demand. In this form the role of the distribution of types is most transparent. The more elastic is the demand function, the higher is the fraction of low valuation types in the population that is consistent with an optimal tariff. In contrast, except for its impact on the degree of pass through, the distribution of types plays no direct role in determining the sign of the optimal policy under uniform pricing. This leads to the following proposition:

PROPOSITION 2 *If a foreign monopolist uses an optimal non-linear price schedule to discriminate between domestic consumers, then the optimal tariff on q_H is the revenue maximizing tariff and the optimal tariff on q_L , t_L , can be either positive or negative. However, the optimal t_L is decreasing in the fraction of high types in the population, β , and also decreasing in the elasticity of demand, $\epsilon(q_L)$.*

4.4 Single rate trade policy

While optimal taxes that vary by the quantity shipped offer many insights, they may prove difficult to implement especially since it is possible that small quantities are likely to be subsidized. Consequently a single rate policy is more practical with the associated the objective of the domestic government in this case as follows:

$$\max_t W = \beta(\theta_H - \theta_L)u(q_L) + t((1 - \beta)q_L + \beta q_H) \quad (29)$$

To characterize the optimal tariff, differentiate domestic welfare with respect to the import tax.

$$\frac{\partial W}{\partial t} = \beta(\theta_H - \theta_L)u'(q_L)\frac{\partial q_L}{\partial t} + Q + t\frac{\partial Q}{\partial t} \quad (30)$$

where $Q = (1 - \beta)q_L + \beta q_H$. The structure of this derivative represents the sum of the partials in the quantity dependent case $\left(\frac{\partial W}{\partial t_L} + \frac{\partial W}{\partial t_H}\right)$. Consequently, when evaluated at free trade, this implies that the incentive to subsidize imports in the single rate case is smaller than for the low quantity in the quantity dependent case.

The optimal tariff with incomplete information for the single rate case can be expressed as:

$$\begin{aligned}
t^* &= \frac{-Q}{dQ/dt} \left(1 + \frac{\beta(\theta_H - \theta_L)u'(q_L)\frac{dq_L}{dt}}{Q} \right) \\
&= \frac{-Q}{dQ/dt} \left(1 - \frac{\beta(\theta_H - \theta_L)}{(\theta_L - \beta\theta_H)}\epsilon(q_L)s_L \right)
\end{aligned} \tag{31}$$

where $s_L = \frac{(1-\beta)q_L}{Q}$. As with sign of (28) the sign of (31) depends on the term in parenthesis. However, since $s_L \leq 1$ the range of parameter values that are associated with a subsidy is smaller under a single rate policy than a quantity dependent policy.

Turning to the role of the terms of trade effect, note that calculations similar to those performed above allow the optimal tariff to be expressed as:

$$t^* = \frac{-Q}{dQ/dt} \left(1 - \frac{\beta q_L (\theta_H - \theta_L)}{Q \theta_L} \left(\frac{u'(q_L)}{\frac{u(q_L)}{q_L} - u'(q_L)} \right) \frac{dp_L}{dt} \right) \tag{32}$$

Since the terms of trade effect interacts with various parameters in the model, no general characterization of its role in determining optimal trade policy is possible. However, by holding preferences constant, we can make progress by considering the interaction of the terms of trade with the distribution of types.

To sharpen our understanding of the relative importance of these influences we analyze two standard demand functions, linear and constant elasticity. These demand functions are particularly interesting to study since they predict that the opposite trade policy (subsidy/tax) will be implemented in a uniform price setting as they generate different predictions about the terms of trade impact of a tariff. In the case of a linear demand curve, a tax is always optimal while under a constant elasticity demand curve a subsidy is optimal. Therefore, it is of interest to examine whether these stark predictions carry over to the non-linear pricing setting.

5 Two Common Preference Specifications

To gain insight into the relative importance of the terms of trade effect versus the distribution of types for the determination of the optimal trade policy we begin with an example where the optimal trade tax is always positive under uniform pricing and ask the question whether this also holds for non-linear pricing. Assume that $\theta_i u(q) = \theta_i (q - \frac{q^2}{2})$, which implies $\theta_i u'(q) = 1 - q$. With this

preference structure, the profit maximizing quantities are $q_L = 1 - \frac{(1-\beta)(c+t)}{\theta_L - \beta\theta_H}$ and $q_H = 1 - \frac{c+t}{\theta_H}$. To determine the nature of the terms of trade effect, evaluate (25) to get $\frac{dp_L}{dt} = \frac{\theta_L(1-\beta)}{2(\theta_L - \beta\theta_H)} \geq 1$. In contrast to the uniform price result, the qualitative nature of the terms of trade effect is ambiguous, increasing from $\frac{1}{2}$ when $\beta = 0$ to be greater than one if $\frac{\theta_L}{2\theta_H} < \beta < \frac{\theta_L - c}{\theta_H - c}$. To avoid checking cumbersome constraints, assume $\theta_L = 2$, $\theta_H = 3$, $c = \frac{1}{3}$ and $\beta \in [0, \frac{5}{8})$. These parameters ensure that $q_L > 0$ and that pass through can be more than complete. In this context, the following correlation holds between the extent of pass through and the optimal tariffs:

$$\begin{aligned} \left. \frac{\partial p_L}{\partial t} \right|_{\beta=0} &< 1 & \text{and} & \quad t^* > 0 \\ \left. \frac{\partial p_L}{\partial t} \right|_{\beta \rightarrow \frac{5}{8}} &> 1 & \text{and} & \quad t^* < 0 \end{aligned}$$

Although this correlation is exactly what would emerge under the standard terms of trade logic, the underlying mechanics are very different. When $\beta = 0$ there is only one type of consumer, low types, and therefore the monopolist has complete information and can extract all consumer surplus by offering an efficient quantity to the low type. It follows from the results of section 4.1 that the terms of trade plays no role and the optimal tariff is positive regardless of the extent of pass through. In contrast, as $\beta \rightarrow \frac{5}{8}$, the quantity bundle offered to the low type approaches zero. As with the case where $\beta = 0$ the foreign monopolist can extract all of the domestic surplus from consumption, though unlike section 4.1 total production is not equal to the efficient level. Whether or not a tax or a subsidy is optimal depends on the trade-off between the change in information rents and the fiscal cost of the trade policy. Under the parameters chosen, the trade-off yields a subsidy, in part because pass through is more than complete. However, the terms of trade logic should not be over-emphasized. To see this consider what happens when there is no terms of trade effect, $\left. \frac{\partial p_L}{\partial t} \right|_{\beta=\frac{1}{2}} = 1$. In this case the optimal tariff is positive, $t^* > 0$, and therefore by continuity the optimal tariff can be positive even when pass through is more than complete. Thus in comparison to uniform pricing in the presence of a linear demand curve, non-linear pricing results in a more varied pass through effect and a richer optimal tariff response.

The intuition for how trade policy responds to changes in the distribution of types is clarified in the Figures 2 and 3. As in figure 1 the graphs depict the demand curve for each type and the quantity chosen. Figure 2 illustrates the impact of a small tariff if the fraction of high types in the population is relatively small. In this case, the decrease in information rents due to the increase in

the tariff is more than compensated by the increase in tariff revenue. This tariff revenue comes from two sources, the imports by the high types and the imports by the low types. For the low types, this is the only source of surplus that is captured by the home country since their participation constraint binds (i.e. $\theta_L u(q_L) = T_L$). Given this trade-off between information rents and tariff revenue, the optimal tariff is positive.

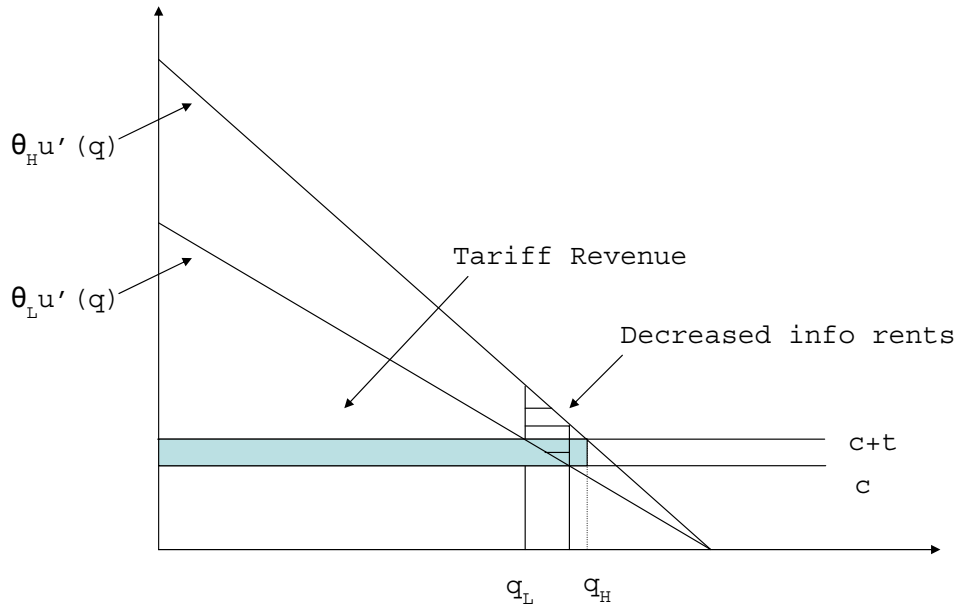


Figure 2: Low proportion of high types

Figure 3 illustrates the case where the fraction of high valuation types is relatively large. In the absence of any tariffs an increase in the fraction of high types reduces the equilibrium consumption of low types, while the equilibrium consumption level of the high types remains unchanged at the first best level. However, the information rents captured by the high types is reduced significantly since they now have less incentive to imitate the low types. This change in the distribution of surplus also impacts the optimal choice of policy. If the distribution is sufficiently weighted toward high types, then the loss of information rents from a positive tariff is now greater than the increase in tariff revenue. This situation is illustrated in Figure 3, and the corresponding optimal policy is to subsidize imports, consistent with the example above.

While the differences between the optimal policy in the two pricing scenarios (linear pricing and non-linear pricing) are very stark in the case of a linear demand function, they become even more

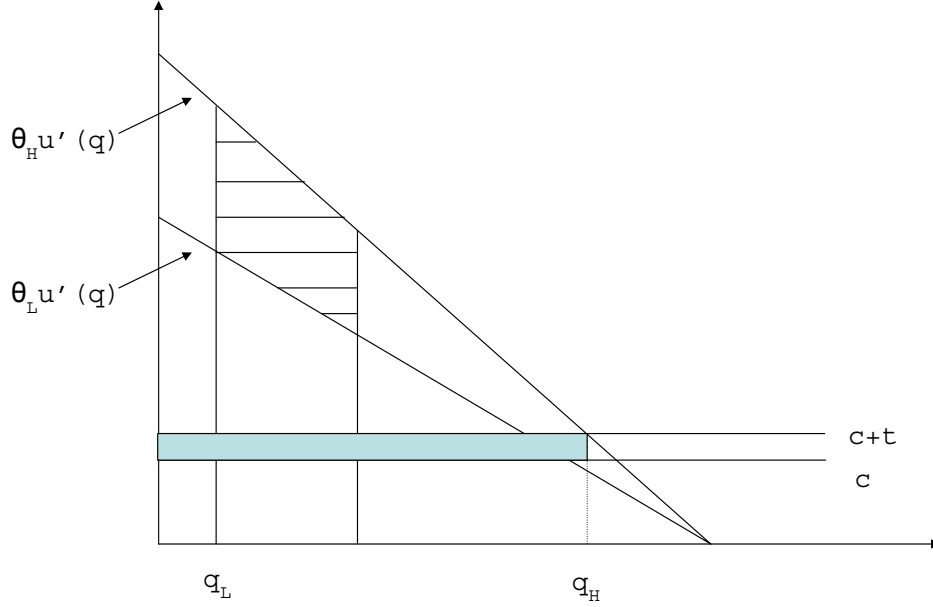


Figure 3: High proportion of high types

pronounced if the demand function has a constant elasticity. Such a demand curve is derived from a utility function of the following form, $\theta u(q) = \theta \frac{q^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}}$, where $0 < \frac{1}{\epsilon} < 1$ is imposed to ensure the utility function is strictly concave. This implies $u' = \theta q^{-\frac{1}{\epsilon}}$ and the profit maximizing quantities are $q_L = \left(\frac{\theta_L - \beta \theta_H}{(1-\beta)(c+t)} \right)^\epsilon$ and $q^H = \left(\frac{\theta_H}{c+t} \right)^\epsilon$. Note that there is always more than complete pass through of the tariff onto the average price of the low type with $\frac{dp_L}{dt} = \frac{(1-\beta)\theta_L}{(\theta_L - \beta\theta_H)(1-\frac{1}{\epsilon})} > 1$ for $\beta \in [0, \frac{\theta_L}{\theta_H}]$.

Such a pronounced terms of trade effect would usually imply that the optimal trade tax is negative. However, this logic is flawed when the monopolist uses non-linear prices. To see this evaluate (31) for the CES case:

$$t^* = \frac{-Q}{dQ/dt} \left(1 - \frac{\beta(\theta_H - \theta_L)}{(\theta_L - \beta\theta_H)} s_L \epsilon \right)$$

Therefore, whenever $\beta < \frac{\theta_L}{\theta_H + (\theta_H - \theta_L) s_L \epsilon}$ the optimal tariff is positive under non-linear pricing with a constant elasticity demand curve, exactly the opposite of the result under a uniform price, which is a subsidy!¹⁶ The intuition is similar to that of the linear demand function case. When $\beta = 0$, it

¹⁶ Helpman and Krugman (1989) also consider a case where the optimal tariff is not based on a terms of trade benefit. Their model assumes quasi-linear preferences with the non-numeraire sector consisting of differentiated goods produced by monopolistically competitive firms. The terms of trade motivation is removed by assuming that both the CRS numeraire and the differentiated good are produced using the same factor of production (though the fixed cost for the differentiated good requires a unique inelastically supplied input, which also pins down the number of varieties).

is optimal to tax regardless of the extent of pass through. However, as $\beta \rightarrow \frac{\theta_L}{\theta_H}$ and $q_L \rightarrow 0$, the optimal policy is to apply a subsidy. Consequently, even though the pass through of the trade tax is always more than complete, the optimal policy can be either a tax or a subsidy, with the nature of the optimum determined by the distribution of types in the population.

Together these examples show that the terms of trade effect is neither a necessary nor sufficient condition for trade policy intervention in the presence of a non-linear price foreign monopoly. Instead it is the distribution of valuations within the population that is the critical factor.

PROPOSITION 3 *When a foreign monopolist uses an optimal non-linear price schedule to discriminate between domestic consumers, then the optimal tariff on Q can be either positive or negative. In this setting knowledge of the extent of pass through is not sufficient to know the sign of the optimal tariff. However, the optimal tariff is decreasing in the fraction of high types in the population, β , decreasing in the elasticity of demand, $\epsilon(q_L)$ and decreasing in the low types consumption share of output, s_L .*

6 Product Quality and Ad Valorem Tariffs

The analysis so far has considered the case of a homogeneous product that is sold to different types at different average prices. This requires that resale opportunities are restricted. While there are products where this property is a reasonable assumption primarily due to transaction costs involved (e.g. most people don't buy the larger quantity of soft drink in order to gain a quantity discount and then attempt to find another consumer to share both the drink and the expense), it may seem more natural to consider products that differ in quality. Such products have the property that they typically can't be divided for arbitrage purposes (e.g. the price of a 40 inch TV might be less than double the price of 20 inch TV, but you cannot divide a 40 inch screen in half to get two 20 inch screens). Adopting this interpretation requires very little change to the analysis of the decisions by consumers and the foreign monopolist. In this case, a consumer would like to buy one unit of a product and the variable q indexes the quality of the product. Similarly the foreign monopolist now chooses the quality that it provides to each type rather than the quantity. However, the representation of trade policy is altered by a quality interpretation. In particular, if specific

Given this setup the optimal tariff is positive for second best reasons, domestic production of the differentiated sector is too small since price is greater than marginal cost. Since a tariff is associated with an expenditure switch toward domestic production, the optimal tariff is positive. However, the optimal policy is to subsidize consumption of domestic production.

tariffs are applied they are based on the quantity imported, which is one unit regardless of quality. Consequently, ad valorem tariffs that are based on the value of the imports are a more natural instrument to consider. To see how this changes the analysis, let τ denote the ad valorem tariff rate. In this case the objective function of the foreign monopolist and the resulting first order conditions can be expressed as:

$$\max_{q_L, q_H} \Pi = \beta((1 - \tau)[\theta_H u(q_H) - \theta_H u(q_L) + \theta_L u(q_L)] - cq_H) + (1 - \beta)((1 - \tau)[\theta_L u(q_L)] - cq_L) \quad (33)$$

Taking first order conditions gives:

$$\begin{aligned} \frac{\partial \Pi}{\partial q_L} &= \beta(1 - \tau)(\theta_H - \theta_L)u'(q_L) - ((1 - \tau)\theta_L u'(q_L) - c)(1 - \beta) = 0 \\ &\Rightarrow (\theta_L - \beta\theta_H)u'(q_L) - \frac{(1 - \beta)c}{(1 - \tau)} = 0 \end{aligned} \quad (34)$$

$$\frac{\partial \Pi}{\partial q_H} = \theta_H u'(q_H) - \frac{c}{(1 - \tau)} = 0 \quad (35)$$

Once again the high type is offered an efficient quality, conditional on the tariff, while the low type is offered an inefficiently low quality good.

With an ad valorem tariff the government's objective function becomes:

$$\max_{\tau} W = \beta(\theta_H - \theta_L)u(q_L) + \tau((1 - \beta)T_L + \beta T_H) \quad (36)$$

To characterize the optimal tariff, differentiate domestic welfare with respect to the import tax.

$$\frac{\partial W}{\partial \tau} = \beta(\theta_H - \theta_L)u'(q_L)\frac{\partial q_L}{\partial \tau} + T + \tau T' = 0 \quad (37)$$

where $T = (1 - \beta)T_L + \beta T_H$ and $T' = \beta \frac{\partial T_H}{\partial q_L} \frac{\partial q_L}{\partial \tau} + (1 - \beta) \frac{\partial T_L}{\partial q_L} \frac{\partial q_L}{\partial \tau} < 0$.

Solving for the optimal ad valorem tariff yields:

$$\begin{aligned} \tau^* &= \frac{-T}{T'} \left(1 + \frac{\beta(\theta_H - \theta_L)u'(q_L)\frac{\partial q_L}{\partial \tau}}{T} \right) \\ &= \frac{-T}{T'} \left(1 - \frac{\beta(\theta_H - \theta_L)u'(q_L)}{T} \frac{q_L}{(1 - \tau)} \epsilon(q_L) \right) \end{aligned} \quad (38)$$

Once again the sign of the optimal ad valorem tariff depends on the distribution of types. When $\beta = 0$ the optimal tariff is a tax and coincides with the revenue maximizing ad valorem rate. However

as $\beta \rightarrow \frac{\theta_L}{\theta_H}$, the optimal rate declines and a subsidy becomes more likely. To see the role for the terms of trade note that the optimal tariff can be written as:

$$\tau^* = \frac{-T}{T'} \left(1 + \frac{\beta(\theta_H - \theta_L)}{\theta_L} \left(\frac{u'(q_L)}{\frac{u(q_L)}{q_L} - u'(q_L)} \right) \frac{q_L}{T} \frac{\partial p_L}{\partial \tau} \right)$$

Thus, the size of the terms of trade effect is not a sufficient static in determining the nature of the optimal tariff. Furthermore, under a uniform price monopoly, the optimal tariff is non-negative for any demand function that is less convex than a constant elasticity demand curve. In fact, for the constant elasticity of demand case, the optimal ad valorem tariff is zero. The constant elasticity case serves as a useful benchmark and leads to the following proposition:

PROPOSITION 4 *If a foreign monopolist uses an optimal non-linear price schedule to discriminate between domestic consumers, and the domestic demand curves have a constant elasticity, then the optimal ad valorem tariff is positive for β close to zero and negative for β sufficiently close to $\frac{\theta_L}{\theta_H}$. This contrasts with the optimal ad valorem policy when facing a uniform price foreign monopolist which is free trade.*

7 Conclusion

While the practice of non-linear pricing is well documented in domestic models of industrial organization, the implications of such techniques for international transactions are relatively unexplored. This paper represents an attempt to fill this gap. It finds that the calculus of welfare maximization is very different when the foreign monopolist implements second degree price discrimination. While there are still terms of trade effects from the imposition of a tariff, the existence of such effects are neither necessary nor sufficient for the government to intervene. Instead the distribution of valuations across the population is the key determinant of the nature of policy intervention. If there is a relatively large fraction of high types in the population, then domestic information rents can be increased substantially by subsidizing imports thereby increasing the consumption of the low valuation types and moving the incentive constraint in favor of the high valuation types. However, if the fraction of high types is relatively small then the increase in information rents will also be small but the fiscal implications of a subsidy will be large. Consequently, the optimal policy will be to impose a trade tax.

This difference in motivation for trade policy also has implications for the design of trade agreements. While it is true that a trade tax imposes a dead weight loss from a global perspective, an import subsidy may actually improve global welfare. This differs from the standard prisoners dilemma that analysis of trade agreements are based on. The implications of this observation will be pursued in future research.

Another avenue to explore is the incentives to undertake FDI for a discriminating foreign monopoly, especially in the context of quality discrimination. The conditions for Proposition 4 provide a neat perspective from which to consider these incentives. If the foreign monopolist employs linear prices, then the optimal policy is free trade and the foreign monopolist has no incentive to consider a strategy of FDI. However, with non-linear prices the optimal policy is not free trade, and the foreign monopolist may consider jumping the trade policy. If it does consider the option of FDI the quality discrimination scenario raises a new twist on the standard tariff jumping model since the foreign monopolist has a choice of whether or not to relocate both the high and low quality production lines or just one of the production lines. If only one production line is relocated, which will it be?

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A Robust Regression results

Due to the possibility of outliers generated by reporting errors, the following table reports results from robust regression. The qualitative results are confirmed; quantity discounts are associated with greater differentiation of goods.

Table 4: Robust Regression Estimates

	CRT Monitors	White Shirts	Fuel Oil
$\ln(Q_{spm})$	-0.091*** (0.003)	-0.041*** (0.002)	-0.0014 (0.006)
$\ln(Q_{sm})$	-0.024 (0.02)	-0.026*** (0.007)	-0.014 (0.01)
$\ln(\text{distance})$	-0.011 (0.03)	-0.0041 (0.02)	-0.057*** (0.008)
Observations	3677	5381	670
R^2	0.78	0.78	0.51

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Estimates include separate Exporter and Month fixed effects

B Results by mode of shipment

The trade data can be further disaggregated to consider mode of transportation. There are two possible categories, air or sea. Since the number of units is not available, but weight is recorded, the price to weight ratios are constructed. The analogues of Tables 2 and 3 are reported below for each product by each mode of transportation.¹⁷ Once again the main result of quantity discounts is a robust result across all specifications.

Table 5: OLS Price to weight ratio across Ports - Air

	CRT Monitors	White Shirts
$\ln(Q_{spm}^{air})$	-0.29*** (0.01)	-0.11*** (0.01)
$\ln(Q_{spm})$	-0.019 (0.03)	-0.039* (0.02)
$\ln(\text{distance})$	-0.38*** (0.1)	-0.055 (0.09)
Observations	1892	2727
R ²	0.52	0.69

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Estimates include separate Exporter and Month fixed effects

Table 6: OLS Price to weight ratio across Ports - Sea

	CRT Monitors	White Shirts
$\ln(Q_{spm}^{sea})$	-0.073*** (0.02)	-0.093*** (0.01)
$\ln(Q_{sm})$	-0.079 (0.06)	-0.034 (0.03)
$\ln(\text{distance})$	-0.42** (0.2)	-0.19* (0.10)
Observations	1551	3028
R ²	0.46	0.50

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Estimates include separate Exporter and Month fixed effects

¹⁷Naturally air shipments do not occur in fuel oil.

Table 7: OLS Price to weight ratio within Ports - Air

	CRT Monitors	White Shirts
$\ln(Q_{spm}^{air})$	-0.29*** (0.01)	-0.14*** (0.02)
$\ln(Q_{spm})$	-0.0073 (0.02)	0.012 (0.02)
Observations	1892	2727
R ²	0.67	0.83

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Estimates include Month and Exporter*Customs_District Fixed Effects

Table 8: OLS Price to weight ratio within Ports - Sea

	CRT Monitors	White Shirts
$\ln(Q_{spm}^{sea})$	-0.079*** (0.03)	-0.065*** (0.01)
$\ln(Q_{sm})$	-0.0085 (0.05)	-0.023 (0.03)
Observations	1551	3028
R ²	0.61	0.70

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Estimates include Month and Exporter*Customs_District Fixed Effects