Product Proliferation and Differentiation in Export Markets

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Abstract

Multiproduct firms often export only a portion of their available product range to any given market. This paper analyzes and empirically tests a multi-product, multinational firm’s export decisions about product proliferation and differentiation. It considers a duopoly where the multiproduct firm chooses whether to export one or both of its quality levels. The firm must choose from its existing qualities, reflecting the notion that exporting firms do not design distinct products for individual export markets but rather choose products for export from an existing portfolio. Firms choose their products for export in Stage 1 of the game and compete in prices in Stage 2. Solving for the subgame perfect Nash equilibrium reveals that product proliferation is profitable if tariffs are low enough and quality differentiation is not too large. The degree of quality differentiation determines whether the multiproduct firm benefits from exporting a “buffer product,” which is closer in quality to the competitor’s product but earns low profit margins. If quality gaps are small, then the buffer product protects the firm’s other product from the most intense price competition. However, if quality gaps are large, then price competition is not intense enough to warrant the use of a buffer product. Lower tariffs make the multi-product firm more competitive and enhance the impact of the buffer product, enabling it to steal more market share from the competitor’s product while the protected product earns a particularly high per-unit profit due to the low tariff. Data from the Mexican auto market, which saw trade liberalization due to free trade agreements starting in the mid-1990s, provides empirical support for the relationship between lower tariffs and product proliferation. JEL: F12, L13 Keywords: product differentiation, export product choice, multi-product firms

1 Introduction

Multinational firms are also typically multiproduct firms: Bernard et al. (2007) document that in 2000, U.S. firms exporting more than five products accounted for 98 percent of export value. And even though
these firms accounted for only 25.9 percent of exporting firms in the U.S., more than half of exporting firms exported more than one product. Firms also frequently offer many quality levels of any given product. The auto industry offers numerous examples. For instance, there are three different trim levels of the Honda Civic available, with the more expensive versions offering more options such as navigation systems, satellite radio, etc. The BMW 3 Series is available with multiple engines and in four different body styles (sedan, wagon, convertible, and coupe). The practice is common throughout the industry: different engines consume different types of fuel and provide varying amounts of torque and horsepower, different trims include varying options, and different body styles provide varying levels of convenience and capacity.

While multinational firms often export multiple products or versions of the same product, the range of products available is often bigger than what is sold in any single export market. For example, automobile manufacturers often sell only cars with large, powerful engines and automatic transmissions in Mexico while they sell cars with smaller, often diesel, engines in Europe. Similarly, not all car models from any given manufacturer, or all trims of any given car model, are sold in the United States. In 2009, for example, three Honda Civic models were sold in the U.S. (the DX, LX, and EX trims) but only two were sold in Mexico (EX and LX only). In the same year, there was little overlap in the versions of the BMW 5 Series that were sold in Mexico and the U.S.: the 528, the 535, and the 550 were sold in the U.S., while consumers in Mexico could choose instead from the 525, the 530, and the 550. Consumers in England, however, could choose from six different versions of the BMW 5 Series (the 520, 523, 525, 530, 540, and 550). Kitchen appliances also come in multiple quality levels, as do computers, power tools, and stereo equipment, and typically only a portion of those available versions are exported to any given market.

Firms may limit the product range available in a given market for a number of reasons. A particular market might be too small to support the full range of varieties and qualities; consumers may be unable to afford the highest quality levels available if income levels are low; or high income levels may eliminate the need for the lowest quality products. Given the market conditions, a firm must determine how many versions of each product to export to a particular market as well as which specific versions to export.

As Figure 1 suggests, tariff levels may also affect these decisions: if high tariff levels effectively limit demand for a firm’s goods, the firm may export only one version, or one quality level, of the product. High tariffs may reduce demand to the extent that segmentation of customers is not profitable. Lower tariffs, on the other hand, may leave enough room for product proliferation.

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1 Occasionally, a make or model will be renamed for sale in a foreign country without any substantive changes to the product itself. These are not considered different products.
2 These were just the petrol engines; there were an additional 4 diesel versions available.
3 These examples are consistent with the finding in Hummels and Klenow (2005) that each country exports to only a subset of countries, which seems to suggest that a firm does not export all its products to every market but rather that it chooses the countries to which it exports each version of a product.
In addition to its own tariffs, a firm will also naturally consider the characteristics and prices of competing products when deciding on the number of versions for a given market. These may alter the firm’s calculus: if the competitor offers a product that is close in quality to one of the firm’s own versions, the firm may opt to export only one version (the one further in quality from the competitor’s product) in order to reduce the intensity of competition.

This paper focuses on an exporting firm’s choice of how many and which quality levels to export to a specific market. It specifically addresses the question of whether lower tariffs make quality discrimination profitable for the firm in the presence of competition from another firm’s product. That is, if the importing country reduces the tariff rate, does a firm react with product proliferation?

The model is formally close to Neven and Thisse (1990), who analyze a duopoly where products are both horizontally and vertically differentiated. They find that, when firms simultaneously and endogenously choose both their variety and quality characteristics, firms will either differentiate maximally along the vertical (quality) dimension and not at all along the horizontal (variety) dimension, or vice versa. Gilbert and Matutes (1993) use a similar setup to study an oligopoly with differentiation in two dimensions. In contrast to Neven and Thisse (1990), however, they allow each firm to produce up to two vertically differentiated products, but they assume that the firms are symmetric and that production exhibits economies of scope. The current model also incorporates both vertical and horizontal differentiation but assumes that the available variety and quality levels are discrete and finite. The endogenous choice of quality and variety from a continuum are more relevant to large (including world-wide) markets, while the choice from an existing...
produc
t line is more appropriate to small mark
et s. Rather than choosing the quality level from a continuous
range, the firm chooses which of the set of available, discrete quality levels to sell. The difference is one
of long-term versus a medium-term analysis: in the long run, firms can adjust the quality of each product
by making investments in research, development, and design activities. In the medium term, however, the
firm’s investment is fixed. Instead, it chooses which products to sell in each market, and then sets a price
for each product.

Product differentiation has been a central theme of the trade literature since Krugman (1979, 1980).
His seminal papers show that, in a model with economies of scale, gains from trade accrue from both
increased choice for consumers (i.e. from horizontal differentiation) and an increase in real wages due to
increased production. Flan and Helpman (1987), on the other hand, consider the role of quality (vertical
differentiation) in trade, specifically in north-south trade. These early papers were focused on the existence
of intra-industry trade, and product differentiation was considered primarily for its role in causing such
trade. Indeed, Krugman (1979) notes that "it is indeterminate which n goods are produced, but it is also
unimportant, since the goods enter into utility and cost symmetrically," and further that "the direction
of trade—which country exports which goods—is indeterminate." The goods are simply differentiated; their
particular characteristics are not known.

It is exactly the specific goods and their characteristics at which a separate branch of the literature aims.
Also in 1979, the same year that Krugman’s seminal paper was published, Falvey studied the effects of trade
policies (quotas, specific tariffs, and ad valorem tariffs) on the quality of imports. He found that a quota or
a specific tariff works through the demand side to shift the composition of imports toward the high-quality
good, while the ad valorem tariff reduces total imports but not their composition. A number of subsequent
papers considered various permutations of this question, analyzing the effects of quotas and other trade
policies on the quality level of imports (see Krishna, 1987; Das and Donnenfeld, 1987; Das and Donnenfeld,
1989; Krishna, 1990a; and Schmitt, 1995, among others; Zhou et al., 2002, consider strategic policies that
target the quality of exports). Feenstra (1988) lends empirical support to these models with his finding that
U.S. quotas and Japanese voluntary export restraints resulted in quality upgrading of Japanese auto exports
to the United States. Beard and Thompson (2003) model horizontal instead of vertical differentiation, and
find that quotas may cause a relative but not an absolute increase in the quality of imports. Recent work

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4In their analysis, intra-industry trade is a consequence of high-income consumers’ preferences for high-quality goods and
northern firms’ ability to produce the high-quality good.
5In contrast to Krugman’s papers, the analysis is at a partial equilibrium level.
6This result comes directly from the assumption that world prices remain constant. Imposing a quota or a specific tariff
lowers the relative price of the high-quality import and therefore shifts the composition of imports toward that good.
7The quality increase in Feenstra works through the cost side, in contrast to many of the theoretical papers in which quality
increases in response to demand.
8See Krishna (1990b) for a survey of the early works on this topic. Herguera and Lutz (1998) review the literature on
the effects of trade policy on quality leapfrogging and conclude that results depend critically on assumptions about cost and
on this theme includes Moraga-Gonzáles and Viaene (2005), in which a small tariff on the imported high-quality good combined with a small subsidy to the low-quality domestic producer results in a reduction of the quality gap between imports and domestically produced products, and McCalman (2010), which analyzes the optimal tariff when a foreign monopolist engages in second-degree price discrimination.

This body of trade literature is concerned with product differentiation and focuses directly on the firm’s decisions about product differentiation in response to trade policies. In an attempt to resolve some of the indeterminacy, noted by Krugman, about which firms export which products with which characteristics, the literature combines the strategic interaction models of industrial organization with trade policy in order to identify the quality levels of products that are traded. The papers vary in their assumptions about the number of firms (monopoly or duopoly), costs (symmetric or asymmetric), and the type of differentiation (vertical or horizontal). But they all have in common that they focus on the development and design stage of production, with firms choosing the characteristic of the product in a single dimension of differentiation. In addition, those papers that analyze a duopoly consider only single-product firms. This paper, on the other hand, allows for differentiation in two dimensions and considers a duopoly where one of the firms is a multiproduct firm. Critically, the multiproduct firm is no longer choosing the characteristics of its products, but rather is choosing how many products to export to a given market.

The current analysis is therefore also related to the product line rivalry literature, and in particular its focus on product selection by multiproduct firms. Brander and Eaton (1984) use the terms “market segmentation” and “market interlacing” to describe the potential configurations of firms in a duopoly in which each firm produces two horizontally differentiated products. They focus on a case in which each firm chooses a pair of products (out of four available products) to produce and then competes in quantities; both segmentation and interlacing are possible outcomes, although the latter is excluded if product line choices are sequential rather than simultaneous. If the decision of how many products to produce is endogenized, as in Martinez-Giralt and Neven (1988), then firms choose to produce only one horizontally differentiated product each rather than two in order to relax price competition. And when the model is modified to allow for asymmetric costs, then interlacing is also an equilibrium outcome even when firms choose product lines sequentially (Chen and Chen (2011)).

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9 This literature naturally overlaps with the strategic trade policy literature.
10 This is distinct from the multiproduct firms literature that focuses on economies of scope; I abstract from economies of scope.
11 Market segmentation describes the case when a firm’s products are close substitutes for each other but not for the rival firm’s products; market interlacing describes the reverse, when the firm’s products are close substitutes for the rival’s products but not for each other.
12 In a note on the paper, Wernerfelt (1986) finds that if fixed costs are high firms will offer only one product each. Whether the products are differentiated or standardized depends on the degree of homogeneity of consumer tastes.
13 This result holds for both a Hotelling model and a circle model. In contrast, Verboven (1999) considers a symmetric duopoly where each firm offers both a high-quality and a low-quality product.
14 See also Canoy and Peitz (1997) for a model with asymmetries among firms: there are two high-quality goods that are
In a recent development that combines these two strands of inquiry, Bernard, Redding, and Schott (2011) develop a model of multiproduct firms that trade internationally.\textsuperscript{15} They find that there is a correlation between the intensive and extensive export margins. Firms with more ability have both greater product scope and export more of any given product. As a result of trade liberalization, firms drop the products in which they have the least expertise, so that trade liberalization reduces product scope but increases average expertise.\textsuperscript{16} Their paper thus considers the impact of trade policy on the number of products sold by the multiproduct, multinational firm (product scope).

One of the key contributions of this paper is its focus on the question of how many versions of a product the multinational corporation chooses to export. Rather than assuming a single product, it allows the firm to choose not only which product it exports (from the given available set of products), but critically how many products it chooses to export. The firm chooses what to export in two dimensions: the number of products (product proliferation), and the type of products (product differentiation). This is in contrast, for example, to Neven and Thisse (1990) in which the two dimensions of choice are both regarding product differentiation. It analyzes this question using a duopoly model where one of the competitors is a multiproduct firm. Products are differentiated in two dimensions, variety and quality. The variety and the available levels of quality are exogenous to the model, representing the notion that multinational firms often choose which versions (qualities) to export to a given market from their existing product portfolios rather than developing a new product quality for each export market.\textsuperscript{17} One of the firms has three possible strategies: export only its lower quality product, export only its higher quality product, or export both products. The central question is whether, as the tariff rate falls, the firm continues to sell only one of its quality levels or chooses instead to export both of them (in the model the firm has only two available quality levels).

The multiproduct firm's optimal strategy depends on multiple factors, including the relative ordering of quality levels, the distance between both quality levels and varieties, the size of the tariff preference, the size of the tariff itself, and the cost of quality. Under some conditions, as tariffs fall the two-quality strategy profits grow faster than the single-quality strategy profits. If tariffs far fall enough, profits under the two-quality strategy overtake those under the single-quality strategy, and the firm chooses to export both of its

\textsuperscript{15}Firms are heterogeneous in two dimensions, ability and product expertise.
\textsuperscript{16}Ries (1993) also considers multiproduct firms. The firms compete in quantity, have asymmetric cost functions, and produce all products that are profitable. Under quantity constraints, he finds that the firm initially producing the lower quality goods has no incentive to upgrade quality; it may, however, be optimal for both firms to produce a lower quality than prior to the imposition of a quantity constraint. Although this finding contradicts the quality-upgrading results of many single-good firm models, it does still find that quantity constraints may lead to an adjustment in the quality of goods being produced.
\textsuperscript{17}While the central question is similar to one of the questions in Bernard et al. (2011), the approach is quite different. Bernard et al. consider only horizontal differentiation of products; a second dimension of differentiation is in the ability or productivity of firms. The firms also produce a continuum of products, so that the average variety is increased with trade liberalization. Furthermore, consumers in Bernard et al. have CES preferences and buy more than one good in a given industry. Products in the present model are differentiated in both variety and quality, consumers purchase only one good (e.g. consumer durables), and the products are discrete. Trade liberalization may lead to an increase or a decrease in the average quality of products, depending on the ordering of product qualities.
quality levels, instituting quality discrimination among its own customers.

Analysis of the model shows that if the firm’s available quality levels are close enough to each other and to the quality level of the competing product, then as tariffs fall the firm benefits from selling both of its quality levels. In this case, the product that is closer in quality to the competitor’s product acts as a competition buffer for the firm’s other product (the one that is further in quality from the competitor’s product). However, if the gap between the quality level of the firm’s own products and that of its competitor is too large, then this buffer product is not necessary. If the firm chooses to introduce a buffer product to the market, the buffer will compete for market share not only with the competitor’s product but also with the firm’s other product. When qualities are close, the beneficial buffer effect outweighs the harmful effect of intra-firm competition. When quality levels are too far apart, competition is weak and the firm is better off selling just one of its products rather than introducing the buffer product. The buffer effect is minimal; instead, the primary impact of the buffer product is to steal market share from the product that it is supposed to protect from competition.

In order for profits from the two-quality strategy to exceed those of the single-quality strategy as the tariff falls, the firm’s tariff rate must also be lower than its competitor’s. If the firm is at a tariff disadvantage, then a decrease in the tariff-inclusive consumer price will increase market share only a little. The product is competitively disadvantaged because it is still subject to a relatively high tariff. If the firm has a tariff advantage, however, as its tariff falls further, the tariff-inclusive price (paid by consumers) is not only lower than it was at a higher tariff rate, is also has a competitive advantage due to the lower tariff rate. This allows the firm’s combined market share to increase fast enough for profits from the two-quality strategy to outpace profits from the one-quality strategy. In this case, then, when the firm has a tariff advantage and needs a buffer product, as tariffs fall the firm will choose to export both of its quality levels.

Data from the Mexican auto market provides empirical support for the hypothesis that trade liberalization induces product proliferation. Using two different measures of the proliferation of quality levels at the make-model-year level, tariffs have an economically and statistically significant effect on the number of versions of a product that are offered for sale. Evidence on the effect of quality differentiation on product proliferation is mixed. While the effect of some quality measures (horsepower and engine size) is significant, other quality attributes (fuel efficiency and physical size) do not have a significant effect on the number of versions offered for sale.

The next section of the paper sets up the oligopoly model. Section 3 analyzes assumptions about demand, and 4 finds the optimal price and product configuration in equilibrium. Section 5 introduces the data and provides background on the automobile market in Mexico. Section 6 presents the results of empirical analysis, and the final section concludes.
2 Oligopoly with Multiple Qualities

There are two firms, \( n = \{1, 2\} \), each producing and exporting a single variety of a product, \( v_n \), where \( v \in [0, 1] \). To simplify, Firm 2 has available only one quality of its product, \( q = q_2 \); the other firm (Firm 1) has available two qualities of its product, \( q_j \in (0, \infty), j = \{h, l : q_h > q_l\} \). The choice of variety and quality levels depends on global market research and product engineering constraints and happens prior to choosing products for each individual export market. Therefore the product varieties and available quality levels are exogenous to the current setup: each firm has a fixed portfolio of products available for production and export.

I assume (without loss of generality) that \( v_1 \leq v_2 \). I also assume that \( q_h > q_l \). This assumption is entirely innocuous, as it simply names Firm 1’s higher quality product \( q_h \). Given these assumptions, there are three possible cases to analyze:

1. Firm 2 produces the highest of the three qualities (\( q_2 > q_h > q_l \), henceforth Case 1),
2. Firm 2 produces the lowest of the three qualities (\( q_h > q_l > q_2 \), henceforth Case 2), or
3. Firm 2 produces the median quality (\( q_h > q_2 > q_l \), henceforth Case 3).

The marginal cost of producing a product, \( c(q) \), is constant in quantity but increasing in quality. Specifically, I assume that the marginal cost is linear in quality, \( c(q_j) = k \times q_j, k > 0 \). Note that the marginal cost is independent of the product variety \( v \). There is also a fixed cost, \( F \geq 0 \), to exporting each quality level of the product. Finally, each product is also subject to \textit{ad valorem} tariffs levied by the importing country, \( t_n, t \geq 0 \). Given the competitive configuration, costs, and tariffs, Firm 1 must decide whether to export one or both of its available qualities to a given market when tariffs are set at \( t_n \).

2.1 Firms

The firms play a 2-stage, non-cooperative game. In Stage 1, each firm chooses its product mix and pays the fixed cost associated with exporting the product. In particular, Firm 1 can choose whether to export one or both of its products to the market in question. In Stage 2, the firms compete in prices. As is typical, the game is solved backwards.

I use the subgame perfect Nash equilibrium solution concept, which entails first finding equilibrium prices in the final stage of the game for any outcome chosen in the first stage: Firm 1 exports only its high quality

\(^{18}\)This parameter represents horizontal differentiation, which allows for product differences that are not ranked in the same order by all consumers. Some consumers may prefer a lower \( v \) (variety) while others will prefer a higher variety. This becomes clear if \( v \) is interpreted as physical location as is standard: consumers naturally prefer the product at a location that is closer to their own. However, in this paper, products are produced in different countries and exported to a third market. In order to avoid confusion with the location of production, I therefore describe \( v \) as the variety of a firm rather than its location.
good, Firm 1 exports only its low quality good, Firm 1 exports both goods, or Firm 1 exports no goods. Since Firm 2 has only one good available, it has only two available strategies: export or don’t export. The equilibrium of the entire game is then the pair of strategies that nets each firm the greatest profit, given the product mix and prices chosen by the other firm. A firm’s strategy, $s_n$, specifies both the products it offers and a price vector for each possible product configuration. Recall that there is a fixed cost to exporting each variety-quality pair. Thus, if Firm 1 exports both of its products, then the variable profits of doing this must be greater than the variable profit of selling just one product by more than the fixed cost of exporting the additional product.

This paper focuses only on those equilibria in which each firm exports at least one product. This means that Firm 2 always exports its product, and there are three feasible choices of product for Firm 1: export only its high quality good, export only its low quality good, or export both its high and low quality goods.

2.1.1 Equilibrium Prices and Profits

Each variety-quality combination that is exported to the foreign market generates some profit for the firm. The profits generated by a product of variety $n$ and quality $j$ are given by $\pi_{n,j} = [p_j - c_j] \times D_{n,j}(p_j, p_{-j}, q_j, q_{-j}, v_n, v_{-n}, t_j, t_{-j}) - F$, where $D_{n,j}$ is the demand for the good with variety $v_n$ and quality $q_j$ and depends on the characteristics of other products. $F$ is the fixed cost of exporting an additional quality level of the product.

The variable profits for each firm are given by the profit per unit times the demand for the product. The profit per unit is the price set by the firm less the cost of producing a single unit (recall that cost is constant in quantity but increasing in quality). Demand for a particular product quality depends on the price set by the firm for that quality, the tariff rate, the prices and tariff rates of products with adjacent qualities, and the difference between the quality of the product and the quality of adjacent products.

In stage 2, given the products that are available, each firm chooses its price(s) in order to maximize variable profits, taking the other firm’s prices as fixed and its own fixed costs as sunk:

$$\max_{p_{j,i} \in J} \sum_{j \in J} [p_j - c_j] \times D_{n,j}(p_j, p_{-j}, q_j, q_{-j}, v_n, v_{-n}, t_j, t_{-j}),$$

where $J$ is the set of qualities that the firm has chosen to export.

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19Formally, Firm 1’s strategy set is $\{h, l, hl, 0\} \times \{p_1(\cdot) : \{h, l, hl, 0\} \times \{2, 0\} \rightarrow [0, \infty)^g, g \in \{0, 1, 2\}\}$ and Firm 2’s strategy set is $\{2, 0\} \times \{p_2(\cdot) : \{h, l, hl, 0\} \times \{2, 0\} \rightarrow [0, \infty)^h, h \in \{0, 1\}\}$, where $\{p_1(\cdot) : \{h, l, hl, 0\} \times \{2, 0\} \rightarrow [0, \infty]\}$ is the space of functions that map from the products that each firm chooses in Stage 1 to the price for each product.
2.1.2 Firm 1’s Problem

In Stage 1, Firm 1 must decide on its product mix. Its maximization problem in Stage 1 is

\[
\max \left\{ \max_{p_h} (p_h - c_h) \times D_h - F, \max_{p_l} (p_l - c_l) \times D_l - F, \max_{p_h, p_l} (p_h - c_h) \times D_h + (p_l - c_l) \times D_l - 2F \right\}.
\]

As in section 2.1.1, the demand in this problem depends on the quality levels and varieties (which are exogenous and fixed) as well as the firm’s own price and Firm 2’s price, which in turn depends on the product qualities that Firm 1 is selling. Letting \( J \in \{ h, l, hl \} \) be the product quality mixes that are available to Firm 1 and \( \pi(s_n, p, q) \) be the sum of variable profits from selling that product mix at optimal prices. This problem can be rewritten as

\[
\max_{s_1 \in S_1} \pi(s_1, p, q) - F(s_1),
\]

where \( S_1 \) is Firm 1’s strategy set as defined in Section 2.1. This says that Firm 1 will choose the strategy such that the maximum variable profit minus the fixed cost of that strategy is greater than the maximum variable profit minus fixed cost of the other strategies, given the price and quality of the competing product.

2.2 Consumers

The consumer side of the market is as in Neven and Thisse (1990). Consumers in the export market care about both quality and variety. Each consumer is characterized by a pair \((\theta, x)\), where \( \theta \) is the consumer’s valuation of quality and \( x \) is the consumer’s preferred variety. The consumers are distributed in these dimensions uniformly in the unit square. Each consumer, \( i \), gets linear utility

\[
u_{i,j} = \theta_i q_j - (v_n - x_i)^2 - (1 + t_n)p_j + K  
\]

from purchasing a good of quality \( j \) and variety \( n \) at price \( p_j \). Each consumer buys only one good, naturally the good that delivers the greatest net utility given the consumer’s own characteristics and the quality, variety, and price of the available products. \( K \) is a constant assumed to be big enough such that every consumer has positive utility from at least one variety-quality combination (Neven and Thisse 1990).

Given this setup, it is possible to find the quality valuation of the marginal consumer for each pair of goods. That is, for every \( x \) (most preferred variety) I find the \( \theta \) of the consumer who is just indifferent to purchasing the good described by \((v_n, q_j)\) and the one described by \((v_n', q_{j'})\), where \( q_j \) and \( q_{j'} \) are adjacent qualities and \( q_j > q_{j'} \). This valuation is a function of the consumer’s preferred variety \( x \) and is given by the
\[ \theta_{j,j'}(x) = (1 + t_n)p_j - (1 + t_{n'})p_{j'} + v_n^2 - v_{n'}^2 - 2x(v_n - v_{n'}) \]

found by equating the net utility derived by this marginal consumer from each product. The indifferent consumers determine the portion of the unit square of consumers who demand each good (each variety-quality combination). Consumers at \( x \) with \( \theta > \theta_{j,j'}(x) \) will always prefer the higher quality good, \( q_j \), while consumers with \( \theta < \theta_{j,j'}(x) \) will prefer the lower quality good. It should be noted that the marginal consumer need not always exist: it may be the case that all consumers with the same \( x \) prefer one good over the other.\(^{20}\)

### 2.3 Demand

As stated in Section 2.2, the indifferent consumers determine the boundaries of the regions of the unit square that constitute demand for each product being offered. For example, in Case 3 (where \( q_h > q_2 > q_l \)), the consumer with quality valuation \( \theta_{h,2}(x) \) is exactly indifferent between the good of the higher quality and higher price, \( q_h \), and the competing good of lower quality and lower price, \( q_2 \). Of all the consumers with the same variety preference \( x \), those with a higher quality valuation will strictly prefer \( q_h \) while those with a lower quality valuation will strictly prefer \( q_2 \).\(^{21}\) Thus, if the firm chooses to sell only its higher quality product in Case 3 (so that \( q_l \) is not an option), then for any given preferred variety \( x \), demand for each product is as follows:

\[
D_h(x) = 1 - \theta_{h,2}(x) \\
D_2(x) = \theta_{h,2}(x) - 0.
\]

Because consumers are distributed across the entire range of variety preferences, there is an entire set of such indifferent consumers, one at each variety preference \( x \in [0,1] \).\(^{22}\) Integrating demand over the range of consumers’ variety preferences produces total demand for each product across the whole unit square of

\(^{20}\)The constant term in the utility function, which ensures that every consumer buys something, sets up some asymmetric incentives. In general, each producer has opposing incentives with regard to setting the price: a lower price attracts more customers, but a higher price generates more profit per sale. However, in the case when every consumer buys something, the lowest quality good is affected by only one side of this. In particular, if the constant is assumed big enough so that every consumer buys something, then it is guaranteed that the consumers with the lowest quality valuations will purchase the lowest quality good rather than abstaining from any purchase. The firm that produces this product therefore has no incentives to lower its price to attract those customers. In this case, the producer only has an incentive to raise the price in order to increase the profit per sale (as long as the price isn’t so high that the higher quality good is preferred). However, this assumption is made for simplicity. Eliminating it would necessitate finding the consumer who is indifferent between buying the lowest quality good and buying nothing. In this case, some portion of consumers would buy an outside option (e.g., public transportation), significantly complicating the analysis.

\(^{21}\)Naturally, if the qualities are ordered so that \( q_2 > q_h \) as in Case 1, then consumers with higher quality valuations will prefer \( q_2 \) and vice versa.

\(^{22}\)As noted above, it may be the case the the marginal consumers doesn’t exist at some \( x \), so that all consumers with that variety preference prefer either \( q_h \) or \( q_2 \).
consumers (see the left-most graph in Figure 2).23 Letting \( \hat{\theta} = \int_0^1 \theta_{h,2}(x)dx \), demand across all consumers in Case 3 when Firm 1 sells only its high-quality good is then

\[
D_h = 1 - \hat{\theta} = 1 - \frac{(1 + t_1)p_h - (1 + t_2)p_2 + v_2^2 - v_1^2 - v_1 + v_2}{q_h - q_2} \quad \text{and} \quad D_2 = \hat{\theta} = \frac{(1 + t_1)p_h - (1 + t_2)p_2 + v_1^2 - v_2^2 - v_1 + v_2}{q_h - q_2}. \quad (4)
\]

For Case 3 when either both qualities or only the lower quality is sold, demand is similarly derived. Thus, defining \( \tilde{\theta} = \int_0^1 \theta_{1,2}(x)dx \) as the proportion of consumers who prefer \( q_1 \) to \( q_2 \), when Firm 1 exports only its low-quality good in Case 3, the demand expressions are

\[
D_l = \tilde{\theta} = \frac{(1 + t_2)p_2 - (1 + t_1)p_l + v_2^2 - v_1^2 - v_2 + v_1}{q_2 - q_l}
\]

\[
D_2 = 1 - \tilde{\theta} = 1 - \frac{(1 + t_2)p_2 - (1 + t_1)p_l + v_1^2 - v_2^2 - v_2 + v_1}{q_2 - q_l}. \quad (5)
\]

And when Firm 1 exports both its high- and low-quality goods in Case 3, then demand for each good is24

\[
D_h = 1 - \hat{\theta} = 1 - \frac{(1 + t_1)p_h - (1 + t_2)p_2 + v_1^2 - v_2^2 - v_1 + v_2}{q_h - q_2}
\]

\[
D_2 = \hat{\theta} - \tilde{\theta} = \frac{(1 + t_1)p_h - (1 + t_2)p_2 + v_1^2 - v_2^2 - v_1 + v_2}{q_h - q_2} - \frac{(1 + t_2)p_2 - (1 + t_1)p_l + v_2^2 - v_1^2 - v_2 + v_1}{q_2 - q_l}
\]

\[
D_l = \tilde{\theta} = \frac{(1 + t_2)p_2 - (1 + t_1)p_l + v_2^2 - v_1^2 - v_2 + v_1}{q_2 - q_l}. \quad (6)
\]

Figure 2 shows Firm 1’s market share under each of these possible strategies.

![Figure 2: Market Shares For the 3 Available Strategies when \( q_h > q_2 > q_l \)](image_url)

These expressions for demand, however, apply only when the demand for each product is positive at all

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23As with the consumer side of the market, demand analysis follows Neven and Thisse (1990), although they consider the endogenous choice of product quality and have only 1 product quality for each firm.

24Demand is defined analogously in the other two cases, see Table ??.
locations. This means that, at each preferred variety, at least one consumer buys each product. But demand for each product will be positive at every variety preference only when each of the following conditions is met:

\[ \theta_{h,2}(0) \geq 0 \]
\[ \theta_{h,2}(1) \leq 1 \]
\[ \theta_{2,1}(0) \leq 1 \]
\[ \theta_{2,1}(1) \geq 0. \]

Rewritten, these become

\[ (1 + t_2)P_{h} - (1 + t_2)P_2 + v_1^2 - v_2^2 \geq 0 \]
\[ (1 + t_1)P_{h} - (1 + t_2)P_2 + v_1^2 - v_2^2 - 2(v_1 - v_2) - q_h + q_2 \leq 0 \]

for the case when Firm 1 sells only its high-quality product. (Analogous expressions apply when it sells only the low-quality product or when it sells both products.) Recall that optimum prices are themselves dependent on the demand function, but the appropriate form of the demand function depends on the relationship between equilibrium prices, as given by these conditions. Thus, optimum prices depend on the demand function which is determined by the relations between those optimal equilibrium prices. This implies that these bounds can implicitly be expressed in terms of the primitives of the model, that is, the quality levels, varieties, and cost parameters, and that demand will be positive at all variety preferences only for certain parameter ranges. If demand is not positive at all variety preferences for a given parameter specification, then the expression for demand takes a different form and optimal prices are therefore also different.

For example, suppose that Firm 1 is selling only its high-quality good. Then it is possible that if its price is high enough, there is no demand for the product from consumers with variety preferences close to 1 (that is, consumers whose preferred variety is much closer to \( v_2 \) than \( v_1 \)). Stated differently, it may be the case that all consumers with a certain variety preference purchase Firm 2’s product because Firm 2’s variety \( v_2 \) is so much closer to their variety preference \( x \) than is Firm 1’s variety \( v_1 \). Even though Firm 1 offers a higher quality product (at a higher price), the higher quality is not enough to override these consumers’ strong preference for Firm 2’s variety and the disutility from paying a higher price. In this case, the demand for each firm is represented in the unit square as in Figure 3.

The expression for demand will then be different from those in equations (4), as will the conditions on relative prices. In this more complicated case, the demand for Firm 1’s high-quality good is integrated only over a portion of the unit square (specifically, from the variety preference \( x = 0 \) to the intersection of \( \theta \) with
the upper edge of the unit square). Firm 2’s market share then consists of the remainder of consumers. An analogous situation is also possible, where consumers with variety preferences at the lower end of the range buy only Firm 1’s product.

Still more demand configurations are possible when Firm 1 sells both of its products. Demand when each of the three products is sold may be positive for each product at each variety (as in the right-hand side of Figure 2 and as discussed above) or it may be zero for some products for a subset of variety preferences (as in Figure 4).

In this example, consumers with variety preferences at the lower end of the range (i.e. those with $x$ close to 0) will buy either the high-quality or the low-quality product, but never Firm 2’s product. Since $v_1 < v_2$, Firm 1’s variety is much closer to their variety preferences, and it may be that none of these consumers find Firm 2’s product attractive. For some, the combination of a high-quality good that is closer to their own variety preferences is sufficient to justify the higher price of $q_h$. For others, the higher quality of $q_2$ compared to $q_l$ is not enough to overcome its higher price and the less-preferred variety. This case will again produce different demand functions than those in equations (6).

Various combinations of the demand configurations described above may obtain at optimal prices. For
example, it may be that when all three goods are sold, only Firm 1’s low-quality good sees demand at all variety preferences; demand for Firm 1’s high-quality good (Firm 2’s good) may not exist at high (low) variety preferences. Cases 1 and 2 present similar potential for complexity in demand structure. The precise configuration will depend on the relative differences between qualities, varieties, and prices of goods. The remainder of this analysis focuses only on the case when demand for each product is positive at each variety preference, which happens only when the equilibrium prices are in certain relation to each other. I refer to this as the Market-wide Demand case. In other words, there are bounds on the equilibrium prices that determine whether this is the case.

3 Market-wide Demand

Market-wide Demand allows for a closed-form analytical solution to Firm 1’s problem. The current section provides details and analysis for this demand configuration. I first find the parameter ranges for which optimal prices generate the Market-wide Demand structure. Bounds on the parameters show that large quality differences between Firm 1 and Firm 2 and small variety differences between the firms produce a Market-wide Demand structure.

I adopt the following notation for the remainder of the paper:

- \( \varphi \equiv (v_1 - v_2)(v_1 + v_2 - 1) \)
- For Case 1, \( q_2 - q_h \equiv a \) and \( q_2 - q_l \equiv b \), so that \( a < b \) and \( b - a = q_h - q_l > 0 \)
- For Case 3, \( \rho \equiv \frac{(q_h - q_2)(q_2 - q_l)}{q_h - q_l} \).

Since \( v_1 - v_2 \leq 0 \) by assumption, \( \varphi \) will be negative only if \( v_1 > 1 - v_2 \), that is if Firm 1 is closer to the median consumer’s most preferred variety. (Firm 1 and Firm 2 are equidistant from the median consumer when \( v_1 = 1 - v_2 \).) The sign of \( \varphi \) thus indicates whether Firm 1 or Firm 2 has an advantage in variety, in the sense that the firm’s variety is closer to the preferences of the median consumer: if \( \varphi < 0 \) then Firm 1 has the variety advantage, if \( \varphi > 0 \) then Firm 2 has the advantage, and if \( \varphi = 0 \) then neither has an advantage (they are equidistant). In Case 1, \( a \) and \( b \) are simply the difference in qualities between Firm 2’s product and Firm 1’s high-quality and low-quality product, respectively, and the notation is used for convenience. The variable \( \rho \), used in analyzing Case 3, can be rewritten as \( \frac{(q_h - q_2)(q_2 - q_l)}{(q_h - q_2) + (q_2 - q_l)} \), showing that it is the ratio of the product of quality differences to the sum of quality differences. It increases as the gap between the highest and lowest qualities \( (q_h \text{ and } q_l) \) increases; the impact of a change in the middle quality \( (q_2) \) is ambiguous, depending on whether it is closer to the highest or lowest quality.
3.1 Bounds for Market-wide Demand

I use the following steps to find the parameter ranges that generate Market-wide Demand under each strategy:

1. Solve for equilibrium prices (under each strategy in each Case), assuming that demand is market-wide.

2. Identify the bounds on prices for market-wide demand.

3. Given the equilibrium prices and bounds, find the parameter restrictions such that the equilibrium prices satisfy these bounds.

4. Verify that the equilibrium prices are indeed optimal.

As noted, I first derive the optimal price for each product assuming Market-wide Demand. Finding the optimal prices is then a matter of solving the first-order conditions of the profit functions, for each strategy in each case, based on the appropriate expression for demand.\textsuperscript{25} Table 1 gives these prices.

\textsuperscript{25}Recall that the cost of quality is linear, $c_j = kq_j$, so that the profit per unit is $p_j - kq_j$. 
<table>
<thead>
<tr>
<th>Firm 1’s strategy</th>
<th>$p_h$</th>
<th>$p_l$</th>
<th>$p_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sell $q_h$ only</td>
<td>$\frac{1(q_2-q_h)-\varphi+2(1+t_1)kq_2h_q+(1+t_2)kq_2}{3(1+t_1)}$</td>
<td>n/a</td>
<td>$\frac{2(q_2-q_h)+\varphi+(1+t_1)kq_2(1+t_2)kq_2}{3(1+t_2)}$</td>
</tr>
<tr>
<td>Sell $q_l$ only</td>
<td>$\frac{(q_2-q_h)-\varphi+2(1+t_1)kq_2h_q+(1+t_2)kq_2}{3(1+t_1)}$</td>
<td>$\frac{2(q_2-q_h)-2\varphi}{6(1+t_2)}$</td>
<td>$\frac{2(q_2-q_h)+\varphi+(1+t_1)kq_2(1+t_2)kq_2}{3(1+t_2)}$</td>
</tr>
<tr>
<td>Sell both $q_h$ and $q_l$</td>
<td>$\frac{3q_h+q_l-4q_2-2\varphi}{6(1+t_1)}$</td>
<td>$\frac{2(q_2-q_2)+\varphi+(1+t_1)kq_2(1+t_2)kq_2}{3(1+t_2)}$</td>
<td>$\frac{(q_1-q_2)+\varphi+(1+t_1)kq_2(1+t_2)kq_2}{3(1+t_2)}$</td>
</tr>
</tbody>
</table>

Table 1: Optimal Prices under Market-wide Demand
But these prices are calculated from profit functions that assume Market-wide Demand. Since Market-wide Demand will only obtain when the prices are within certain ranges, it is necessary to verify that the optimal prices found by assuming that demand is market-wide are indeed within these ranges. For example, if Firm 1 chooses to sell only its high-quality good in Case 3, then there is some \( p_h^* \) such that for any \( p_h < p_h^* \), Firm 2’s demand will be 0 for some preferred varieties (those closest to \( v_1 \)). Similarly, there is some \( p_h^* \) such that for any \( p_h > p_h^* \), Firm 1’s demand will be 0 for some preferred varieties (those that are closest to \( v_2 \)). Figure 5 demonstrates. The left-most graph is an example of demand when \( p_h < p_h^* \); the right-most is an example of demand when \( p_h > p_h^* \); only in the middle graph, when \( p_h < p_h < p_h^* \), is the demand for both Firm 1 and Firm 2 market-wide (there is positive demand for each product at all variety preferences). The constraints in Table ?? define these ranges for each strategy-case combination in terms of prices and varieties.

![Figure 5: Three Different Demand Configurations in Case 3](image)

Before proceeding, then, it is necessary to determine the conditions under which the prices for each strategy in each Case satisfy these constraints for Market-wide Demand. To determine when the assumption of market-wide demand holds, I substitute the optimal prices from Table 1 into the conditions for market-wide demand. The resulting inequalities specify the parameter ranges that generate the market-wide demand structure; they are given in Table 2. That is, these parameter ranges generate optimal prices under the Market-wide Demand assumption that satisfy the constraints on Market-wide Demand.26

Finally, it is necessary to show that the equilibrium prices under the Market-wide Demand assumption are indeed optimal. Having found the parameter restrictions that actually generate Market-wide Demand when the optimal prices as given in Table 1, I need to verify that Firm 1 would not earn greater profits

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26Although there are two constraints in the case of exporting either \( q_h \) or \( q_l \) alone and four if exporting both of them, when expressed in the primitives of the model these all reduce to four restrictions in Case 1 and Case 2. This is because in Case 1 (Case 2), the restrictions on selling only the high-quality (low-quality) product are always stronger. Each of the restrictions in these cases can be rearranged into a restriction on \( \frac{q_l}{q_h} \) and \( \frac{q_h}{q_l} \). Since it is always true that \( \frac{q_l}{q_h} < \frac{q_h}{q_l} \), the restrictions in Case 1 (Case 2) when selling only the low-quality (high-quality) good are automatically satisfied by those on selling only the high-quality (low-quality) good. In addition, the last two constraints when selling other goods reduce to the same restrictions. In Case 3, however, there remain 7 restrictions on the parameters.
by setting a different price, which would in turn generate a different demand formulation. For example, I need to rule out the possibility that when selling only its high-quality good, Firm 1 earns a higher profit by lowering its price (so that Firm 2 has zero demand at some variety preferences) than by charging the optimal price that still generates market-wide demand. Such possibilities are ruled out because each Firm’s profit function is quasiconcave given the parameter restrictions, so that the optimal price for market-wide demand is the global optimum.\textsuperscript{27}

\textsuperscript{27}The proof in the single-good case is given in Neven and Thisse (1990) as the proof of Proposition 1. In the two-good case, the proof incorporates the parameter restrictions into similar reasoning.
<table>
<thead>
<tr>
<th>Firm 1’s strategy</th>
<th>Parameter Restrictions for Positive Demand at each Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case 1 ($q_2 &gt; q_h &gt; q_l$)</td>
</tr>
<tr>
<td>Sell $q_h$ only</td>
<td>$(4 - v_1 - v_2)(v_2 - v_1) - q_2 + q_h \leq k[(1 + t_2)q_2 - (1 + t_1)q_h] \leq 2(q_2 - q_h) - (v_2 - v_1)(v_1 + v_2 + 2)$</td>
</tr>
<tr>
<td>Sell $q_l$ only</td>
<td>$(4 - v_1 - v_2)(v_2 - v_1) - q_2 + q_l \leq k[(1 + t_2)q_2 - (1 + t_1)q_l] \leq 2(q_2 - q_l)(v_1 + v_2 + 2)$</td>
</tr>
<tr>
<td>Sell both $q_h$ and $q_l$</td>
<td>$k[(1 + t_2)q_2 - (1 + t_1)q_b] \leq 2(q_2 - q_h) - (v_2 - v_1)(v_1 + v_2 + 2)$</td>
</tr>
<tr>
<td></td>
<td>$2kq_2(t_1 - t_2) \leq (q_2 - q_h)[2 - k(1 + t_1)] + 2(v_2 - v_1)(v_1 + v_2 - 4)$</td>
</tr>
<tr>
<td></td>
<td>Case 2 ($q_h &gt; q &gt; q_2$)</td>
</tr>
<tr>
<td>Sell $q_h$ only</td>
<td>$(v_1 + v_2 + 2)(v_2 - v_1) - q_h + q_2 \leq k[(1 + t_1)q_h - (1 + t_2)q_2] \leq 2(q_h - q_2) - ((v_2 - v_1)(4 - v_1 - v_2)$</td>
</tr>
<tr>
<td>Sell $q_l$ only</td>
<td>$(v_1 + v_2 + 2)(v_2 - v_1) - q_l + q_2 \leq k[(1 + t_1)q_l - (1 + t_2)q_2] \leq 2(q_l - q_2) - ((v_2 - v_1)(4 - v_1 - v_2)$</td>
</tr>
<tr>
<td>Sell both $q_h$ and $q_l$</td>
<td>$(v_1 + v_2 + 2)(v_2 - v_1) - q_2 + q_2 \leq k[(1 + t_1)q_l - (1 + t_2)q_2]$</td>
</tr>
<tr>
<td></td>
<td>$k(1 + t_1) \leq 1$</td>
</tr>
<tr>
<td></td>
<td>$2kq_2(t_1 - t_2) \leq (q_2 - q_l)[1 + k(1 + t_1)] + 2(v_2 - v_1)(v_1 + v_2 - 4)$</td>
</tr>
<tr>
<td></td>
<td>Case 3 ($q_h &gt; q_2 &gt; q_l$)</td>
</tr>
<tr>
<td>Sell $q_h$ only</td>
<td>$(v_1 + v_2 + 2)(v_2 - v_1) - q_h + q_2 \leq k[(1 + t_1)q_h - (1 + t_2)q_2] \leq 2(q_h - q_2) - ((v_2 - v_1)(4 - v_1 - v_2)$</td>
</tr>
<tr>
<td>Sell $q_l$ only</td>
<td>$(4 - v_1 - v_2)(v_2 - v_1) - q_l + q_l \leq k[(1 + t_2)q_2 - (1 + t_1)q_l] \leq 2(q_2 - q_l)(v_1 + v_2 + 2)$</td>
</tr>
<tr>
<td>Sell both $q_h$ and $q_l$</td>
<td>$3k(1 + t_1)q_h - 2k(1 + t_2)q_2 - k(1 + t_1)q_l \leq 3(q_h - q_2) + 2(v_2 - v_1)(v_1 + v_2 - 4) + \rho$</td>
</tr>
<tr>
<td></td>
<td>$3k(1 + t_1)q_l - 2k(1 + t_2)q_2 - k(1 + t_1)q_2 \leq 2(v_2 - v_1)(v_1 + v_2 - 4) + \rho$</td>
</tr>
<tr>
<td></td>
<td>$k(t_2 - t_1)q_2 \leq (v_2 - v_1)(v_1 + v_2 + 2) + \rho$</td>
</tr>
</tbody>
</table>

Table 2: Parameter Restrictions for Market-wide Demand
3.2 Meeting the Constraints for Market-wide Demand

Comparative statics show that the parameter restrictions in Table 2 are more likely to be satisfied the lower is Firm 2’s variety ($v_2$) and the higher is Firm 1’s variety ($v_1$). For a fixed Firm 1 variety ($v_1$), the variety term in the lower (upper) bound is minimized when Firm 2’s variety is 0. Since $v_2 \geq v_1$ by assumption, this means that Firm 2’s variety must be as close to Firm 1’s variety as possible in order to minimize the variety terms and make the bounds as small (large) as possible. A similar procedure shows that with a fixed $v_2$, the larger is Firm 1’s variety the smaller is the variety term in the bounds. Note that, at the extreme when $v_1 = v_2$ or the two firms have the same variety, then the terms containing the variety parameters drop out of the restrictions entirely. This leads to the following proposition:

**Proposition 1.** A smaller difference in the firms’ varieties ($v_2 - v_1$) increases the range of parameters for which demand for every product is positive at every preferred variety ($x$), and market-wide demand obtains.

When the firms are far apart in variety, then a consumer with extreme variety preferences may exclude one or the other firm’s product simply because the firm’s variety is too far from his own preferences. For example, if a consumer is located at $x_i = 1$, then all else equal the consumer will always (weakly) prefer Firm 2’s product, since $v_1 \leq v_2 \leq 1$. Even if Firm 1 offers a higher quality or a lower price, this may not be enough to induce the consumer to buy Firm 1’s offering if for example $v_1 = 0$ and $v_2 = 1$ (the variety difference between firms is large). Regardless of its price or quality advantages, Firm 1’s variety is simply too far from the consumer’s preferences to capture her as a customer; the variety difference is so big that it outweighs the quality and price differences. In this case, Firm 1 would have no demand at $x_i = 1$. On the other hand, if the firms’ varieties are close, then it is much less likely that a consumer will find the variety difference to be so big as to outweigh all quality and price differences. In this case, some consumers at each variety preference will choose the higher quality product, while others will choose the lower priced product; each firm will have positive demand at all locations.

While a small difference in varieties increases the set of parameters that generate market-wide demand, the opposite is true of the firms’ qualities. It is clear that, when Firm 1 chooses to sell only one of its goods, the lower bound is less restrictive the larger is the difference in qualities between Firm 1’s good and Firm 2’s good. (This will make the left-hand side of the inequality smaller and the right-hand side of the inequality bigger.) This is also true of the upper bound as long as $k(1 + t_n) \leq 2$. To demonstrate, rearrange the upper bound for selling only the high-quality good in Case 1 to get $q_h[2 - k(1 + t_1)] \leq q_2[2 - k(1 + t_2)] - (v_2 - v_1)(v_1 + v_2 + 2)$. As long as $k(1 + t_n) < 2$, both sides of this are clearly increasing in the quality parameter. The restriction will therefore be weaker the smaller is $q_h$ and the bigger is $q_2$, or the bigger is the difference between the quality levels. A similar analysis applies to the other strategies where Firm 1 sells only one of its goods.
In Case 1 and Case 2, the last restriction when selling both goods is also clearly weaker the larger is the difference in qualities, given \( k(1 + t_n) < 2 \), as the right-hand side of the inequality is then increasing in the quality difference.

Selling both goods in Case 3 requires a slightly different approach. First, comparative statics show that the \( \rho \) term is increasing in the quality difference between Firm 1’s own products, causing the right-hand side of the inequalities to increase.\(^{28}\) Clearly, the left-hand side of the second restriction is increasing in \( q_1 \). Furthermore, as long as \( k(1 + t_1) \leq 1 \), the right-hand side of the first restriction will increase faster in \( q_h \) than the left-hand side. Therefore, if \( k(1 + t_1) \leq 1 \), the larger is \( q_h \) and the smaller is \( q_l \), the weaker are the restrictions on market-wide demand in Case 3. The foregoing analysis is the basis for the following proposition:

**Proposition 2.** For Cases 1 and 2, as long as \( k(1 + t_n) \leq 2 \), a bigger difference between Firm 1’s qualities and Firm 2’s quality (\( |q_h - q_2| \) and \( |q_l - q_2| \)) increases the range of parameters for which market-wide demand obtains. For Case 3, as long as \( k(1 + t_n) \leq 1 \), a bigger difference between Firm 1’s own qualities (\( q_h - q_l \)) increases the range of parameters for which market-wide demand obtains.

This is because a big difference in quality levels leaves each firm with a distinct advantage in either quality or price. If Firm 1 offers lower qualities than Firm 2 (Case 1), then it will have an advantage in price while Firm 2 has the quality advantage. If the quality of Firm 1’s products is low enough, then its price advantage is big enough to ensure positive demand from consumers market-wide, regardless of their preferred varieties or the tariff rate applied to Firm 1’s products. At the same time, Firm 2’s quality advantage is also big enough to ensure positive demand from consumers market-wide. Similarly, if Firm 1’s products are of a higher quality than Firm 2’s products (Case 2), then it has the quality advantage. When this advantage is big enough (Firm 1’s quality levels are high enough), it will attract consumers across the whole market. Even if the firms locate at extreme varieties (i.e. if \( v_1 = 0 \) and \( v_2 = 1 \)), if the difference in qualities (\( q_2 - q_h \) and \( q_2 - q_l \) in Case 1, or \( q_h - q_2 \) and \( q_l - q_2 \) in Case 2) is big enough, then the parameter restrictions are satisfied and demand is market-wide.

The cost and tariff rates also matter to the strength of the the restrictions because a higher cost of quality \((k)\) or a higher tariff rate \((t)\) both result in higher prices for the consumer. If the product of the cost of quality and the tariff is high enough, then this can effectively destroy the quality or price advantage.

\(^{28}\)The effect of the difference in quality between Firm 1’s goods and Firm 2’s good is ambiguous. Since \( q_2 \) is between Firm 1’s qualities in this Case, then as \( q_2 \) increases it increases the difference between \( q_2 \) and Firm 1’s low quality product and decreases the difference between \( q_2 \) and Firm 1’s high quality product. Thus if the difference between \( q_l \) and \( q_2 \) is increasing due to an increase in \( q_2 \), this will decrease the difference between \( q_h \) and \( q_2 \) and may cause the \( \rho \) term to fall.
of a firm. If the firm has a quality advantage, the price of the product may become so high that at some points of the market, no consumer is willing to buy the product. Even with a high quality, the price is so high that the consumer chooses the product closer to her preferred variety. Similarly, if the firm has a price advantage, the high cost of quality and tariff can significantly reduce that price advantage. As a result, since the product no longer enjoys such a large price advantage, some consumers with extreme variety preferences may no longer be willing to forgo a product that is closer in variety to those preferences.

4 Variable Profits and Optimal Strategies

Using the prices in Table 1, Firm 1’s profits at optimal prices for each of its three possible strategies are given in Table 3.

<table>
<thead>
<tr>
<th>Firm 1’s strategy</th>
<th>Firm 1’s profit</th>
</tr>
</thead>
</table>
| Case 1 ($q_2 > q_h > q_l$) | $\begin{align*}
\text{Sell } q_h & \text{ only:} & [\frac{q_2-q_h-k(1+t_1)q_h+k(1+t_2)q_2}{9(1+t_1)(q_2-q_h)}]^2 \\
\text{Sell } q_l & \text{ only:} & [\frac{q_2-q_l-k(1+t_1)q_l+k(1+t_2)q_2}{9(1+t_1)(q_2-q_l)}]^2 \\
\text{Sell both } q_h & \text{ and } q_l: & \frac{[q_2-q_h-k(1+t_1)q_h+k(1+t_2)q_2]^2 + k^2(1+t_1)}{9(1+t_1)(q_2-q_h)}(q_h - q_l)
\end{align*}$ |
| Case 2 ($q_h > q_l > q_2$)  | $\begin{align*}
\text{Sell } q_h & \text{ only:} & \frac{[2(q_h-q_2)-q_2-k(1+t_1)q_h+k(1+t_2)q_2]^2}{9(1+t_1)(q_h-q_2)} \\
\text{Sell } q_l & \text{ only:} & \frac{[2(q_l-q_2)-q_2-k(1+t_1)q_l+k(1+t_2)q_2]^2}{9(1+t_1)(q_l-q_2)} \\
\text{Sell both } q_h & \text{ and } q_l: & \frac{[2(q_h-q_2)-q_2-k(1+t_1)q_h+k(1+t_2)q_2]^2 + (1-k(1+t_1))^2}{4(1+t_1)}(q_h - q_l)
\end{align*}$ |
| Case 3 ($q_h > q_l > q_2$)  | $\begin{align*}
\text{Sell } q_h & \text{ only:} & \frac{[2(q_h-q_2)-q_2-k(1+t_1)q_h+k(1+t_2)q_2]^2}{9(1+t_1)(q_h-q_2)} \\
\text{Sell } q_l & \text{ only:} & \frac{[q_2-q_l-k(1+t_1)q_l+k(1+t_2)q_2]^2}{9(1+t_1)(q_2-q_l)} \\
\text{Sell both } q_h & \text{ and } q_l: & \frac{[3(q_h-q_2)-2q_2+2k(1+t_1)q_h+k(1+t_2)q_2-3k(1+t_1)q_h+\rho]^2}{36(1+t_1)(q_h-q_2)} \\
& & + \frac{[-2q_2+2k(1+t_2)q_2+k(1+t_1)q_2-3k(1+t_1)q_l+\rho]^2}{36(1+t_1)(q_2-q_l)}
\end{align*}$ |

Table 3: Firm 1’s Profits When Demand is Market-wide

4.1 The Less Profitable Strategy

When optimal prices are consistent with market-wide demand, then one of Firm 1’s strategies is easily ruled out in Case 1 and Case 2. In particular, when $q_2 > q_h > q_l$ ($q_h > q_l > q_2$) then exporting both qualities generates more variable profits for Firm 1 than exporting only the high (low) quality. This means that Firm 1 can rule out exporting only that product which is closest in quality to Firm 2’s product, since selling both quality levels is unambiguously more profitable. The intuition is clear: if Firm 1’s product is close in quality to Firm 2’s product, then price competition will be intense, reducing profits. Selling both quality levels is
more profitable because the product that is further in quality from Firm 2’s product is not subject to such intense price competition and thus generates greater profit margins for Firm 1. Indeed, the product that is further in quality is shielded from competition not only by the greater differentiation in qualities but also by the presence of the product that is closer in quality, which bears the brunt of the competition. Thus Firm 1’s least profitable strategy is exporting only the product that is closer in quality to Firm 2’s product.  

**Proposition 3.** In Case 1, Firm 1’s variable profit of selling both qualities is greater than that of selling the high quality only.

In Case 2, Firm 1’s variable profit of selling both qualities is greater than that of selling the low quality only.

**Proof.** If \( q_2 > q_h > q_l \), then \( \pi_{h,l} > \pi_h \) iff (from Table 3) \[ \frac{k^2(1+t_1)}{4} (q_h - q_l) > 0. \] Since \( q_h > q_l \), this is clearly true.

If \( q_h > q_l > q_2 \), then \( \pi_{h,l} > \pi_l \) iff \[ \frac{(q_h - q_l)(1-k(1+t_1))^2}{4(1+t_1)} > 0. \] Since \( q_h > q_l \), then this is clearly true.

For Cases 1 and 2, then, the decision is between exporting both goods and exporting only the good that is more differentiated from the competitor’s good in quality. I refer to these strategies as the two-good strategy and the single-good strategy, respectively.

If on the other hand \( q_h > q_2 > q_l \) (Case 3), so that Firm 2’s product quality is in between the quality levels that Firm 1 can offer, none of Firm 1’s strategies can be ruled out. In Case 1 and Case 2, one of Firm 1’s products is by definition always closer in quality to Firm 2’s product. This is not true in Case 3: whether the high quality or the low quality is closer to Firm 2’s quality depends entirely on the specific parameter values. This means that whether the high quality or low quality good is subject to more intense price competition also varies. In addition, neither good shields the other from competition. And so the argument for Cases 1 and 2 does not apply to Case 3, for which none of the strategies is ruled out.

### 4.2 Effect of Tariff on the Optimal Strategy

Comparing the profit equations in Table 3 gives the following conditions, for Case 1 and Case 2 respectively, under which exporting both products is at least as profitable as the single-good strategy (\( \pi_l \leq \pi_{h,l} \) and \( \pi_h \leq \pi_{h,l} \)):  

\[ ^{29} \text{This says nothing about whether selling only the product further in quality is more or less profitable than selling both products. It means only that Firm 1 always sells the product that is further in quality, and it may or may not sell the product that is closer in quality.} \]

\[ ^{30} \text{This can be seen, for example, by setting parameter values as follows: } k = .5, t_1 = -2, t_2 = .35, q_h = 5, q_l = 1, v_1 = .4, v_2 = .6. \text{ When } q_2 = 2, \text{ then selling only the high-quality product is more profitable than selling both products. When } q_2 = 3, \text{ then selling only the low-quality product is more profitable.} \]

\[ ^{31} \text{Note that the left-hand side is the profit earned from the single-good strategy strategy while the first term on the right-hand side (the profit from selling both goods) is equal to the total profit that Firm 1 would earn by selling only its high quality product (a strategy that has already been ruled out). Note also that the expression in Table 3 for profits from selling both goods consists of two terms, however, it is not the case that each term represents profits from only one of the goods.} \]
\[
\frac{\left[ q_2 - q_1 - \varphi - k(1 + t_1)q_1 + k(1 + t_2)q_2 \right]^2}{9(1 + t_1)(q_2 - q_1)} \leq \frac{\left[ q_2 - q_h - \varphi - k(1 + t_1)q_h + k(1 + t_2)q_2 \right]^2}{9(1 + t)(q_2 - q_h)} \\
+ \frac{k^2(1 + t_1)}{4}(q_h - q)
\]

(7)

\[
\frac{\left[ 2(q_h - q_2) - \varphi - k(1 + t_1)q_h + k(1 + t_2)q_2 \right]^2}{9(1 + t_1)(q_h - q_2)} \leq \frac{\left[ 2(q_1 - q_2) - \varphi - k(1 + t_1)q_1 + k(1 + t_2)q_2 \right]^2}{9(1 + t_1)(q_2 - q_1)} \\
+ \frac{[1 - k(1 + t_1)]^2}{4(1 + t_1)}(q_h - q_1).
\]

(8)

For ease of exposition, define the following variables:

- \( \xi \) is the difference between the left-hand side and the first term on the right-hand side of equation (7) (Case 1);
- \( \gamma \equiv \frac{k^2(1 + t_1)}{4}(q_h - q_1) \), the second term on the right-hand side of equation (7);
- \( \zeta \) is the difference between the left-hand side and the first term on the right-hand side of equation (8) (Case 2);
- \( \lambda \equiv \frac{(1 - k(1 + t_1))^2}{4(1 + t_1)}(q_h - q) \), the second term on the right-hand side of equation (8).

Thus, the two-good strategy will be at least as profitable as the single-good strategy if \( \xi \leq \gamma \) for Case 1 and if \( \zeta \leq \lambda \) for Case 2.

Rearranging, \( \xi \) becomes\(^{32}\)

\[
\xi = \frac{(b - a)}{9ab(1 + t_1)} \times \left[ ab(1 + k(1 + t_1))^2 - (kq_2)^2(t_1 - t_2)^2 + 2kq_2\varphi(t_2 - t_1) - \varphi^2 \right].
\]

\(^{32}\)This expression can be found by expanding the expression, adding and subtracting \( k^2q_2^2(1 + t_1)^2 \), and rearranging.
Similarly, \( \zeta \) becomes
\[
\zeta = \frac{(q_h - q_l)}{9(q_h - q_2)(q_l - q_2)(1 + t_1)} \times \\
\left[(q_h - q_2)(q_l - q_2)(2 - k(1 + t_1))^2 - (kq_2)^2(t_1 - t_2)^2 + 2kq_2\varphi(t_2 - t_1) - \varphi^2\right].
\]

Using these expressions for \( \xi \) and \( \zeta \), manipulating equations (7) and (8) produces the following necessary and sufficient conditions, for Case 1 and Case 2 respectively, under which the two-good strategy is no less profitable than the single-good strategy:

\[
(q_2 - q_h)(q_2 - q_l)\left[4 + 8k(1 + t_1) - 5k^2(1 + t_1)^2\right] \leq 4[kq_2(t_1 - t_2)]^2 + 4\varphi^2 + 8kq_2\varphi(t_1 - t_2)
\]

and

\[
(q_h - q_2)(q_l - q_2)\left[7 + 2k(1 + t_1) - 5k^2(1 + t_1)^2\right] \leq 4[kq_2(t_1 - t_2)]^2 + 4\varphi^2 + 8kq_2\varphi(t_1 - t_2).
\]

These equations are the basis for the following proposition about the effect of tariffs on Firm 1’s optimal strategy regarding product proliferation:

**Proposition 4.** In Case 1 and Case 2, if:

- the tariff on Firm 1’s products is small enough and \( k \leq \frac{4}{5} \), and
- the tariff on Firm 2’s product is large enough

then the profit from the two-good strategy is greater than or equal to the profit from the single-good strategy for Firm 1.

**Proof.** The left-hand side of equation (9) is constant in \( t_2 \). The right-hand side is increasing in \( t_2 \) if \( t_2 > t_1 + \frac{\varphi}{kq_2} \), that is, if \( t_2 \) is big enough. Therefore if \( t_2 \) is big enough then the equation will hold.

The partial derivative of the left-hand side of (9) with respect to \( t_1 \) is \((q_2 - q_h)(q_2 - q_l)[8k - 10k^2(1 + t_1)]\), while the partial derivative of the right-hand side is \( 8kq_2[kq_2(t_1 - t_2) + \varphi] \). The left-hand side is increasing in \( t_1 \) as long as \( t_1 < \frac{1}{k} - 1 \). Since \( t_1 \geq 0 \), then this is possible only if \( k \leq \frac{4}{5} \). The right-hand side is decreasing in \( t_1 \) as long as \( t_1 < t_2 - \frac{\varphi}{kq_2} \). Therefore if \( k \leq \frac{4}{5} \) and \( t_1 \) is small enough, then the equation will hold.

The proof for Case 2 proceeds analogously. \( \square \)
If Firm 1’s tariff falls far enough, two effects combine to make product proliferation profitable. First, exporting a second product provides the firm with a competition buffer. The additional product that Firm 1 chooses to export is the one that is closer in quality to Firm 2’s product. It competes more directly with Firm 2’s product and so protects Firm 1’s market share and Firm 1’s other product from the most severe competition. This allows Firm 1 to take full advantage of its lower tariff rate by setting the price of its protected product even higher, thereby earning a greater per-unit profit. That is, a buffer product allows Firm 1 to increase the price of its other product faster as the tariff falls. However, taking advantage of falling tariffs in this way also requires tariffs to be sufficiently low. Due to the proximity of qualities, the buffer product is forced to compete intensely with Firm 2’s product. If Firm 1’s tariff is too high, the buffer product is not competitive enough to adequately protect Firm 1’s market share. Although the other product is still protected from competition, Firm 1 does not maintain enough market share to make the extra per-unit profit worthwhile. Product proliferation, which entails the introduction of a buffer product by Firm 1, is therefore only profitable for Firm 1 when tariffs are low enough. This enables the buffer product to fulfill both of its functions: maintaining sufficient market share, and protecting the per-unit profit of the firm’s other product.

4.2.1 Cases 1 and 2: when tariffs are equal

Analysis of the special case when \( t_1 = t_2 \) provides additional insight in the relationship between tariff levels and Firm 1’s optimal strategy.

In this special case, the expression in equation (7) when tariffs are equal simplifies to\(^{33}\)

\[
\xi_{t_1=t_2} = \frac{[b - \varphi - k(1 + t)b] - [a - \varphi - k(1 + t)a]}{9(1 + t)b} = \frac{(b - a)\left\{ ab[1 + 2k(1 + t)] + k^2(1 + t)^2(q_hq_l - q_2q_h - q_2q_l) + 2k(1 + t)q_2[k(1 + t)q_2 - \varphi] - [k(1 + t)q_2 - \varphi]^2 \right\}}{9ab(1 + t)} = \frac{(b - a)}{9ab(1 + t)} \left\{ ab[1 + 2k(1 + t)] + k^2(1 + t)^2(q_hq_l - q_2q_h - q_2q_l + q_2^2) - \varphi^2 \right\} = \frac{(b - a)}{9ab(1 + t)} \left\{ [1 + k(1 + t)^2]^2 - \frac{\varphi^2}{9ab(1 + t)} \right\} < \frac{k^2(1 + t)}{4} (q_h - q_l) \equiv \gamma.
\]

Rewriting this produces the following necessary and sufficient condition for profits from the two-good strategy

\(^{33}\)Recall that \( q_2 - q_h \equiv a \) and \( q_2 - q_l \equiv b \).
exceeding profits from the single-good strategy in Case 1 under equal tariffs:

\[(q_2 - q_h) \times (q_2 - q_l) \times [4 + 8k(1 + t) - 5k^2(1 + t)^2] - 4\varphi^2 < 0. \tag{12}\]

Similarly, \(\zeta_{t_1 = t_2}\) simplifies to:

\[\zeta_{t_1 = t_2} = \frac{(q_h - q_l)}{g(q_2 - q_h)(q_2 - q_l)(1 + t_1)} \left\{ (q_2 - q_h)(q_2 - q_l)[2 - k(1 + t_1)]^2 - \varphi^2 \right\}. \tag{13}\]

Profits from the two-good strategy will be greater than profits from the single-good strategy if and only if \(\zeta_{t_1 = t_2} < \lambda\). Substituting and rearranging produces the following necessary and sufficient condition (similar to the inequality in equation (12)) for \(\pi_{h,2} > \pi_h\) in Case 2 when tariffs are equal:

\[(q_h - q_2) \times (q_l - q_2) \times [7 + 2k(1 + t_1) - 5k^2(1 + t_1)^2] - 4\varphi^2 < 0. \tag{14}\]

The outline for the proof of Proposition 5 (below) comes from examining these necessary and sufficient conditions (equations (12) and (14)) for Firm 1 to choose its two-good strategy under equal tariffs. Lemma 1 shows that, in Case 1, \(k(1 + t_1) \leq 2\) when \(t_1 = t_2\). The term in equation (12) that is quadratic in the tariff and cost of quality is therefore positive. Similarly, in Case 2, the bounds of market-wide demand require that \(k(1 + t_1) \leq 1\), so that the analogous term in equation (14) is also positive. Hence the first term of both equation (12) and equation (14) is positive. Since \(|\varphi| \leq \frac{1}{4}\) so that \(4\varphi^2 \leq \frac{1}{4}\), these two conditions can only be satisfied if quality differences (\(|q_h - q_2|\) and \(|q_l - q_2|\)) are small. The proof shows that such small quality differences violate the parameter restrictions for market-wide demand, and neither equation (12) nor equation (14) can be satisfied.

**Lemma 1.** In Case 1 when \(t_1 = t_2\), \(k(1 + t_1) \leq 2\).

**Proof.** From Table 2, when \(q_2 > q_h > q_l\) and \(t_1 = t_2\), then \((q_2 - q_h)[2 - k(1 + t_1)] + 2(v_2 - v_1)(v_1 + v_2 - 4) \geq 0\) in order for the bounds to be satisfied when Firm 1 sells both quality levels. Since \((v_2 - v_1)(v_1 + v_2 - 4) \leq 0\), then in order for this bound to be satisfied, a necessary (but not sufficient) condition is that \((q_2 - q_h)[2 - k(1 + t_1)] \geq 0\). And since \((q_2 - q_h) > 0\) then it must be true that \(2 - k(1 + t_1) \geq 0\), or \(k(1 + t_1) \leq 2\). \(\square\)

**Proposition 5.** In Case 1 and Case 2, if Firm 1 and Firm 2 face the same tariff rates \((t_1 = t_2)\), then Firm 1 earns higher profits under its single-good strategy (selling only the low-quality good or the high-quality good, respectively) than its two-good strategy (selling both goods).

**Proof.** For Case 1, if \(t_1 = t_2 = t\) then the bounds (see Table 2) require that \(a \geq \frac{(v_2 - v_1)(v_1 + v_2 + 2)}{2 - k(1 + t)}\) and \(b \geq \frac{(v_2 - v_1)(v_1 + v_2 + 2)^2}{2 - k(1 + t)^2}\). Together, these imply that \(ab \geq \frac{(v_2 - v_1)^2(v_1 + v_2 + 2)^2}{[2 - k(1 + t)]^2}\). But equation (12) requires that
\( ab < \frac{4\varphi^2}{4 + 8k(1 + t_1) - 5k^2(1 + t_1)^2} \) in order for the two-good strategy to be more profitable. Since \((v_2 - v_1)^2(v_1 + v_2 + 2)^2 \geq 4(v_1 + v_2 - 1)^2 = 4\varphi^2\), and \([2 - k(1 + t)]^2 \leq 4 + 8k(1 + t_1) - 5k^2(1 + t_1)^2\), then \((q_2 - q_h)(q_2 - q_l) = ab \geq \frac{(v_2 - v_1)^2(v_1 + v_2 + 2)^2}{[2 - k(1 + t)]^2} \geq \frac{4\varphi^2}{4 + 8k(1 + t_1) - 5k^2(1 + t_1)^2}\), which contradicts equation (12). Therefore, the two-good strategy cannot be more profitable in Case 1 when tariffs are equal.

For Case 2, if \( t_1 = t_2 = t \) then the bounds require that \( q_h - q_2 \geq \frac{(v_2 - v_1)(v_1 + v_2 + 2)}{2 - k(1 + t)} \) and \( q_2 - q_l \geq \frac{(v_2 - v_1)^2(v_1 + v_2 + 2)^2}{[2 - k(1 + t)]^2}\). Together, these imply that \( (q_h - q_2)(q_l - q_2) \geq \frac{(v_2 - v_1)^2(v_1 + v_2 + 2)^2}{[2 - k(1 + t)]^2}\). But \((v_2 - v_1)^2(v_1 + v_2 + 2)^2 \geq 4\varphi^2 = 4(v_1 + v_2 - 1)^2\), and \([2 - k(1 + t)]^2 \leq 4 + 8k(1 + t_1) - 5k^2(1 + t_1)^2\) when \( k(1 + t) \leq 1 \) as required by the bounds. Therefore, as in the first case, \( (q_h - q_2)(q_l - q_2) \geq \frac{(v_2 - v_1)^2(v_1 + v_2 + 2)^2}{[2 - k(1 + t)]^2} \geq \frac{4\varphi^2}{4 + 8k(1 + t_1) - 5k^2(1 + t_1)^2}\), which contradicts equation (14). Therefore, the two-good strategy cannot be more profitable in Case 2 when tariffs are equal.

When demand is market-wide and tariffs are equal, the single-good strategy dominates the two-good strategy in Cases 1 and 2, and (12) and (14) never hold given the parameter restrictions for market-wide demand. Under the additional parameter restriction that tariffs are equal, then, Firm 1 will never choose its two-good strategy. Combining this results with the result stated in Proposition 4 gives the overall result that the 2-good strategy will be optimal only if Firm 1’s tariff advantage is big enough.

### 4.3 Optimal Strategy in Case 1 and Case 2

As noted above, profits from the two-good strategy will be greater than profits from the single-good strategy when

- in Case 1, \( \xi < \gamma \)
- in Case 2, \( \zeta < \lambda \).

The next two propositions provide conditions under which the two-good strategy is the optimal choice. To provide intuition for these conditions, I first introduce a result concerning Firm 1’s market shares. Since Firm 1 competes with Firm 2 over market share, the result concerning market share is important for both determining and understanding Firm 1’s optimal strategy.

**Lemma 2.** In Case 1 and Case 2, Firm 1’s total market share is greater under the two-good strategy than under the single-good strategy if and only if \( t_2 > t_1 + \frac{\varphi}{kq_2} \).

This result comes directly from comparing the market share under the single-good strategy to the total market share under the two-good strategy as given in Table 4.
Table 4: Firm 1’s Market Share

As stated in section 3, \( \varphi > 0 \) means that Firm 2 has the advantage in variety while \( \varphi < 0 \) means that Firm 1 has the advantage in variety. Rewriting the condition from Lemma 2 as

\[
q_2 > \frac{\varphi}{k(t_2 - t_1)} \quad \text{if} \quad t_2 > t_1
\]

\[
q_2 < \frac{\varphi}{k(t_2 - t_1)} \quad \text{if} \quad t_2 < t_1
\]

allows for easier analysis. There are four possible combinations to consider:

- Firm 1 has the variety advantage (\( \varphi < 0 \)) and the tariff advantage (\( t_1 < t_2 \));
- Firm 1 has the variety advantage and the tariff disadvantage (\( t_1 > t_2 \));
- Firm 1 has the variety disadvantage (\( \varphi > 0 \)) and the tariff advantage;
- Firm 1 has the disadvantage in both variety and tariffs.

If Firm 1 has both the variety and the tariff advantage, then its combined market share under the two-good strategy is always greater. If Firm 1 has has the variety advantage but the tariff disadvantage, its market share is greater under the two-good strategy only if the (variety) advantage is large relative to the (tariff) disadvantage. If the converse is true and Firm 1 has the variety disadvantage and the tariff advantage, then similarly its market share is greater under the two-good strategy only if the advantage (now in tariffs) is large relative to the disadvantage (in variety). And finally, if Firm 1 has the disadvantage in both respects, then the market share is never greater under the two-good strategy.

<table>
<thead>
<tr>
<th>Firm 1’s strategy</th>
<th>Total demand for Firm 1’s products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sell ( q_l ) only</td>
<td>( \frac{q_2 - q_l}{q_2} - k(1 + t_1)q_2 + k(1 + t_2)q_2 )</td>
</tr>
<tr>
<td>Sell both ( q_h ) and ( q_l )</td>
<td>( \frac{3(q_2 - q_l)}{3(q_2 - q_h)} )</td>
</tr>
</tbody>
</table>

Case 1 (\( q_2 > q_h > q_l \))

| Sell \( q_h \) only | \( \frac{2(q_h - q_2)}{2(q_h - q_2)} - \frac{\varphi - k(1 + t_1)q_h + k(1 + t_2)q_2}{2(q_h - q_2)} \) |
| Sell both \( q_h \) and \( q_l \) | \( \frac{3(q_2 - q_h)}{3(q_2 - q_l)} \) |

Case 2 (\( q_h > q > q_l \))

| Sell \( q_l \) only | \( \frac{2(q_l - q_2)}{2(q_l - q_2)} - \frac{\varphi - k(1 + t_1)q_l + k(1 + t_2)q_2}{2(q_l - q_2)} \) |
| Sell both \( q_h \) and \( q_l \) | \( \frac{3(q_2 - q_l)}{3(q_2 - q_h)} \) |

Case 3 (\( q_h > q_2 > q_l \))

| Sell both \( q_h \) and \( q_l \) | \( \frac{2(q_h - q_2)(q_2 - q_l) - (q_h - q_1)(1 + t_1)q_2 - k(1 + t_1)q_2 - \varphi}{2(q_h - q_2)(q_2 - q_l)} \) |

30
Lemma 2 says that if Firm 1 has a relatively large tariff advantage or a relatively large variety advantage, then its combined market share is greater under the two-good strategy than the market share under the single-good strategy. A big tariff advantage means that Firm 1, with prices less inflated by tariffs, will easily be able to steal market share from Firm 2 by offering a close competitor.34 On the other hand, if Firm 1 offers only a distant competitor (i.e. only the product that is further in quality from Firm 2's product), the quality difference is big enough that Firm 1 simply is not competitive enough and therefore cannot capture quite as much market share.

The variety advantage works similarly. If Firm 1 has a significant variety advantage, it is better able to compete with Firm 2 for market share.35 This competition will be more effectual if Firm 1 exports both goods: in this case, the good that is closer in quality to Firm 2's good can capture a large share of the market, since it has a significant advantage in variety and only a small disadvantage in quality (if Firm 1 sells the lower quality) or price (if Firm 1 sells the higher quality). If, on the other hand, Firm 1 exports only the good that is further in quality from Firm 2's good, then Firm 1 is not as competitive with Firm 2, even with the variety advantage, and cannot capture as much market share.

This provides the information necessary to interpret the following proposition about equations (9) and (10), which give the conditions under which the two-good strategy is at least as profitable as the single-good strategy:

**Proposition 6.** If Firm 1 has both the variety and the tariff advantage over Firm 2, then the range of quality parameters for which its profits from the two-good strategy are greater than profits from the single-good strategy is (weakly) larger.

Having both the tariff and variety advantage, then, means that Firm 1's combined market share under the two-good strategy is greater than its market share under the single-good strategy. Without these advantages, the profit margins under the two-good strategy may not be big enough to outweigh the single-good strategy's profit for some quality parameter specifications. The larger market share associated with the two-good strategy under tariff and variety advantages, however, may be enough so that the two-good strategy dominates the single-good strategy for these same quality parameters.

**Proposition 7.** In Case 1 and Case 2, if the difference in quality between Firm 1's products and Firm 2's product is small enough then the profit from the two-good strategy is greater than or equal to the profit from the single-good strategy for Firm 1.

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34Of course, if Firm 1 is at a tariff disadvantage, then offering a close competitor means that Firm 1 loses even more market share to Firm 2 than it would if it offered only the more distant competitor.

35Indeed, the parameter restrictions for market-wide demand indicate that, if Firm 2's variety disadvantage is big enough, it may have 0 market share at some preferred varieties.
Proof. For Case 1, equation (9) gives the condition under which the two-good strategy is no less profitable than the single-good strategy. The right-hand side is clearly constant in both $q_h$ and $q_l$. The right-hand side is also non-negative, which is shown by contradiction. In order for the right-hand side to be negative, all of the following must hold:

- neither $\varphi$ nor $t_1 - t_2$ are equal to 0,
- $\varphi$ and $t_1 - t_2$ are of opposite sign, and
- $\frac{2}{kq_2(t_2-t_1)} + \frac{\varphi}{kq_2(t_2-t_1)}$.

Taking first and second partial derivatives of the last condition with respect to $kq_2(t_2-t_1)$ and $\varphi$ reveals that $\frac{2}{kq_2(t_2-t_1)} + \frac{\varphi}{kq_2(t_2-t_1)}$ is minimized when $kq_2(t_2-t_1) = \varphi$. But when $kq_2(t_2-t_1) = \varphi$, then $\frac{2}{kq_2(t_2-t_1)} + \frac{\varphi}{kq_2(t_2-t_1)} = 2$. The third condition is therefore violated, and the right-hand side must be non-negative.

If $k(1 + t_1) < 2$ then the left-hand side of the inequality is decreasing in $q_h$ and $q_l$ and approaches 0 as $q_h$ and $q_l$ approach $q_2$. Thus, for any given $q_2$, if $q_h$ and $q_l$ are close enough to $q_2$, the inequality will hold. If $k(1 + t_1) \geq 2$ then the left-hand side is non-positive and equation (9) (weakly) holds.

The proof for Case 2 proceeds analogously.

The intuition is developed using Case 2 as an example. If the quality differences ($q_h - q_2$ and $q_l - q_2$) are small enough, then Firm 1 can benefit from what I refer to as a “buffer product”. With a large quality difference, price competition is not very intense. In this case, Firm 1 is better off selling only its high-quality product. In the presence of minimal price competition, Firm 1 can set a high price, thereby earning a high per-unit profit. At the same time, Firm 2 also sets a relatively high price so that Firm 1 does not lose too much market share due to its own high price. Thus, with a large quality difference, limited price competition allows Firm 1 to earn a high profit margin per unit while maintaining significant market share with only its high-quality product. However, if qualities are close and price competition is intense, then Firm 1 would lose significant market share by selling only its high-quality product and setting a high price (which generates a high per-unit profit) for it. In order to maintain sufficient market share, Firm 1 would have to lower its price, giving up on the high profit margin. Instead, Firm 1 chooses to export both qualities, using the low-quality good as a “buffer product”. This good competes intensely with Firm 2’s product, capturing more market share from Firm 2 than the high-quality product alone could. Meanwhile, the price of the high-quality product does not have to be set quite as low in order for Firm 1 to compete with Firm 2’s product, allowing Firm 1 to still earn a reasonably large per-unit profit on that good.$^{36}$

$^{36}$This intuition is similar to that in Martinez-Giralt and Neven (1988), where duopolistic firms always choose to produce only one horizontally differentiated product in order to relax price competition. The results here, however, are quite different.
To summarize, when quality differences are small, price competition is severe. In this instance, Firm 1 benefits from having a “buffer product,” which competes intensely with Firm 2 for market share. This allows Firm 1 to set a higher price for the protected product that is further away in quality. This combination produces greater profits under the two-good strategy than the single-good strategy.

4.4 Case 3: the $q_h > q_2 > q_l$ Case

In Case 3, there is no “buffer product;” Firm 1’s high-quality product competes with Firm 2’s product from above, and Firm 1’s low-quality product competes with Firm 2’s product from below. Also, in Case 3, Firm 1’s products never compete with each other directly; any competitive effect one product has on the other is only through its effect on Firm 2’s product. This means that Firm 1’s products never internalize their competitive effects on each other, a critical feature of Case 3.

As seen in Section 4.1, when Firm 2 offers the middle quality, none of Firm 1’s strategies can be ruled out. However, it is true that per-unit profits are never greatest when Firm 1 exports both goods.

**Proposition 8.** If $\frac{q_2 - q_l}{q_h - q_2} < \frac{2 - k(1 + t_1)}{1 + k(1 + t_1)}$, then Firm 1 earns its highest per-unit profit $(p_h - c_h)$ in Case 3 when exporting only its high-quality good. If $\frac{q_2 - q_l}{q_h - q_2} > \frac{2 - k(1 + t_1)}{1 + k(1 + t_1)}$, then Firm 1 earns its highest per-unit profit $(p_l - c_l)$ in Case 3 when exporting only its low-quality good.

**Proof.** From Table 5 it is easy to see that the profit per unit for the high-quality good is always greater when selling only the high-quality good than when selling both goods. Similarly, the profit per unit for the low-quality good is always greater when selling only the low-quality good than when selling both goods. Under the two possible single-good strategies, the profit per unit for the high-quality good is greater than the profit per unit for the low-quality good if and only if

$$\frac{2(q_h - q_2) - \varphi + k(1 + t_2)q_2 - k(1 + t_1)q_h}{3(q_h - q_2)} > \frac{(q_2 - q_l) - \varphi + k(1 + t_2)q_2 - k(1 + t_1)q_l}{3(q_2 - q_l)}.$$

This simplifies to $\frac{q_2 - q_l}{q_h - q_2} < \frac{2 - k(1 + t_1)}{1 + k(1 + t_1)}$.\(^\text{37}\) When this expression is true, then the profit per unit when selling only the high-quality good is greater than the profit per unit when selling only the low-quality good. But the profit per unit of selling only the low quality is always greater than the profit per unit on the low-quality good when selling both goods. By transitivity, the profit per unit when selling only the high quality good must therefore be greater than the profit per unit on the low-quality good when selling both goods. And the profit per unit of selling only the high quality is always greater than the profit per unit on the high-quality good when selling both goods. Therefore, under this condition, the greatest profit per unit is earned by

\(^{37}\)When $k(1 + t_1) > 2$, this is never true, since the right-hand side will be non-positive and the left-hand side will be positive.
solving only the high quality good. A *mutis mutandis* argument for the opposite condition completes the proof.

\[
\begin{array}{|c|c|}
\hline
\text{Firm 1’s per-unit profit} & \text{Case 1 \((q_2 > q_h > q_l)\)} \\
\hline
\text{Sell } q_l \text{ only} & \frac{(q_2 - q_l) - \varphi - k(1 + t_1)q_l + k(1 + t_2)q_2}{3(1 + t_1)} \\
\text{Sell both, } q_l \text{ per-unit profit} & \frac{2(q_2 - q_l) - 2\varphi - 3k(1 + t_1)q_l + 2k(1 + t_2)q_2}{6(1 + t_1)} \\
\text{Sell both, } q_h \text{ per-unit profit} & \frac{q_h - q_2 - 2\varphi + k(1 + t_2)q_2 - k(1 + t_1)q_h}{3(1 + t_1)} \\
\hline
\text{Case 2 \((q_h > q_l > q_2)\)} & \text{Sell } q_h \text{ only} \frac{2(q_h - q_2) - \varphi - k(1 + t_1)q_h + k(1 + t_2)q_2}{3(1 + t_1)} \\
\text{Sell both, } q_h \text{ per-unit profit} & \frac{3(q_h - q_2) + (q_2 - q_l) - 2\varphi - 3k(1 + t_1)q_h + 2k(1 + t_2)q_2 + k(1 + t_1)q_l}{6(1 + t_1)} \\
\text{Sell both, } q_l \text{ per-unit profit} & \frac{2(q_2 - q_l) - \varphi + k(1 + t_2)q_2 - k(1 + t_1)q_l}{3(1 + t_1)} \\
\hline
\text{Case 3 \((q_h > q_2 > q_l)\)} & \text{Sell } q_h \text{ only} \frac{2(q_h - q_2) - \varphi - k(1 + t_1)q_h + k(1 + t_2)q_2}{3(1 + t_1)} \\
\text{Sell } q_l \text{ only} & \frac{(q_2 - q_l) - \varphi - k(1 + t_1)q_l + k(1 + t_2)q_2}{3(1 + t_1)} \\
\text{Sell both, } q_h \text{ per-unit profit} & \frac{3(q_h - q_2) - 2\varphi - 3k(1 + t_1)q_h + 2k(1 + t_2)q_2 + k(1 + t_1)q_2 + \frac{(q_h - q_2)(q_2 - q_l)}{q_h - q_l}}{6(1 + t_1)} \\
\text{Sell both, } q_l \text{ per-unit profit} & \frac{2k(1 + t_2)q_2 + k(1 + t_1)q_2 - 2\varphi - 3k(1 + t_1)q_l + \frac{(q_h - q_2)(q_2 - q_l)}{q_h - q_l}}{6(1 + t_1)} \\
\hline
\end{array}
\]

Table 5: Firm 1’s Profit Margins

Intuitively, if the quality difference between \(q_h\) and \(q_2\) is relatively large compared to the difference between \(q_2\) and \(q_l\), then competition between the first pair \((q_h\) and \(q_2\)) is less intense than between the second pair \((q_2\) and \(q_l\)). Firm 1 is free to set a high price for its high-quality product and consequently to earn a large profit per unit. Since competition between the low-quality good and Firm 2’s product is more intense, Firm 1 is forced to lower its price and earn a smaller profit per unit on the low-quality good.

Profits per unit on the high-quality will also be lower when selling both goods because Firm 1 does not fully internalize the competition that it creates for itself by selling both goods. (In this sense, Firm 2’s product is the “buffer product” in this case.) If Firm 1 sells both of its goods, then the low-quality good competes with Firm 2’s good. This price competition causes Firm 2 to set a low price, which in turn forces Firm 1 to lower the price on its high-quality good in order to maintain sufficient market share for that good. This lowers the profit per unit when compared to selling only the high-quality good. Thus when the difference between \(q_h\) and \(q_2\) is large, the greatest per-unit profit is when Firm 1 sells only its high-quality good. Similar reasoning explains why selling only the low-quality good generates the greatest profits when the difference between \(q_2\) and \(q_l\) is larger.

According to Proposition 8, the greatest profit per unit is generated under one of the two single-good strategies. Then the only situation in Case 3 in which Firm 1 will choose to export both products is one where this strategy allows Firm 1 to capture enough market share to make up for the lower per-unit profits. The
necessary (but not sufficient) conditions for the two-good strategy to deliver the greatest profits are therefore:

- If selling only the low-quality good delivers the highest profit per unit, the combined market share under the two-good strategy is greater than the market share under the low-quality only strategy, and
- If selling only the high-quality good delivers the highest profit per unit, the combined market share under the two-good strategy is greater than the market share under the high-quality only strategy.

Comparing the market shares in Table 4 produces the following proposition:

**Proposition 9.** Firm 1’s combined market share under its two good strategy is greater than its market share under the high-quality only strategy and the low-quality only strategy, respectively, when

\[
k(1 + t_2)q_2 > k(1 + t_1)q_l + \varphi \\
q_h - q_2 + k(1 + t_2)q_2 > k(1 + t_1)q_h + \varphi.
\]

Clearly, if \( t_1 < t_2 \) and \( \varphi \leq 0 \), then the first expression will necessarily be satisfied and Firm 1’s market share under the two-good strategy is bigger than the market share under the high-quality only strategy in Case 3.\(^{38}\) The second expression will necessarily be satisfied when Firm 1 has the tariff and variety advantage (as with the first expression) and if \( 1 - k(1 + t_1) > 0 \).

In addition, when Firm 1 has the tariff and variety advantage, then the smaller the quality differences between Firm 1 and Firm 2, the greater the difference in market shares will be. This is seen by taking the derivative of the expressions for market share in Table 4 with respect to the quality differences \((q_h - q_2)\) and \((q_2 - q_l)\).

This relation between the market shares under each strategy supplies the intuition for comparing profits under each strategy. Suppose, for example, that selling only the low-quality good generates the greatest profit per unit for Firm 1. Then Firm 1’s market share under the two-good strategy must be greater than its market share under the low-quality strategy in order for the two-good strategy to be more profitable. This is possible only if, by also introducing its high-quality good to the market, Firm 1 is able to steal a significant portion of Firm 2’s high-valuation customers (those customers with high \( \theta \) values). This will tend to happen the less differentiated in quality are Firm 1’s high-quality product and Firm 2’s product, as this will increase competition and make the high-quality product more attractive to consumers (since it is higher in quality and, due to intense competition, relatively low in price).\(^{40}\) Thus the results here are similar to the results

\(^{38}\)Having both the tariff advantage and the variety advantage is sufficient but not necessary; it is possible for the market share under the two-good strategy to be greater even if Firm 1 has neither the tariff nor the variety advantage.

\(^{39}\)Again, this is sufficient but not necessary.

\(^{40}\)Even if \( t_2 < t_1 \), and \( \varphi > 0 \), then it is possible that Firm 1’s combined market share will be greatest under the two-good strategy than under either single-good strategy. This would require a very large quality differentiation between Firm 1’s products and Firm 2’s product.
in Cases 1 and 2: when Firm 1 has both the variety and tariff advantages ($\varphi \leq 0$ and $t_2 > t_1$), then if the quality difference between Firm 1 and Firm 2 is small enough, the two-good strategy will be more profitable (in Cases 1 and 2) or capture a greater market share (in Case 3).

5 The Automobile Market in Mexico

The analytic results in the foregoing section yield testable predictions. The automobile market in Mexico affords a suitable environment for the empirical test. Until the early 1990s, Mexico imported very few automobiles. Since that time, it has signed numerous free trade agreements, which have resulted in numerous changes to the tariffs on automobiles. These changes have been phased in at different times for different trading partners, producing significant variation in the tariff levels. Furthermore, some auto exporters such as China and South Korea have not benefitted from any tariff liberalization. In addition, the automobile market is oligopolistic, and each car model is typically offered in a number of trim levels or with a number of options packages at multiple quality levels.

Although it has grown significantly, the Mexican auto market is still a relatively small piece of the global market. In 2008, according to Standard & Poor’s/Bloomberg Businessweek, global light vehicle sales totaled 66.785 million. Light vehicle sales in Mexico in the same year were just over 1 million, accounting for 1.5% of world sales. This was significantly less than the U.S., European, Chinese, and Japanese markets (19.8%, 27.7%, 8.9%, and 7.6% respectively). It was also less than the Brazilian, Indian, and Korean markets (3.3%, 2.2%, and 1.9% respectively), although less markedly so. While still accounting for a relatively small portion of the world market, Mexico’s auto market has grown and changed drastically over the past 30 years.

In 1962, in an attempt at import substitution and industrialization (ISI), Mexico banned auto imports and instituted a high local content requirement for cars build in Mexico. A 1977 decree reinforced these policies with a balanced trade requirement. While this policy did induce some foreign auto manufacturers to build production and assembly plants in Mexico in order to access the Mexican market, many stayed away. The Mexican auto industry managed to produce just 500,000 cars in 1980, and even then the production process was inefficient and the output of low quality (Hufbauer and Schott, 2005; Wall Street Journal Jan. 1984). In 1983, according to the Wall Street Journal, the auto industry in Mexico was producing an average of just 13,000 on each of 19 lines. Even in 1989, almost 30 years after the ban, Mexico imported only one car model (the Oldsmobile Cutlass). Only after the Mexican Automotive Decree liberalized these policies in 1989 (Hufbauer and Schott, 2005) did Mexico start importing significant numbers of cars in the 1990s.

Both the automobile industry and the new car market in Mexico have been impacted by numerous trade agreements that were negotiated in the two decades since the 1989 Decree. In 1994, the North American
Free Trade Agreement (NAFTA) entered into force, promising to lower tariffs on trade between Mexico, the U.S., and Canada over the next 15 years. Mexico subsequently pursued many other trade deals. The car market was particularly impacted by the EC-Mexico Free Trade Agreement, which entered into force in 2000, and the Japan-Mexico Free Trade Agreement, entering into force in 2005. By 2010, Mexico also had specific trade agreements with Chile, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Israel and was also a member of the Global System of Trade Preferences among Developing Countries (GSTP) and the Latin American Integration Association (ALADI). While most of these agreements have minimal impact on the automobile sector in Mexico and no GSTP tariff concessions have been made on automobiles (there are some on trucks and buses), the ALADI members have agreed to significant reciprocal tariff concessions on automobiles.

The market for new automobiles in Mexico grew rapidly during the first two decades of imports, from 1989-2009. Sales of new cars (exclusive of light trucks) in Mexico were just 271,260 in 1989 but more than doubled to 585,618 by 2008. The intervening years included periods of both significant growth in sales (the early 1990s, the early 2000s) and decline (the peso crisis in 1995, the years 2005-2008).

Car production in Mexico grew even faster than car sales. In 1989, Mexico produced 435,250 cars (exclusive of light trucks). This figure grew to 854,818 by 1997 and, after a slight dip from 2002 to 2004, to 1,312,024 in 2007. Indeed, following the unsuccessful ISI policies of the 1960s and 1970s and the subsequent drastic increase in auto imports in the 1990s, Mexican auto production finally exceed sales again in 2003 (Hufbauer and Schott, 2005). A large portion of these cars were made for export. For example, in 2007 Mexico produced almost 343,000 Volkswagen Jetta cars but Mexican consumers purchased only about 70,000 of them. Even though some of the models most popular with Mexican consumers are produced locally, including the VW Jetta, the Chevrolet Chevy, and the Nissan Tsuru, a majority of the car models sold in Mexico are still imported.

While both sales and production in Mexico have grown significantly over the past two decades, another measure provides even more stark evidence of the growth of the Mexican auto market. Over just two decades, the choices available to new car buyers in Mexico increased manyfold. In 1990, only five auto manufacturers were actively selling vehicles in Mexico: Chrysler, Ford, General Motors, Nissan, and Volkswagen. These manufacturers sold 12 different makes (brands) of car, with Chrysler selling Chrysler, Dodge, and Plymouth cars, Ford selling Ford, Lincoln, and Mercury cars, and GM selling Buick, Cadillac, Chevrolet, and Oldsmo-
<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Car Brands</th>
<th>Entrants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>11</td>
<td>Jaguar, Peugeot</td>
</tr>
<tr>
<td>1999</td>
<td>13</td>
<td>Volvo</td>
</tr>
<tr>
<td>2000</td>
<td>14</td>
<td>Renault, Saab, Seat</td>
</tr>
<tr>
<td>2001</td>
<td>17</td>
<td>Cadillac, Mini, Toyota</td>
</tr>
<tr>
<td>2003</td>
<td>23</td>
<td>MG Rover, Mitsubishi, Pontiac</td>
</tr>
<tr>
<td>2004</td>
<td>23</td>
<td>Smart; Pontiac (exit)</td>
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<tr>
<td>2005</td>
<td>24</td>
<td>Acura</td>
</tr>
<tr>
<td>2006</td>
<td>31</td>
<td>Bentley, Fiat, Mazda, Mercury, Pontiac, Subaru, Suzuki</td>
</tr>
<tr>
<td>2007</td>
<td>31</td>
<td>Alfa Romeo; MG Rover (exit)</td>
</tr>
<tr>
<td>2008</td>
<td>35</td>
<td>Faw, Ferrari, Maserati, Maybach</td>
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</table>

Table 6: Car Brands Available in Mexico

<table>
<thead>
<tr>
<th>Year</th>
<th>Compact</th>
<th>Midsize</th>
<th>Luxury</th>
<th>Sports</th>
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<tr>
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<td>5</td>
<td>23</td>
<td>21</td>
<td>11</td>
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<td>1999</td>
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<td>2001</td>
<td>16</td>
<td>32</td>
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<td>2004</td>
<td>22</td>
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<td>2005</td>
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<td>2007</td>
<td>34</td>
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<td>19</td>
</tr>
<tr>
<td>2008</td>
<td>38</td>
<td>37</td>
<td>68</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 7: Mexico: Number of Models per Year by Segment

Not only did many new firms enter the Mexican auto market, most of them introduced multiple car models. Table 7 gives the number of models available for sale in each segment of the Mexican auto market. While the choices for consumers increased in each of the four segments, those in the compact and luxury segments multiplied especially rapidly.

44 The number of Porsche cars sold was very small (fewer than 100) and remains small in 2009. If light trucks are included, the number of firms active in Mexico in 1997 was 10, as a small number of Land Rovers were also sold by that time.
45 Three car makers, Alfa Romeo, MG, and Infiniti, both entered and exited the Mexican market between 1990 and 2009.
Even with this remarkable rate of entry, in 2008 well over half of the Mexican new car market was dominated by just three producers. Together, Nissan, General Motors, and Ford accounted for 68% of the market (Datamonitor 2008). The most popular cars in that year were the Nissan Tsuru (6.75% of the light vehicle market), the VW Jetta (6.37%), and the Chevrolet Chevy (a rebadging of the Opel Corsa, with 5.5%). In both 1990 and 1997, two of the three most popular vehicles were the Nissan Tsuru (14.73% in 1990, 7.96% in 1997) and the VW Beetle (15.81% in 1990, 6.84% in 1997). While the most popular cars have not changed much over the past two decades, the greater range of choices available to consumers is still evident in the much smaller market share that these popular cars had in 2008 compared to 1997.

5.1 Data

The Mexican Automobile Dealer Association (Asociación Mexicana de Distribuidores de Automotores A.C., AMDA) compiles raw monthly data on the prices of the makes, models, and brief descriptions of new cars for sale at dealerships throughout Mexico. These data also assigns each car to one of the following categories: subcompact, compact, luxury, or sports. Using this data, I constructed two different count variables of the number of quality levels available for each product. Each car model is considered a separate product, while the multiple trims and packages available are different quality levels of the same product. Count Variable 1 counts each distinct combination of trim level, body style, and transmission as a separate quality level, while Count Variable 2 counts only distinct combinations of trim level and body style. Model years in Mexico closely track those in the United States, and therefore multiple model-years were often sold in any given calendar year. If two model-years of an otherwise identical version were sold in the same calendar year, then these were counted as a single version of the car.

The specifications of each car, including physical dimensions, horsepower, engine displacement, and fuel efficiency, are gathered primarily from online databases. Fuel efficiency data comes from the U.S. Department of Energy for cars also sold in the U.S. and from online databases for other cars. These data are used as a proxy for the quality of a car.

Using this data, I calculate a series of variables to represent the degree of quality differentiation between a product and its competitors. This variable is calculated as the absolute value of the difference between the quality of a given model and the average of the same measure for all other cars in the same segment in the same year. While the physical dimensions do not vary much across versions of a single model-year, other

\[ \text{Quality Differentiation} = |\text{Model Quality} - \text{Average Quality of Segment}| \]

---

\[ \textbf{46}\text{ The models in the AMDA data are consistent with data from Ward's Automotive, which lists sales at the make-model level but not the make-model-trim level.} \]

\[ \textbf{47}\text{ For cars that are also sold in the U.S., the specifications come from Edmunds. For cars not sold in the U.S. but sold in Canada, Europe, or Brazil, the data come from the auto specifications databases automobile-catalog.com, auto-types.com, and ???. In most cases, data from two different sources were compared to verify accuracy. Finally, for cars produced and sold only in Mexico, the data are from car reviews in Reforma, a Mexico City daily newspaper and from online listings of used cars for sale.} \]
attributes such as horsepower and fuel efficiency do. To account for these difference within a model-year, I calculate the degree of quality difference using the median, mean, minimum, and maximum quality variable for each model-year. As expected, there is a very high correlation between the variables quality difference variables calculated using these various quality measures per model.

The data on tariffs are gathered from the World Integrated Trade Solution (WITS), which incorporates data from the UN Comtrade database (from the United Nations Statistical Division), the TRAINS database (from the United Nations Conference on Trade and Development), and the IBD and CTS databases (from the World Trade Organization). Since Mexican auto tariffs are based on engine displacement, tariff rates are assigned to each observation based on the year of sale, country in which the vehicle was assembled, and engine size. For example, the tariff rate in 2001 on any car imported from Canada was 4.4%, while the tariff rate in 2003 on cars with engine displacements between 1001 and 1500 cc from Japan was 30%. Vehicle assembly location is based on data available on corporate websites and in newspaper and car magazines.

There are a total of 1,235 observations at the year-make-model level, for the years 1997 and 1999 through 2008. For 26 of these observations (3 car models), complete data on specifications (quality proxies) is not available; these are not included in the summary data or the empirical estimates. Summary statistics are provided in Table 8.

<table>
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<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
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<td>5.86</td>
<td>6.11</td>
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<tr>
<td>Count Variable 2</td>
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<td>2.95</td>
<td>2.22</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Ad valorem tariff</td>
<td>1209</td>
<td>.106</td>
<td>.140</td>
<td>0</td>
<td>.5</td>
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<td>Car Size (L x W x H) / 1000</td>
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<td>107.6</td>
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</tr>
<tr>
<td>Engine size</td>
<td>1209</td>
<td>2.79</td>
<td>1.25</td>
<td>.6</td>
<td>8.4</td>
</tr>
<tr>
<td>Price (thousands of pesos, base year 2005)</td>
<td>1209</td>
<td>498762.5</td>
<td>558846.2</td>
<td>71571.2</td>
<td>6104374</td>
</tr>
<tr>
<td>Difference between quality measure and average for segment</td>
<td>1209</td>
<td>5.4</td>
<td>4.3</td>
<td>.015</td>
<td>33.2</td>
</tr>
<tr>
<td>Wheelbase</td>
<td>1209</td>
<td>49.9</td>
<td>52.0</td>
<td>.027</td>
<td>335.3</td>
</tr>
<tr>
<td>Horsepower</td>
<td>1209</td>
<td>3.05</td>
<td>2.81</td>
<td>.004</td>
<td>20.08</td>
</tr>
<tr>
<td>Engine size</td>
<td>1209</td>
<td>.747</td>
<td>.705</td>
<td>0</td>
<td>5.15</td>
</tr>
</tbody>
</table>

Table 8: Summary Statistics

48Both qualitative and quantitative results were similar when those observations were included in the analysis.
6 Empirical Analysis of Product Proliferation

The focus of the theoretical model is on the effect of tariffs on product proliferation. The analytical results of section 4 provide two testable hypotheses. The first is that product proliferation is greater the lower is the tariff. The second is that product proliferation is greater the smaller is the degree of quality differentiation.

To examine these hypotheses empirically, I regress the count of quality levels (versions) of each model-year on the tariff level and the degree of quality differentiation. Both variables should have a negative effect on the number of quality levels available. In order to control for variety and the growth of market size, I also include brand and year dummies. Because the right-hand side variable is discrete, I test assuming both Poisson and negative binomial distributions of the count variable. The resulting estimating equation is

\[
\log (E[Count_{i,y}]) = \beta_0 + \beta_1t_{j,y} + \beta_2|q_{i,y} - \mu_{q,s,y}| + \gamma \bar{y} + \kappa \bar{b}
\]

where \(Count_{i,y}\) is the number of quality levels offered in year \(y\) of make/model \(i\), \(t_{j,y}\) is the tariff rate applied to auto imports from country \(j\) (the origin of make/model \(i\)) in year \(y\), \(q_{i,y} - \mu_{q,s,y}\) is the degree of quality differentiation, \(\bar{y}\) is a series of dummy variables (fixed effects) for the year, and \(\bar{b}\) is a series of dummy variables (fixed effects) for the brand (make).

6.1 Results

Table 9 presents estimates of the baseline model, which does not include the degree of quality differentiation variables. I use the baseline model to determine which distributional assumption is the most appropriate, and test the effect of tariffs on both constructed Count variables. Results are reported in Table 9; the first four columns use the count variable that takes transmission type into account, while the last three columns use the variable that counts only trim and body type as a distinct quality level. For each count variable, the first column reports the results of a Poisson estimation with standard errors adjusted by the Pearson chi-squared statistic to account for overdispersion of the dependent variable. The second column reports the results of a truncated Poisson estimation with clustered standard errors, while the third and fourth columns report the results of a truncated negative binomial estimation with clustered standard errors. The second and third columns use a truncated distribution to account for the fact that there are no observations with a count of 0. All estimations include brand-level fixed effects to account for any corporate strategies regarding market penetration that are common across models. Five of the estimations include year fixed effects to account for the effects of overall economic environment and population growth.\footnote{Estimating the negative binomial with both year and brand fixed effects for Count Variable 2 did not produce convergence and hence is not reported.}
In all cases, the tariff rate has the expected negative sign, indicating that a lower tariff induces an increase in the number of versions available. In all but one case, the estimated coefficient is significant at either the 1% or the 5% level. Not surprisingly, the coefficient on the tariff is larger (in absolute value) for Count Variable 1, which considers each transmission type as a separate quality level and would therefore typically see a bigger increase in the number of versions whenever a new trim is made available with both automatic and manual transmission.

Three pieces of evidence support use of the negative binomial assumption for Count Variable 1: the distribution of the variable itself (see Figure 6), the fact that its variance is significantly greater than its mean, and the high $\alpha$ estimate in the third column and fourth columns (an indication of overdispersion). This is not the case for Count Variable 2. In that case, the variance is only slightly bigger than the mean, the distribution of the variable itself (see Figure ??) is closer to the Poisson distribution, and the $\alpha$ estimate is ambiguous (it is both smaller and the confidence interval ends just above 0).
<table>
<thead>
<tr>
<th></th>
<th>Count Variable 1</th>
<th>Count Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poisson</td>
<td>Poisson</td>
</tr>
<tr>
<td></td>
<td>(truncated)</td>
<td>(truncated)</td>
</tr>
<tr>
<td></td>
<td>(adjusted SE)</td>
<td>(clustered SE)</td>
</tr>
<tr>
<td><strong>Tariff Rate</strong></td>
<td>-.86** (.210)</td>
<td>-1.17** (.407)</td>
</tr>
<tr>
<td><strong>Year FE</strong></td>
<td>yes (.585)</td>
<td>no (.407)</td>
</tr>
<tr>
<td><strong>Brand FE</strong></td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>-.501 (.648)</td>
<td>-17.22** (1.55)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td>1209</td>
<td>1209</td>
</tr>
<tr>
<td><strong>ln(L)</strong></td>
<td>-3671.09</td>
<td>-2900.45</td>
</tr>
<tr>
<td><strong>alpha (SE)</strong></td>
<td>.45 (.10)</td>
<td>.41 (.09)</td>
</tr>
</tbody>
</table>

**Significant at the 1% level; * significant at the 5% level.**

Table 9: Baseline Model: Poisson and Negative Binomial Distributions
I incorporate the quality difference variables into the estimation to test the effect of degree of quality differentiation on the number of varieties available. Since each variable is a proxy for quality, I estimate them separately as well as together. Recall that the quality difference variables are calculated relative to cars in the same market segment, and therefore measure the degree of quality difference only with competing products, not with all cars on the market.

The results are given in Table 10. While the coefficients, when estimated individually, have the expected negative sign, they are generally not statistically significant. The horsepower of the car is significant at the 5% level but small in magnitude. The engine size (in liters) is significant at the 1% level and also of larger magnitude. Together, these suggest that the power of a car, which is often characterized by engine displacement and horsepower, has an effect on product proliferation. Specifically, as the analytic results predict, a small difference between the power of a car and its competitors encourages product proliferation.\footnote{While torque is actually the primary determinant of a car’s pickup, horsepower and engine size are more frequently referenced in advertising and are therefore critical to perceptions of engine power.}
According to the estimation results, neither the difference in wheelbase nor the difference in fuel efficiency have an impact on the number of versions available. The wheelbase of a car is closely related to its physical size and also determines its turning radius. The fact that is does not have a significant effect is likely an indication that this is not a good proxy for quality. Some consumers may prefer a bigger car while others prefer a smaller car, suggesting that wheelbase and size contribute more to horizontal differentiation than quality differentiation.

The lack of significance for the fuel efficiency variable is more surprising. The difference between a model’s fuel efficiency and the average fuel efficiency for other cars in the same segment does not have a significant effect on the number of versions offered for sale. It is possible, however, that while consumers do not perceive fuel efficiency itself as a measure of quality, they may put more emphasis on fuel efficiency when the price of gasoline is high. To test for this effect, I construct a variable that measures dollars per gallon using the fuel efficiency and the pump price of gasoline in Mexico (in U.S. dollars) per liter. The quality difference variable is then constructed as for other quality measures. Using this variable as the measure of quality differentiation produces a much different result. When Count Variable 1 is used as the outcome, the coefficient on the tariff variable is -1.21 (clustered standard error of .524), which is significant at the 5% level. The coefficient on the quality differentiation variable (difference of dollars per mile from average) is -7.55 (clustered standard error of 4.40), which is significant at the 10% level. Using dollars per mile driven

\[ \text{dollars per mile} = \text{fuel efficiency} \times \text{pump price of gasoline} \]

The data for fuel prices are from German Agency for Technical Cooperation. Since data are available only for every other year; in constructing the “dollars per mile” variable, I use the price for a given year both for that year and for the prior year.

---

Supplementary Table 10: Effect of Quality Differences: Count Variable 1

<table>
<thead>
<tr>
<th>Horsepower</th>
<th>Fuel Efficiency</th>
<th>Wheelbase</th>
<th>Engine Size</th>
<th>Full Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tariff Rate</td>
<td>-1.18*</td>
<td>-1.16*</td>
<td>-1.16*</td>
<td>-1.18*</td>
</tr>
<tr>
<td></td>
<td>(.522)</td>
<td>(.540)</td>
<td>(.530)</td>
<td>(.524)</td>
</tr>
<tr>
<td>Horsepower</td>
<td>-.003*</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(.001)</td>
<td></td>
<td></td>
<td>(.002)</td>
</tr>
<tr>
<td>Fuel Efficiency</td>
<td>-.02</td>
<td></td>
<td></td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>(.001)</td>
<td></td>
<td></td>
<td>(.027)</td>
</tr>
<tr>
<td>Wheelbase</td>
<td>-.006</td>
<td>-</td>
<td>-1.79</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.007)</td>
<td></td>
<td>(.068)</td>
<td></td>
</tr>
<tr>
<td>Engine Size</td>
<td>-230**</td>
<td>-</td>
<td>-179</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.068)</td>
<td></td>
<td>(.110)</td>
<td></td>
</tr>
<tr>
<td>Year FE</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Brand FE</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Constant</td>
<td>-18.16**</td>
<td>-18.48**</td>
<td>-18.34**</td>
<td>-17.80**</td>
</tr>
<tr>
<td></td>
<td>(1.30)</td>
<td>(9.65)</td>
<td>(1.11)</td>
<td>(8.59)</td>
</tr>
<tr>
<td>Observations</td>
<td>1209</td>
<td>1209</td>
<td>1209</td>
<td>1209</td>
</tr>
<tr>
<td>ln(L)</td>
<td>-29.6609</td>
<td>-29.6545</td>
<td>-29.6691</td>
<td>-29.5263</td>
</tr>
<tr>
<td></td>
<td>-29.5190</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>alpha</td>
<td>.398</td>
<td>.408</td>
<td>.410</td>
<td>.394</td>
</tr>
<tr>
<td></td>
<td>(.088)</td>
<td>(.087)</td>
<td>(.088)</td>
<td>(.086)</td>
</tr>
</tbody>
</table>

** Significant at the 1% level; * significant at the 5% level.
to measure the quality difference clearly produces a much more significant estimate. This estimate suggests that a large degree of quality differentiation, at least as measured by dollars per mile driven, leads to less product proliferation. Using Count Variable 2, the coefficient estimate on the quality difference variable is not statistically significant: the estimate is -5.6, with a standard error of 4.35.

In the full model, which includes all four measures of quality differences, none of the coefficients on the quality difference variables are significant. The coefficient on the applied tariff remains both statistically significant and of the same magnitude. The quality difference variables have fairly high correlations. In particular, engine displacement and horsepower have a correlation of .73. This high degree of collinearity likely explains the lack of significance when all four of the quality difference variables.

Repeating the estimations in Table 10 using Count Variable 2 as the outcome variable and a zero-truncated Poisson distribution assumption produced qualitatively similar results. As in the baseline model, the coefficient on the tariff variable is significant but smaller than the estimate when Count Variable 1 is the dependent variable. The estimated coefficients for the quality difference variables are also similar in both magnitude and significance.

7 Conclusion

This paper considers how many quality levels a duopolistic firm exports to a given market. Products are differentiated in two dimensions, variety and quality, both of which are fixed to emphasize that a firm selects from its existing product line when choosing the products to export to a small foreign market. I consider only those parameter value for which demand is market-wide.

The firm chooses whether to export one or more quality levels of its product. If it exports only one, it chooses the one that is more differentiated from its competitor’s quality. If the firm has a tariff preference and if quality differentiation is not too great, then exporting both products will be optimal. If qualities are close enough, then the firm can benefit from having a "buffer product," which shields the firm’s other product from severe competition. But if qualities are too far apart, then there is no need for a buffer product. This result is somewhat counter-intuitive, in that even when the firm’s qualities are adjacent (not separated by a competitor’s product), the firm may not always find it optimal to quality discriminate.

The analysis in this paper suggests a number of additional directions for inquiry: extending the analysis to encompass more of the parameter space (i.e. to consider cases when demand is not market-wide), permitting each firm to have multiple (fixed) quality levels from which it must choose the appropriate number, and allowing some consumers to choose to purchase nothing. The results also demand an empirical application to verify whether an exporting firm does indeed sell a greater portion of its product line when there is less
quality differentiation and when its tariffs are lower.

References


