Shipping the good apples under strategic competition[*]

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Abstract

Multinational firms produce a product of which a fraction is a "dud" or "reject" or "seconds," i.e., that has lower value than "firsts." A firm simultaneously chooses how much to produce and what fraction of their first and seconds to export: a model of "shipping the good apples" with strategic competition. Exporting good apples affects both the domestic price of good and bad apples. Despite the consumers' lament of shipping the good apples it is found that domestic consumer welfare increases with exporting. It is also is found that firms may ship more of the "bad" apples than the good ones even though there is a price premium for high quality in the export market. The key is the export market price premium relative to the domestic market.

Keywords: Market power, Cournot, quality, trade.
JEL classification: D3, F12

1 Introduction

The Alchian and Allen (1964) theorem[1] is popularly known as "shipping the good apples" as a result of Borcherding and Silberberg (1978) quoting a Seattle Times article in which a consumer laments the lack of good, locally produced apples:

> Why are Washington apples in local markets so small and old-looking? The dried-up stems might seem they were taken out of cold storage from some gathered last year....Where do these big Delicious apples go? Are they shipped to Europe, to the East or can they be bought here in Seattle?

This effect of best apples being exported while the "seconds" stay at home often resonates with many because they have seemingly observed this effect in their own experiences. This casual empiricism has been confirmed with observed instances including examples cited in Creane and Jeitschko (2006) cite: roses in Tanzania, coffee in Indonesia, and mangoes and tea in India. A particularly interesting example was of Chinese citizens buying Chinese products while vacationing in Japan so as to get the higher quality model, including toilet seats (Beijing Review (2015)).[2] This theoretical result has gather recent empirical interest because of Hummels and Skiba (2004) empirical testing of the phenomenon in international trade and the subsequent empirical papers.

The Alchian-Allen effect has been extensively studied theoretically, but surprisingly, the attention has been on competitive markets, though the phenomenon of bad apples (fixed fraction of 'seconds' from production) and disproportionately exporting the good apples can occur in non-perfectly competitive markets perhaps including Alchian and Allen's (1964) warning to be "more careful buying leather goods in Italy than when buying Italian exports

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[1] Borcherding and Silberberg (1978) present the theorem as "a common charge on two substitute goods leads, real income held constant, to a relative increase in the consumption of the higher to lower quality commodity." In trade context it is roughly that, in competitive markets, adding an identical constant marginal cost to the transportation of two products that differ only in quality results in the higher quality product being exported, while the low quality remains.

[2] From Beijing Review (2015): "The Hangzhou-based toilet lid manufacturer has admitted that ...[t]oilet seats on the Japanese market are therefore of a higher quality than their counterparts sold in China under the same brand..."

[at home];". For example, the toilet seat in question was a specific brand. Likewise, the Beijing Review (2015) article noted several other *branded* Chinese products being bought in Japan, suggesting market power. Indeed, the sorting of product into higher and lower quality has an established history with name brands. For example, famous Bordeaux wineries (as well as others like *Opus One*) have first and "second wine" (or third, etc.) where the latter are the grapes deemed of inferior quality, sometimes varying from year to year as to how much appears as a first growth (Wikipedia (2017)). Likewise, many manufacturers have factory seconds, minor imperfections, and factory refurbished products.[3] A poorly attempted sampling of the *different* products on Sierra Trading Post seconds (461 products), found 6/10 imported seconds.[4] Finally, while roses, mangoes, coffee etc. are seemingly competitive markets, often the export is coordinated through cooperatives with real market power (e.g., National Federation of Coffee Growers of Colombia - "Juan Valdez" Norton and Dann (2013)). That is, "seconds" are a phenomenon not only in competitive markets and are sometimes exported.

This paper examines the Alchian-Allen effect but in oligoolistic rather than competitive markets to study the extent the effect carries over and more generally the Economic effects of trade. Specifically, for each firm, a fraction of its output is a "second" (e.g., inferior apples or grapes, blemished, or in some way not meeting first grade). The firm competes in international trade with other firms who also have a fraction of their production being considered not first class. Starting with a benchmark (monopoly in autarky), it is found that increasing the value for the low quality good, could reduce total output. The reason turns on the marginal buyer of high quality, who determines the price for high quality. This buyer is indifferent between buying high and low quality. Thus, holding constant output, an increase in the value of low quality while it increases the price for low quality (reducing the surplus

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[3]Typing into google "Factory seconds b..." completes with "boots" (e.g, Timberland, interestingly the seconds were imported), "Buckle", "Blundstone", "bumper plates" (i.e., weightlifting plates) and somewhat worryingly, "bullets."

[4]http://www.sierratradingpost.com/2nds~g~2314/ (April, 2017): 1. Jura-Capresso machine, Switzerland; 2. Timberland boots, India; 3. Mountainsmith bag, China; 4. Lamson Fly-wheel, USA; 5. Carhartt work jeans, Nicaragua; 6. Wilderness Systems kayak, USA; 7. Smartwool socks, USA; 8. WellnessMats, USA; 9. Carhartt jacket, Mexico; 10. Neon Buddha dress, Thailand

from buying low quality), the marginal high quality buyer's value for low quality increases more than the price of low quality. This is because, the price for low quality is determined by the marginal buyer of low quality (and so the marginal buyer overall), who has a smaller value from the increase in quality than the marginal high quality buyer. Thus, to keep the marginal buyer of high quality buying high quality, the price of high quality must fall. The optimal adjustment by the firm, then, can be to reduce output to offset the decrease in the price of high quality. As a result, it is possible that an increase in the value of low quality could reduce the firm's profits. Interestingly, in this case consumer surplus also decreases and so welfare. The finding in models of quality discrimination (Mussa and Rosen (1978)) that a monopolist enlarges the quality spectrum compared to the social optimum, may drive the profit result, but the consumer welfare result is less clear. Of course, the monopoly models (but not oligopoly models, see discussion below) assume the firm has complete control over the quality levels, which the above examples show is not always true for firms. In addition, the result that increases in the value of low quality could reduce consumer welfare can hold in oligopoly as well.[5] On the other hand, an increase in the "dud" rate (fraction of lower quality) can induce the firm to increase production.

The model is then expanded to allow the firm ("domestic") to export into a market ("export") in which it competes with a second firm from a third country ("foreign"). with any other firms. In this model, the "shipping the good apples" effect holds when the export country has identical demand to the domestic country, where the effect is defined when a country proportionately exports more of its high quality product instead of its low quality product. This is the criterion rather than in absolute terms since the bad apples (or duds) are usually thought of as a smaller percentage of total production. That is, the measure of shipping the good apples used here is the relative proportion exported of the type of good. There are many ways to introduce heterogeneity between the countries, some with obvious affects (e.g., making the export market have stronger demand for low quality increases the amount of low quality exported). The heterogeneity here is to consider an export market

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[5]The standard assumption in oligopoly models is that there are fixed levels of quality a firm can choose.

that is scaled up or down by a constant k as compared to the domestic market. That is, both demand for high and low quality are change by the same proportion. When the export country is scaled down relative to the domestic market (so that *both* high and low quality demand decrease proportionately and the implication is not obvious), there comes a point in which the firm exports a greater fraction of low quality apples than high quality apples. Further, the export country can be eighty or ninety percent of the domestic market and this occurs. The reason is that to the firm, while exporting another bad apple reduces what it can sell the good apple for in the export market, it raises the price in the domestic market: the relative price mark-up across markets are what matter. As a result, as k decreases, the export price for quality *increases*.[6] However, note that with positive transport cost, the export market can be "smaller" than the domestic market – that is, has a lower willingness-to-pay – and still there can be the shipping of the good apples. Finally, when $k < 1$ and increase in transport cost, leads to a reduction in the fraction of good apples exported.

A second result is that domestic consumer surplus always increases with exporting, regardless of whether there is shipping the good apples or shipping the bad apples. That is, despite the Seattle consumers' lament, in an oligopolistic model they would benefit from shipping the good apples. This is true even though marginal cost of production are constant (so in a one good world exporting has no effect on consumer surplus). When there is shipping of the good apples, total output on the domestic market *increases* over autarky. Thus, though consumers lose disproportionately the "good" apples, there are more apples on the domestic market pushing down the bad apple price and as a result, the good apple price to consumers' benefit. Note that when there is shipping of the good apples to an export market that is smaller than the domestic market ($k < 1$), total production by the monopolist may not increase proportionately with the additional market (that is, less than $1 + k$). Consumers still benefit when there is shipping of the bad apples because there are disproportionately more good apples on the home market. Specifically, when there is shipping of the bad ap-

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[6]As there is competition in the export market, the price of both goods is lower than in the domestic market. However, if the model is changed so that the domestic firm is a monopoly in the export market as well, then the export price for high quality is greater than the domestic price when $k < 1$ – as well as the price for low quality.

ples, there are more high quality apples on the home market than when there is autarky. Comparing between when the domestic firm does and does not have a competitor in the export market, when there is exporting of the good apples ($k > 1$), the interaction between low and high quality in the export market can lead to more good apples on the home market when the firm competes in the foreign market. This is to be further investigated.

Finally, some extensions are considered. For now the focus is on technology differences. For a range of parameters, the less efficient firm (the one with a greater dud rate), set a higher level of production so long as its dud rate is not too high and low demand is not too strong. This leads to a greater amount exported, but there is no net strategic advantage from this: the more efficient firm earns greater profits. Reversed shipping the good apples can occur as a greater fraction of the low quality product may be exported. Even though the total amount of goods can be greater in the less efficient technology, consumer surplus is always greater in the more efficient technology country. Though, the less efficient country has relatively lower consumer surplus, its consumer surplus is still greater than with autarky. A second is comparisons of the effect of competition in the export market.

1.1 Related Literature

The analysis in this paper is obviously related integrally to several strands of work. The motivation is driven by the "Shipping the good apples" effect, Alchian and Allen (1964) and Borcherding and Silberberg (1978), but in an oligopolistic setting. To the best of my knowledge, while there have been many theoretical extensions to the original result, they have focused on competitive markets rather than one of market power and strategic competition. There is an extensive literature of multiproduct quality choice while here the "seconds" are a byproduct. Gal-Or (1983) first took the quality model Mussa and Rosen (1978) to an oligopoly setting and that was extended by De Fraja (1996), Johnson and Myatt (2006), Johnson and Myatt (2015) and others. As noted above, in these models (unlike Mussa and Rosen (1978)) the possible quality levels are given. For the most part these papers do not consider the role of international trade (multiple markets), the role of "seconds",

and trade cost beyond the effect of increasing (doubling) the market size through trade and so the issue of how to allocate high quality across markets is not considered. There has been work in international trade examining quality choice including cost asymmetries. For the most part, these works have examined single quality choice (Park (2001) and Zhou, et al (2002) and papers since). An exception is Ries (1993) who considers the effect of *VERs* on the profits (probably a positive effect) and quality choice (no effect) on exporters with an absolute advantage in low quality products (disadvantage in high quality products). Recently, although a model of (symmetric) horizontal rather than vertical differentiation, Chisholm and Norman (2012) examine product selection and export choice in the Brander and Krugman (1983) setting of reciprocal dumping with trade costs (but not in the Brander and Spencer (1985) setting of third country).[7] In some ways their paper is closest in spirit to this paper. There are two firms (one in each country) and two symmetric products that they can produce and export. Because they consider horizontal instead of vertical, there is symmetry between products and so, for example, if a firm can be indifferent about which product they export. The work also differs in that asymmetric costs (here: dud rate) are not considered in Chisholm and Norman (2012). One analysis not yet completed here is to examine the effect of minimum quality standards, although it has a different interpretation here than in previous work[8] where firms can respond by adjusting quality. Here, instead, MQS would potentially simply block "seconds" from being sold and so have different effects potentially by causing firms to invest in reducing "seconds." To the best of my knowledge, this is the first to analyze minimum quality standards with multiple quality (albeit in a simpler framework then work by Gal-Or (1983) and others.

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[7]See also Eckel and Neary (2010) and citations therein for other work examining product selection in international trade. Unlike Eckel and Neary (2010), almost all of the papers in this literature use monopolistic competition rather than oligopolistic, which allows for strategic interaction.

[8]Ronnen (1991), Crampes and Hollander (1995) and in international trade beginning with Boom (1995).

2 Environment

The structure of the model follows the standard "three country model" (e.g., Brander and Spencer (1985)). There are (for now) three countries (domestic (d), foreign (f) and export (x)). In two of the countries, domestic and foreign, there is a single firm (for now). Each firm sells to its own country's market without competition from the other firm. This firm also exports to the third country (x), where it competes with the other firm. The firms produce a primary good, but there is a fraction of "duds", or low quality version of the good. Quality differentiation is modeled in the standard way, e.g., Tirole (1988). The two-country "reciprocal" dumping model of Brander and Krugman (1983) may also be considered.

2.1 Consumers

In each country there is a mass of consumers whose population is normalized to one. Consumers consume at most one unit of the good. All consumers have a greater willingness-to-pay for higher quality but are heterogeneous in how much their willingness-to-pay increases for higher quality. Specifically, each consumer has value θ for a good of quality s, with θ distributed uniformly on $[0, 1]$, so θ represents the consumers marginal willingness-to-pay for a unit increase in quality. That is, surplus for the consumer is $U = \theta s - p$ if they buy, zero else: consumer θ is willing to pay up to $s\theta$ for a good quality s. There are two types of quality available with s^H and s^L representing high and low quality (superscript indicates quality). Therefore, for consumer θ their marginal willingness-to-pay for the higher quality product is $\theta(s^H - s^L)$, so a lower θ has both a lower willingness-to-pay for low quality, and a lower marginal willingness to pay for an increase in quality. This will allow for a simple sorting of consumers: the consumer with the lowest θ will buy low quality since all consumers with greater θ would out bid this consumer for higher quality. For the same reason, all the high quality units will go to those with the highest θ. Note that if consumer $\hat{\theta}$ is the marginal buyer (that is, the buyer with the lowest willingess to pay, then $1 - \hat{\theta}$ units are bought.

Given Q^H and Q^L high quality and low quality units on the market ($Q^H + Q^L < 1$),

consider the marginal consumer (that is, the consumer who buys with the lowest willingness-to-pay). Denote him $\theta^L = 1 - (Q^H + Q^L)$. Since as argued above, they will buy a low quality rather than a high quality product, the market clearing price for low quality is determined by this consumer's willingness to buy low quality: $s^L \theta^L - P^L = 0$. Thus,

$$P^L = s^L[1 - (Q^H + Q^L)] > 0. \tag{1}$$

Note that the surplus for any consumer with greater θ is strictly positive since they could always choose to buy low quality.

Turning to the marginal consumer of high quality, the market clearing price for high quality must be such that the marginal consumers purchasing high quality (θ^H) is indifferent between buying high quality at the high quality price or low quality at the low quality price (and hence, any consumer with greater θ strictly prefers buying high quality over low quality). Thus, the market clearing price for high quality must satisfy

$$s^H \theta^H - P^H - (s^L \theta^H - P^L) = 0. \tag{2}$$

Given that market clearing requires $Q^H = 1 - \theta^H$ and using (1), equation (2) can be written as

$$P^H = s^H(1 - Q^H) - s^L Q^L. \tag{3}$$

There are some straightforward interactions between the high and low quality markets worth noting now to help later intuition. First, if unit of low quality is transformed into a unit of high quality, low quality price does not change despite the decrease in low quality supply (1). Second, if instead a low quality unit is added, this lowers the low quality price but also the high quality price (3) because the marginal high quality consumer's willingness-to-pay for high quality has decreased since their net surplus from buying low quality has increased (low quality price decreased). Third, if another high quality unit is supplied with no change in low quality output, the price decrease is greater than when a low quality
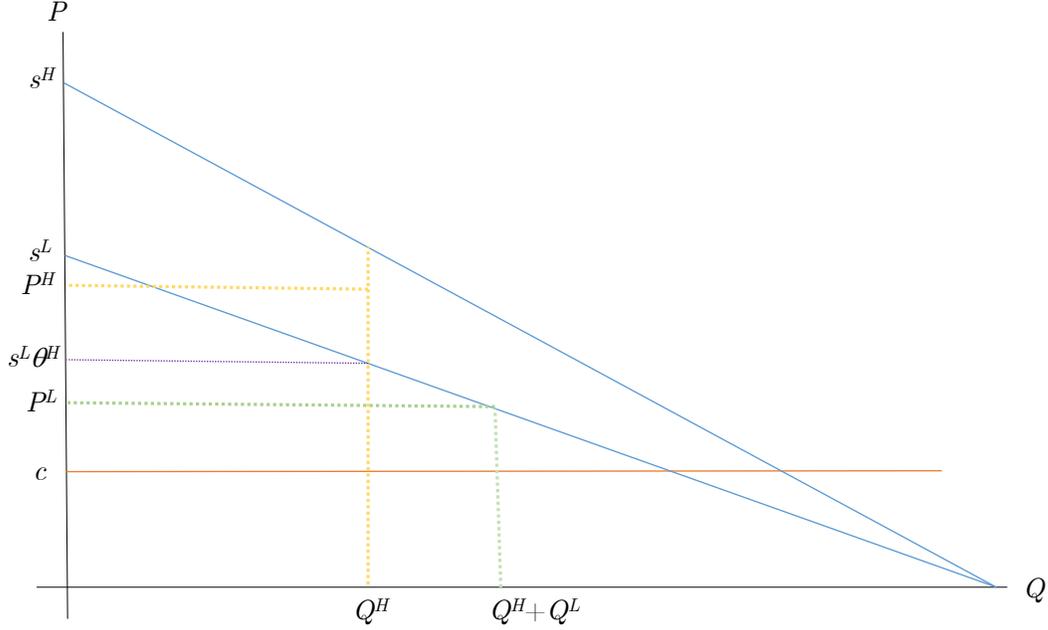
Figure 1: Market clearing prices

unit was transformed to high quality because the opportunity cost for the marginal high quality consumer increases.[9] Finally, the "price premium" – the mark-up for high quality – is independent of low quality production.[10] That is, subtracting P^L (1) from P^H (3) yields

$$P^H - P^L = s^H(1 - Q^H) - s^L Q^L - [s^L[1 - (Q^H + Q^L)]] = (S^H - S^L)(1 - Q^H). \quad (4)$$

That is, the price premium reflects the gain to the marginal high quality buyer. This analysis under a more general model can be found in Johnson and Myatt (2006).

2.2 Firm

The firm in each country produces a product of which a fraction z are "seconds," i.e., lower quality than the primary good. Thus, when, e.g., the domestic firm produces q_d units,

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[9]Though note that the decrease in the high quality price in this case does not directly depend on the low quality market.

[10]This can also be seen in (2).

$z_d q_d$ are low quality and $(1 - z_d)q_d$ are high quality (subscripts indicate location, small q a firm's output, capital Q market output). The firm sells both to its own market and to a third export market where it competes with the other firm. Each unit exported incurs a transport cost t. Thus, for each firm there are three decisions: how much to produce (q_d), and how much to export to the third country of each type of good, high quality (x_d^H) and low quality (x_d^L), which implicitly determines how much of each good remains in its own market. That is, $x_d^L z_d q_d$ of low quality goods and $x_d^H (1 - z_d)q_d$ high quality goods are exported. Thus, domestic market high quality (Q_d^H) is just the amount of high quality the domestic firm does not export $(Q_d^H = (1 - x_d^H)(1 - z_d)q_d)$. Total domestic output, then is $Q_d = Q_d^H + Q_d^L$. The foreign market is symmetric, while for the export market, total high quality is $Q_x^H = x_d^H (1 - z_d)q_d + x_f^H (1 - z_f)q_f$ and total output in the export market is Q_x. To summarize,

Country	High quality output	Low quality output	Total output
Domestic	$Q_d^H = (1 - x_d^H)(1 - z_d)q_d$	$Q_d^L = (1 - x_d^L)z_d q_d$	$Q_d = Q_d^H + Q_d^L$
Foreign	$Q_f^H = (1 - x_f^H)(1 - z_f)q_f$	$Q_f^L = (1 - x_f^L)z_f q_f$	$Q_f = Q_f^H + Q_f^L$
Export	$Q_x^H = x_d^H (1 - z_d)q_d +$ $x_f^H (1 - z_f)q_f$	$Q_x^L = x_d^L z_d q_d +$ $x_f^L z_f q_f$	$Q_x = Q_x^H + Q_x^L$

Firms have strictly positive constant marginal cost of production c, transportation cost t and disposal costs. So there is a basis for production and trade, it is assumed that the value of the first low quality unit is greater than the cost of production and transport: $s^L > c + t$. More generally, the values of the parameters are assumed such that the equilibrium is an interior solution. In particular, disposal costs (or more precisely, *destruction* cost as the firm needs to be sure that the disposal company does not illicitly resell the disposal[11]) or lack of

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[11] For example, Global Sources (www.globalsources.com), a trade company in Hong Kong, recommends "[a]lthough it may seem excessive, one of the best ways to ensure that rejected or defective products dont end up being sold is to destroy them....Once you and your supplier have agreed on destroying the rejected products, how can you be sure the factory actually destroys them?" (Sourcing News & Advice >> Smart Sourcing >>What do suppliers do with rejected products?)

commitment in destroying low quality implies that all low quality is sold.[12] For the firm in the domestic country, then, its profits are its high quality revenue in the domestic market, low quality revenue in the domestic market, high quality revenue in the export market, low quality revenue in the export market, less production costs and the transport cost of the export goods or

$$P_d^H Q_d^H + P_d^L Q_d^L + P_x^H x_d^H (1 - z_d) q_d + P_x^L x_d^L z_d q_d - c q_d - t(x_d^H (1 - z_d) q_d + x_d^L z_d q_d) \qquad (5)$$

Using the price equations (3, 1) , (5) can be written as domestic market revenue, plus export market revenue, less transport cost

$$\begin{aligned}
[s_d^H (1 - Q_d^H) &- s^L Q_d^L] Q_d^H + s_d^L [1 - (Q_d^H + Q_d^L)] Q_d^L \\
&+ [s_x^H (1 - Q_x^H) - s_x^L Q_x^L] x_d^H (1 - z_d) q_d + s_x^L [1 - (Q_x^H + Q_x^L)] x_d^L z_d q_d \\
&- c q_d - t(x_d^H (1 - z_d) q_d + x_d^L z_d q_d)
\end{aligned} \qquad (6)$$

Finally, using the values for Q, (6) can be written as profits as a function of production and fraction of high and low quality exported with revenue from each market (high domestic,

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[12]Positive destruction costs (which could include public outcry from destroying valuable goods, e.g., supermarkets with "old" food) or the ability of the firm to commit to observably destroy low quality is only required for some comparative static results in the benchmark sections 3-3.1. The other results can hold even with free, observable destruction. Intuitively, the reason the firm needs the ability to commit to observably destroy low quality is that consumers may expect the firms not to destroy it and sell it "on the side," as it would obtain a positive price. That is, for reasons somewhat like those in the Coase Conjecture. Appendix A extends the model to explicitly allow the firm this dynamic as well as explicitly deriving the destruction cost needed for the firm to not destroy low quality if the firm could commit to observably destroy low quality. This extension is left for the appendix rather than in the main body as it is only required for a few results in sections3-3.1, while introducing additional parts to the modeling thereby reducing the clarity of the main effects.

low domestic, high export, low export), less transport cost:

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\begin{aligned}
\pi_d(q_d, x_d^H, x_d^L) =& [s_d^H(1 - (1 - x_d^H)(1 - z_d)q_d) - s_d^L(1 - x_d^L)z_dq_d](1 - x_d^H)(1 - z_d)q_d \\
& + s_d^L[1 - ((1 - x_d^H)(1 - z_d)q_d + (1 - x_d^L)z_dq_d)](1 - x_d^L)z_dq_d \\
& + [s_x^H(1 - [x_d^H(1 - z_d)q_d + x_f^H(1 - z_f)q_f]) - s_x^L[x_d^Lz_dq_d + x_f^Lz_fq_f]]x_d^H(1 - z_d)q_d \\
& + s_x^L[1 - ([x_d^H(1 - z_d)q_d + x_f^H(1 - z_f)q_f] + [x_d^Lz_dq_d + x_f^Lz_fq_f])]x_d^Lz_dq_d \qquad (7) \\
& - cq_d - t(x_d^H(1 - z_d)q_d + x_d^Lz_dq_d)
\end{aligned}
$$

The firm chooses q and x to maximize the above.

3   Benchmark: Monopoly in autarky

This section first considers a monopoly in autarky to establish some benchmark results. The problem then simplifies to only choosing output q_d:

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\begin{aligned}
\pi_d(q_d) =& [s_d^H(1 - (1 - z_d)q_d) - s_d^Lz_dq_d](1 - z_d)q_d \\
& + s_d^L[1 - ((1 - z_d)q_d + z_dq_d)])z_dq_d - cq_d. \qquad (8)
\end{aligned}
$$

Maximizing (8) with respect to q_d obtains

$$
q_d^A = \frac{1}{2}\frac{\overline{s}_d - c}{[(1 - z_d)\overline{s}_d + z_ds_d^L]}, \qquad (9)
$$

where the superscript A denotes "Autarky" and $\overline{s}_d = (1 - z_d)s_d^H + z_ds_d^L$ is the average value.

Interestingly, comparative statics show that an increase in s_d^L *decreases* q_d^A ($\partial q_d^A/\partial s_d^L < 0$) so long as s^H is not too close to c.[13] This occurs partly because, holding output constant, though the low quality price (1) increases, the high quality price decreases (3). The reason the high quality price decreases is because the marginal high quality buyer values the increase

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[13]For example, if $z = .10$, and $c = .5$, then one needs $s^H > 1$. If z doubles to $z = .20$, then one needs $s^H > 1^1/8$. There always exist an s^H such that this is true even if there is free destruction.

in low quality more than the marginal low quality buyer does. The latter drives the low quality price increase, which is less than what the marginal high quality buyer gains. So low quality now looks more attractive to the high quality buyer. For the high quality buyer to still buy the high quality product, the high quality price must decrease by the amount the marginal high quality buyer's surplus increased for low quality. Of course, the effect also turns on elasticity and if s^H is too close to c, then total production is lower and in the more elastic range. This result may be related to Mussa and Rosen (1978) finding that a monopolist expands the quality spectrum relative to the social optimum. That is, with price discrimination and only two types quality types the monopolist would have the lower quality less valued.

A second interesting effect is that an increase in z_d causes production to increase under a similar, but slightly stronger condition than the one for $\partial q_d^A / \partial s_d^L < 0$ above: so long as s^H is not too close to c, and the additional condition that $z \leq 1/2$ (a sufficient but not necessary condition).[14] More precisely, if $\partial q_d^A / \partial z_d > 0$, then $\partial q_d^A / \partial s_d^L < 0$. This may seem a bit counter intuitive at first. The reason, however, is partly driven by an increase in z having no effect on the low quality price (1) as total output is constant, but causes an increase in the high quality price (3) because high quality production decreases. Of course, elasticities also play a role and so if d is large enough and s^H is relatively small enough, then an increase in z can decrease output. However, this is a possible source of advantage in strategic competition.

3.1 Welfare in autarky

Inserting the solution (9) into the profit expression (8) yields profits as a function of the value for each type ($s^{(\cdot)}$) and dud rate (z).

$$\pi_d^A(s_d^H, s_d^L, z_d) = \frac{[\bar{s}_d - c]^2}{4[(1 - z_d)\bar{s}_d + z_d s_d^L]} \tag{10}$$

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[14]Since low quality is being referred to as "duds" or "seconds" indicating not the primary product, this seems to be a reasonable restriction. If $z > 1/2$, then s^H need be sufficiently greater than s^L. For example if $z = 3/5$, then s^H need be roughly twice as large as s^L.

The effect of z is as expected: increasing z always decreases profit. Turning to s^L, normally an increase in s^L increases the firm's profit, but if s^H is sufficiently large and destruction costs are not too close to zero (though less than production costs) or if the firm cannot commit itself to destroy low quality output (modeled in Appendix A),[15] then an increase in s^L decreases profit. This possibility is not entirely surprising since an increase in s^L decreases the firm's production when s^H is not too close to c. In addition, the firm's profit is convex in s^L. That is, from that point as s^L increases, eventually profits increase in s^L.

Consumer surplus in this autarkic market is the sum of the two markets welfare, high and low quality. Low quality consumer surplus is the standard triangle with linear demand, $(1/2)s_d^L(Q_d^L)^2$ (recall that capital Q denotes quantity in a specific market, i.e., sold to consumers in that market). High quality consumer surplus includes the standard triangle, $(1/2)s_d^H(Q_d^H)^2$, but also includes the price discount the marginal high quality buyer must receive to induce them to choose high quality over low quality: $s_d^L Q_d^H Q_d^L$. Thus, consumer surplus is $CS(s_d^H, s_d^L, z_d) = [(1/2)s_d^H(Q_d^H)^2 + s_d^L Q_d^H Q_d^L] + (1/2)s_d^L(Q_d^L)^2$. As $Q_d^H = (1 - z_d)q_d^A$ and $Q_d^L = (z_d)q_d^A$ and substituting for (9), obtains

$$CS^A(s_d^H, s_d^L, z_d) = \frac{[\overline{s}_d - c]^2}{8[(1 - z_d)\overline{s}_d + z_d s_d^L]}. \tag{11}$$

Surprisingly, given the price discount included in high quality consumer surplus, consumer surplus in equilibrium turns out to be the standard linear demand result of half the monopolist's profit. Thus, the conditions for the comparative statics found for the firm hold for consumer welfare and country welfare. Specifically, even though output can increase in z_d (that is, output can increase, as there is a higher dud rate), increasing z_d always decreases consumer and total welfare: the increase in output cannot offset the decrease in high quality. However, as with the firm's profits, consumer surplus is convex in s^L and an increase in s^L can decrease consumer surplus when s^H is significantly greater than cost and there are

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[15]Examples of low destruction costs (a fraction of production costs) are in Example 1 below.
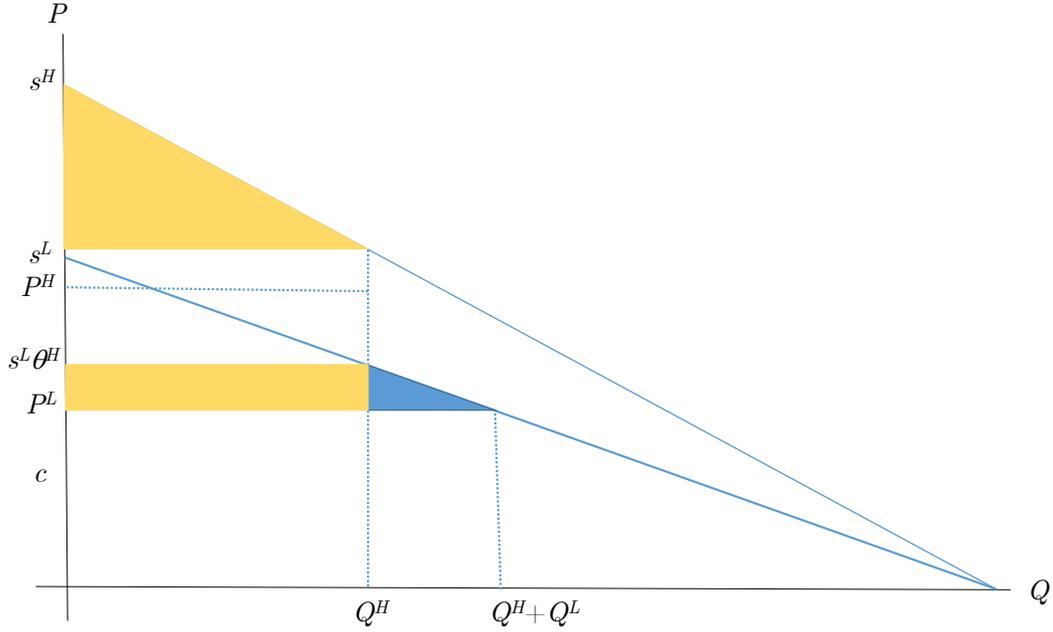
Figure 2: Consumer surplus low quality (blue), high quality (yellow)

positive destruction costs. It is less clear whether the results in Mussa and Rosen (1978) drive this. While the result does not hold for all values and requires positive destruction costs, it can hold for plausible parameters as the following examples show.

Example 1 *Increases in low quality reducing welfare. Let $s^H = 8$, $s^L = 1.5$, $c = 0.3$, and $z = 1/9$. In this case, from (21) in Appendix A.1, if unit destruction costs are $1/16$ – less than a fifth of production costs– then an increase in s^L reduces profits, consumer surplus and welfare. As another example, with $s^H = 6$, $s^L = 1$, $c = 1/8$, $z = 1/15$, then if destruction costs are 3.5% of s^L, then increases in s^L reduce welfare. In both examples, increases in s^L decreases welfare for greater values of s^H as well. Alternatively, if sales occur in two stages, with the firm first selling high quality, then its low quality output as modeled in Appendix A.2, then from the conditions derived in Appendix A.2, even if destruction costs are zero, then increases of low quality reduce welfare in both examples as the firm does not destroy any of its low quality output and q_d^A is optimal.*

15

4   Three country model

The main model is now considered: there are now three countries: domestic, foreign and export. There is a single firm in the domestic and foreign country and none in the export country. The firms are monopolies in their own market but compete in quantities in the export market. The problem for the firm now includes two additional variables: the export fraction of each type of good. So, the firm now chooses q_d, x_d^H and x_d^L (and its rival q_f, x_f^H and x_f^L) to maximize the sum of domestic high quality market, domestic low quality market, export high quality market and export low quality market. As there are now six choice variables (output, export fraction for each quality type and two firms), to obtain a tractable close-form solution the dud rates, marginal cost and "home" demand are assumed symmetric and the export market is assumed scaled by k. Thus, we have $s_d^H = s_f^H$, $s_x^H = ks^H$, $z_d = z_f$, etc.

The domestic firm, then, chooses q_d, x_d^H, x_d^L simultaneously not knowing the foreign firm's choices to maximize the sum of domestic high quality revenue, domestic low quality revenue, export high quality revenue, export low quality revenue, less production cost and export transport cost:

$$
\begin{aligned}
\pi_d(q_d, &x_d^H, x_d^L) = \\
&[s_d^H(1 - (1 - x_d^H)(1 - z_d)q_d) - s_d^L(1 - x_d^L)z_dq_d](1 - x_d^H)(1 - z_d)q_d \\
&+ s_d^L[1 - ((1 - x_d^H)(1 - z_d)q_d + (1 - x_d^L)z_dq_d)](1 - x_d^L)z_dq_d \\
&+ [ks_d^H(1 - [x_d^H(1 - z_d)q_d + x_f^H(1 - z_d)q_f]) - ks_d^L[x_d^Lz_dq_d + x_f^Lz_dq_f]]x_d^H(1 - z_d)q_d \\
&+ ks_d^L[1 - ([x_d^H(1 - z_d)q_d + x_f^H(1 - z_d)q_f] + [x_d^Lz_dq_d + x_f^Lz_dq_f])]x_d^Lz_dq_d \\
&- cq_d - t(x_d^H(1 - z_d)q_d + x_d^Lz_dq_d),
\end{aligned} \tag{12}
$$

and its rival in the foreign country chooses q_f, x_f^H, x_f^L to maximize the symmetric expression.

In comparison to the standard trade models with constant marginal cost and transport cost, e.g., Brander and Krugman (1983), the country markets here are not independent of

each other even though marginal costs are constant.[16] For example, here an increase in low quality export affects the price in the three other markets.

Maximizing (12) with respect to q_d, x_d^H and x_d^L (and symmetrically for the foreign firm), then imposing symmetry obtains after a little algebra the Nash Equilibrium output and export fractions for the domestic firm (and likewise for the foreign firm)

$$q_d = \frac{5}{6} \frac{\bar{s}_d - \frac{(2+3k)c}{5k} - \frac{2t}{5k}}{[(1-z_d)\bar{s}_d + z_d s_d^L]} \qquad (13)$$

$$x_d^H = \frac{2}{2+3k} - \frac{(1-k)}{(2+3k)(1-z_d)}\frac{1}{q_d} \qquad (14)$$

$$x_d^L = \frac{2}{2+3k} - \frac{t}{(2+3k)z_d s_d^L}\frac{1}{q_d}.$$

The output q_d is analogous to the monopoly case (9). To see this most easily, set transport costs to zero ($t = 0$) and scale the export economy to be a duplicate of the home one ($k = 1$). In this case, output becomes

$$q_d = \frac{5}{6} \frac{\bar{s}_d - c}{[(1-z_d)\bar{s}_d + z_d s_d^L]}.$$

The coefficient in this case is $5/6$ instead of $1/2$, which is consistent with the output when a firm sells in a monopoly market ($1/2$) and a duopoly market ($1/3$). Thus, the interesting comparative statics from the previous section carries over: usually increasing in the dud rate z and decreasing in s_d^L. As before it is decreasing in production cost c. For the new variables, the effect is as expected: decreasing in transportation cost and increasing in export country's willingness-to-pay (k). One way to relate the new parameter k and t is to solve for the value of k given c and t such the exporting firm produces the monopoly plus Cournot duopoly output as in the case when transport cost are zero (that is, $5/6$). Simple algebra shows that the firm does not produce proportionately more when $k \leq 1 + t/c$. This is not surprising as the

---

[16]For example, if instead a monopoly sold in two countries one product with linear demand and constant marginal cost and transport cost, then its output in the domestic market would only depend on the intercept, slope and marginal cost; its output in the export market would only depend on the intercept, slope, marginal cost and transport cost. That is, you could solve each as independent problem.

monopolist incurs an additional (transport) cost with exporting and so even if the export market's willingness-to-pay is slightly greater than the domestic market, total production may not increase proportionately. Once $k \geq 1 + {}^t\!/c$, then the export market's willingness-to-pay is sufficiently strong to compensate for the transport cost. This is suggestive that for $k \leq 1 + {}^t\!/c$, since output does not increase proportionately that domestic consumers may be harmed by trade (and *vice-versa*). As is shown below, this is incorrect.

For the exporting of good apples (x_d^H), considering the case in which the export country is the same size as the domestic country provides a useful starting point. Letting $k = 1$, then 2/5 are exported. This makes sense as 2/5 is two-thirds of of 3/5, just like the Cournot output (1/3) is two-thirds the monopoly output (1/2). To put it differently, if the domestic firm faced no foreign competitor in the export market then the fraction would be 1/2. More generally, the high quality export fraction is not directly affected by the transportation costs (though indirectly through transportation costs effect on reducing q_d: there it reduces the export fraction as q_d is decreasing in the transportation costs. For export economies that have a greater willingness-to-pay for the product (larger k), the second term becomes positive: the domestic firm exports more than forty percent of its good apples. However, this effect is ameliorated by the k and q_d in the denominator both which increase in k. The direct effect of an increase in k on the second term is to diminish it so that even though the second term is now positive it is not increasing directly through k. The indirect effect through output q_d also diminishes the positive effect since an increase in k increases q_d. The export fraction though it still increasing in k.

Analysis of specific parameter values suggests that the effect of the other variables on the export of high quality depends critically on whether the export market's willingness-to-pay for either quality level is greater or less than the domestic market, yields some interesting effects. Specifically, if $k > 1$,the export fraction seems to be increasing in the dud rate z, value for low quality s^L (and decreasing in the value for high quality s_d^H), transport cost t – suggestive of shipping the good apples – and production costs c. However, these effects reverse when $k < 1$: the export fraction is *decreasing* in the dud rate, s^L (increasing in s^H)

and production cost. However, perhaps the most interesting result is that x_d^H is decreasing in transport cost t, suggesting the shipping the good apple result does not hold.

Lemma 1 *If $k < 1$, then as transport cost increases, the fraction of high quality good exported decreases.*

Proof. Differentiating high quality export share x_d^H (14) with respect to transport cost t yields when $k < 1$

$$\frac{dx_d^H}{dt} = -\frac{(1-k)}{(2+3k)(1-z_d)}\frac{-\frac{\partial q_d}{\partial t}}{(q_d)^2} < 0,$$

where the inequality follows because $k < 1$ and $\frac{\partial q_d}{\partial t} < 0$. ∎

For the exporting of "bad" apples, $x_d^{L,M}$, so long as transport cost t is sufficiently small or the value for low quality (s^L) sufficiently large, a positive fraction of the "bad apples" will be exported. The analysis here assumes that t is sufficiently small so that this is true. Unlike with high quality, for the baseline case of the export country having an identical economy $k = 1$, the export fraction depends on other variables. Perhaps surprisingly it is increasing in the value for high quality (s^H) and decreasing in the value for low quality (s^L), though the intuition will be given below. It is increasing in the dud rate, and decreasing the transport and production costs. However, if the transport cost is zero $(t = 0)$, it exports exactly $2/5$ as with high quality, that is, the Cournot duopoly output is exported.

4.1 Shipping the bad apples

We now turn to examine if a second interpretation of "shipping the good apples" effect holds in strategic competition. It turns out that is does not hold if k is small enough, that is, the export willingness-to-pay for *both* high *and* low quality are proportionately smaller. Specifically, this effect is interpreted here as a greater proportion of the export is high quality: a greater fraction of the good apples are exported than the bad apples. (Since there are more good apples than bad, even if they the same fraction were exported, one would have more

good apples exported in total. However, if

$$k \leq 1 - t\frac{1 - z_d}{z_d s^L} \equiv k^*, \tag{15}$$

then $x_d^L < x_d^H$. Relatively more high quality apples are exported. It is interesting that this condition does not depend on c nor s^H. To get some sense of the condition, consider some examples. If $s^L = 1$, $c = .15$, $d = .2$, and $t = .1$ then if the export country is sixty percent the size of the domestic country ($k \leq 3/5$) then relatively more high quality apples are exported. However, as is clear from the definition of k^*, the export country could be very close in preferences to the domestic one when there is a high willingness-to-pay for low quality relative to transportation costs. For example, if $s^L = 2$, $d = .25$, and $t = .1$ then if the export country is eighty-five percent the size of the domestic market, a greater fraction of "bad" apples are exported even though the price of good apples in the export market is greater.[17] Making transport costs sufficiently low can move k to near parity (i.e., the countries are nearly identical). If instead, one wanted to show this effect occurring with total production (instead of relative) we could set $z = .5$ (in which case the export country could be nearly identical in size to the domestic country, e.g., $k = 19/20$), and then more "bad" apples are exported.[18]

Proposition 1 *When $k \leq 1 - t\frac{1-z_d}{z_d s^L}$ (the export market willingness-to-pay is sufficiently weaker than the domestic market), there is the shipping of "bad" apples: a greater fraction of low quality goods are shipped than high quality goods. This is also true when the firm faces no competition in the export market so the high quality export price is greater than the low quality export price; otherwise there is the shipping of good apples.*

Intuitively, the result in Proposition 1 turns on the high quality price premium in the export market. As k decreases, the willingness-to-pay for both high and low quality decrease,

---

[17]In these examples, since there is competition in the export market, the price of high quality is lower than in the domestic market. However, if there is no competition in the export market, then the price of high quality is greater than in the domestic market. Interestingly, with or without competition in the export market, as k decreases, the export price *increases.*

[18]For all of these examples there is a range of s^H, such that destruction cost could be zero.

but the demand curves in the export market are compressed: for a given consumer the marginal value of superior quality decreases and so does price: the absolute price premium becomes smaller. For example, if half the good and bad apples were in both markets, low quality apples have a higher value in the domestic market and so the price discount this causes for high quality is greater than in the export market. As a result, by exporting a bad apple, the increase revenue in the domestic market (from the increase in the good apple price premium) is greater than the loss revenue in the export market. The logic is symmetric when k is greater than one and so then fewer bad apples are exported.

4.2 Welfare

Inserting the solutions for q_d, x_d^H, x_d^L from (13) into the profit expression (12) yields profits as a function of the value for each type $(s^{(\cdot)})$ and dud rate (z).

$$
\pi_d(s_d^H, s^L, z_d) = \frac{k(32 + 33k)[(1 - z_d)\bar{s}_d + z_d s^L]}{(3k + 2)^2} q_d^2 + \frac{(1 - k)c + t}{5(3k + 2)} 2q_d \tag{16}
$$
$$
+ \frac{(1 + k)}{(3k + 2)^2} \left[s_d^H (1 - k)^2 + \frac{t[2s^L(1 - k) + t]}{s_d^L} \right]
$$

As a simple check, if $k = 1$ and $t = 0$ (costlessly duplicating the first market), we have that export profits are autarkic profit plus Cournot duopoly profit or,

$$
\frac{13}{36} \frac{[\bar{s}_d - c]^2}{[(1 - z_d)\bar{s}_d + z_d s_d^L]},
$$

where 13/36 equals 1/4 (monopoly profit) plus 1/9 (Cournot duopoly profit).

Turning to domestic consumer welfare, recall that consumer surplus is $CS(s_d^H, s^L, z_d) = [(1/2)s_d^H(Q_d^H)^2 + s_d^L Q_d^H Q_d^L] + (1/2)s_d^L(Q_d^L)^2$. In this case, domestic quantities also depend on how much is exported, so now $Q_d^H = (1 - z_d)(1 - x_d^H)q_d$ and $Q_d^L = (z_d)(1 - x_d^L)q_d$ and substituting for (13), obtains

$$
CS^M(s_d^H, s_d^L, z_d) = CS^A(s_d^H, s_d^L, z_d) + \frac{(s_d^H - s_d^L)}{2(3 + 2k)^2 s_d^L} \frac{[(k - 1)z_d s_d^L + t(1 - z_d)]^2}{(1 - z_d)\bar{s}_d + z_d s_d^L}. \tag{17}
$$

Despite the previous result that output may not increase proportionately with exporting, which should be, all else equal, a negative effect on domestic consumer surplus, domestic consumer surplus always increases with the monopolist exporting. First, when $k = 1$ and $t = 0$ (costlessly replicating the domestic market), consumer surplus is the same as in autarky. However, for any other values of k and t, consumer surplus weakly increases with exporting - with one interesting exception: when $k = k^*$ (then consumer surplus equals autarkic consumer surplus).

Proposition 2 *Exporting by increases domestic consumer surplus.*

The result is surprising partly because as shown above aggregate output may not increase proportionately, but also because with constant marginal cost of production (the standard assumption in trade models, e.g., in Brander and Spencer (1985)), there would be no effect on consumer welfare with exporting. The result does not depend solely on transportation costs as when $t = 0$, consumer surplus strictly increases so long $k \neq 1$. Likewise, it does not depend solely on the export economy being different than the home economy as when $k = 1$ consumer surplus strictly increases so long as there are positive transport cost. However, both play a role through their effect on both the aggregate amount of goods on the domestic market and on the mix of the goods. The mix changes because when the economies are asymmetric or there are positive transport costs, the differential pricing and price mark-ups between the markets causes the optimal export fractions for each quality type to differ.

To help understand these effects consider first the effect of trade on the aggregate amount of apples (good and bad) on the domestic market. First, consider the role of trade cost (t) on domestic market output. To begin, when $k = 1$ and $t = 0$, so that two-fifths of the good and bad apples are exported and so domestic output is unchanged with exporting (as total production increases one-third). Introducing any positive trade cost ($t > 0$), has no effect on the percentage of high quality exports but decreases the percentage of low quality exports (14), so now there are proportionately more "bad" apples domestically than with autarky. If production remained constant, then total output on the domestic market would

increase and consumers would be better-off. However, introducing the transport costs also causes total production to decrease (13). If total output on the domestic market (weakly) decreased, then home consumers would be worse off (since high quality output is unchanged). However, the aggregate amount on the home market increases. Specifically, the difference of total output on the domestic market with trade less with autarky is (recall that capital Q indicates quantity on a specific market so Q_d denotes quantity on the domestic market, which is one and the same with production when there is autarky: $q_d^A = Q_d^A$):

$$
\begin{aligned}
Q_d - Q_d^A &= \left[(1 - x_d^H)(1 - z_d)q_d + (1 - x_d^L)(z_d)q_d\right] - \frac{\overline{s}_d - c}{2[(1 - z_d)\overline{s}_d + z_d s_d^L]} \\
&= \frac{(1 - z_d)(s_d^H - s_d^L)}{s_d^L(3k + 2)} \frac{(1 - z_d)t + d(k - 1)s_d^L}{2[(1 - z_d)\overline{s}_d + z_d s_d^L]}.
\end{aligned}
\tag{18}
$$

As can be seen, if $k = 1$ and $t = 0$, then domestic output is unchanged. With $t = 0$ if $k > 1$ domestic output increases and if $k < 1$ it decreases. More generally, for $k < k^*$ domestic output increases with the introduction of trade. At $k = 1$, if we increase transport cost slightly ($t > 0$, which causes k^* to decrease (15)), then domestic output increases relative to the autarkic case even though total production does not increase proportionately: export quantity is less than the Cournot equilibrium with zero transport cost. Since two-fifths of the good apples are still exported, then total amount of good apples on the domestic market has decreased. Since total output on the domestic market has increased, then the increase in bad apples staying in the domestic market must more than offset the decrease in good apples in the domestic market. This both provides more bad apples for home consumers (and a lower price for bad apples) but also drives down the price of good apples as well to keep the marginal buyer of good apples buying good apples instead of a bad apple. (Intuitively, if total production did not change with trade, then the total amount of good apples on the domestic market does not change, and the price of good apples must decrease since the price of bad apples have.) *Shipping the good apples improves domestic consumer welfare.*

The benefit to domestic consumers, however, is not only driven solely by the transport cost distorting output home nor does the domestic aggregate output always increases (which

it does not if $k < k^*$). The benefit is also driven by the relative willingness-to-pay of the export market (even though facing a rival there) causing the firm to change its export mix (what fraction of high and low quality to export). As a result, with zero transport cost, export fractions differ unless $k = k^*$. That is, the domestic mix of high and low quality differs from the "natural" ratio (z) unless $k = k^*$. Specifically, if $t = 0$ (so the effect does not depend on transport cost), then for $k > 1$ the fraction of high quality exports becomes greater than the fraction of low quality exports and *vice versa*. Note that when $k > 1$ the willingness-to-pay for low quality also increases. However, the price premium for high quality also increases. Then end result, is that the firm distorts its export to more high quality and less low quality than the natural rate of z. The logic reverses for $k < 1$.

The question is how this interacts with total production. To examine this it is useful to simplify by assuming there are no transport cost (setting $t = 0$), which also emphasizes that transport cost is not the driving force. As already noted, domestic consumer surplus still increases with $t = 0$ when $k \neq k^*$ (17). However, the sign of difference between domestic output with and without export (18) depends on k: for $k > 1$ with $t = 0$, domestic output is *greater* than autarkic output (when $t = 0$, $k^* = 1$). When $k < 1$, domestic output is less than with autarky.

Consider first the case when $k < 1$, so domestic output is less with exporting even though $t = 0$. The export market has a smaller price premium than the domestic market so the firm distorts exports to more low quality. Thus, even though production decreases, the total amount of high quality on the domestic market increases. The export market of low quality increases the return for high quality sales and we have a "shipping the bad apples" result. For when $k > 1$, the firm wants to export proportionately more good apples, but this induces an increase in total production, which results in more bad apples on the home market: when the firm wants to ship the good apples, consumers benefit from there being more bad apples pushing down price.

5 Extensions

5.1 Comparison to a model with no competition in the export market

5.2 Three country model with differing dud rates

In this subsection, the effect of differing dud rates is examined. As this introduces an additional variable (z_f), the choices by each firm are no longer symmetric. To make the analysis tractable, for now the export economy is assumed the same as the domestic one $(k = 1)$ and marginal costs are set to zero $(c = 0)$. The differing dud rates could also be interpreted as when one country has a cost or technological advantage – the "North-South" type trade model. The difference could also be based on institutional forces as well making lowering the dud rate for the Southern country prohibitively expensive. The domestic firm now chooses q_d, x_d^H, x_d^L to maximize

$$
\begin{aligned}
\pi_d(q_d, x_d^H, x_d^L) =& [s^H(1 - (1 - x_d^H)(1 - z_d)q_d) - s^L(1 - x_d^L)z_dq_d](1 - x_d^H)(1 - z_d)q_d \\
&+ s^L[1 - ((1 - x_d^H)(1 - z_d)q_d + (1 - x_d^L)z_dq_d)](1 - x_d^L)z_dq_d \\
&+ [s^H(1 - [x_d^H(1 - z_d)q_d + x_f^H(1 - z_f)q_f]) - s^L[x_d^L z_dq_d + x_f^L z_fq_f]]x_d^H(1 - z_d)q_d \\
&+ s^L[1 - ([x_d^H(1 - z_d)q_d + x_f^H(1 - z_f)q_f] + [x_d^L z_dq_d + x_f^L z_fq_f])]x_d^L z_dq_d \\
&- cq_d - t(x_d^H(1 - z_d)q_d + x_d^L z_dq_d),
\end{aligned}
$$

and its rival in the foreign country chooses q_f, x_f^H, x_f^L to maximize the symmetric expression. The equilibrium quantities cannot be presented in a concise form, but are denoted q_d^D and q_f^D, where the superscript D is for "Duopoly. The equilibrium export shares are

$$
\begin{aligned}
x_d^{H,D} &= \frac{8}{15} - \frac{2}{15}\frac{(1 - z_f)}{(1 - z_d)}\frac{q_f^D}{q_d^D} \qquad x_d^{L,D} = \frac{8}{15} - \frac{2}{15}\frac{z_fq_f^D}{z_dq_d^D} - \frac{3}{15}\frac{t}{s^L z_dq_d^D} \\
x_f^{H,D} &= \frac{8}{15} - \frac{2}{15}\frac{(1 - z_d)}{(1 - z_f)}\frac{q_d^D}{q_f^D} \qquad x_f^{L,D} = \frac{8}{15} - \frac{2}{15}\frac{z_dq_d^D}{z_fq_f^D} - \frac{3}{15}\frac{t}{s^L z_fq_f^D}.
\end{aligned} \tag{19}
$$

The comparative statics are as follows. The less efficient firm (the one with a greater dud rate), does indeed set a higher level of production so long as its dud rate is not too high, s^L is not to close to s^H and t is not too close to s^L. This results in a greater fraction of low quality exported for the less efficient firm, but also a smaller fraction (not total amount) of high quality exported for the less efficient firm. This output advantage also translates into a greater amount exported, but always less total amount of high quality exported. Despite the output advantage, profits are greater always for the more efficient firm. With dud rates differ significantly, the high dud rate country can export proportionately more of the low quality good, a type of comparative advantage.

Turning to consumers, the less efficient firm never has more high quality on the domestic market, even though it exports a smaller fraction. While the less efficient producer could ship less (proportionately) of the good apples, it usually ships more of the good apples. It is more likely to ship more of the bad apples, when its disadvantage is greater, low quality has greater value, and transportation costs are lower. Total amount of the good can be greater on the less efficient domestic market, but despite this consumers in the less efficient market have lower consumer surplus than those in the more efficient market primarily because the efficient market mix tilts to high quality. Finally, consider the welfare effect on consumers from trade as having a rival enter the export market should reduce exports, but also total production. Begin by letting the dud rate to be equal across the two countries. In this case, as with the monopoly case, consumer surplus increases with trade. Given the earlier result, this is not entirely surprising as a rival entering is akin to to scaling down the export market – although this raises suggests that if there are enough rivals in the foreign country, the shipping the good apple effect may disappear. If the dud rates are allowed to differ, then while consumer surplus is less in the higher dud rate country, in that country consumer surplus is greater than with autarky. However, consumer surplus is greater with trade than with autarky in the high dud rate country (both countries). Interestingly, the gain to consumer surplus from trade seems proportionately larger in the high dud rate country.

6   Conclusion

This has been a preliminary examination of "shipping the good apples" with strategic competition. Possible directions to take the analysis includes: the role of competition (that is, how does the number of firms in each country affect the results, or single firms in additional countries); the role of differences in demand between the countries; the role of transport costs for comparison to the classic results, etc. In addition to this, future work could include endogenizing z, with the idea that one country has a technical advantage (or superior domestic institutions to make reducing z less expensive, for example, Costinot (2009) models the ability to contract with suppliers depends on institutional quality or Creane and Jeitschko (2006) have quality verification in one country but not the other. Another direction would be to consider the "reciprocal dumping" (Brander and Krugman (1983)) environment though this is not the environment most envisage when thinking about shipping the good apples: we do not think about importing the good apples. However, this extension might provide its own insights and a strategic effect from high z might arise and for benchmark to the incomplete information case.

Appendix

A Non-disposal of low quality

This section examines two effects that would prevent the firm from disposing (destroying) low quality goods: the firm's inability to commit to observably destroy the goods and the cost associated with destroying the goods.

A.1 Deriving destruction costs

In this subsection, the destruction (disposal) cost (possibly zero) needed to prevent the firm from destroying low quality goods are derived. As noted before, these destruction costs need not be pecuniary as a firm destroying valuable goods could create a public outcry that is costly to the firm such as with supermarkets destroying unsold food. For example (Rico (2015)), the NFL stopped destroying the merchandise for the losing Super Bowl team in 1996, instead donating it to charity where it is exported to countries where it is "most needed." Specifically, assume after production is chosen (q_d) and its cost incurred (cq_d), there is a second stage in which the firm could choose to reduce its low quality output in a way that is observable to consumers. That is, the firms chooses the amount of low quality, q_d^L, to maximize

$$\pi_d(q_d) = [s_d^H(1 - (1 - z_d)q_d) - s_d^L q_d^L)(1 - z_d)q_d$$
$$+ s_d^L[1 - ((1 - z_d)q_d + q_d^L)]q_d^L, \tag{20}$$

subject to its choice being less than or equal to the amount of low quality goods available: $q_d^L \leq z_d q_d$. Differentiating 20 with respect to q_d^L yields

$$-s_d^L(1 - z_d)q_d - s_d^L q_d^L + s_d^L[1 - ((1 - z_d)q_d + q_d^L)].$$

The last two terms are the marginal revenue in the low quality market. The first term is the negative effect on the high quality market. This negative effect arises because as you increase q_d^L, you reduce the high quality price by s_d^L (because this how much the low quality price decreases, which the high quality price must decrease too to keep the marginal consumer buying high quality). Collecting terms and then substituting for q_d^A (9), can be written as

$$s_d^L(1 - 2q_d) = s_d^L \left(1 - \frac{\overline{s}_d - c}{[(1 - z_d)\overline{s}_d + z_d s_d^L]} \right). \tag{21}$$

If expression (21) is non-negative, then the firm would not want to destroy any of its low quality output. That is, so long as production is less than $1/2$, even if it could do costlessly, the firm would not choose to destroy some of its low quality. Thus, higher production costs, lower s_d^H, greater s_d^L, and lower dud rates (assumed dud rates are less than half) make the condition more likely met. Specifically, if $c > z_d(1 - z_d)(s_d^H - s_d^L)$, then the condition is met with zero disposal costs. Alternatively, if the marginal destruction cost is greater than $s_d^L(1 - 2q_d^A))$, then the firm would not destroy any of its low quality goods. The RHS of (21) is the destruction cost reported in the examples of subsections 3-3.1. Obviously, as the functions are concave, if disposal costs are just below this value the firm would only destroy an arbitrarily small fraction of the low quality good. The necessary destruction cost for other market structures are derived analogously.

A.2 Need for commitment for observable destruction

In this subsection, a simple modification is made to the monopoly model of subsection 3 to show the "Coase conjecture" type of problem facing a firm that wants to destroy some of its low quality output. That is, when the positive destruction costs are needed to prevent a firm from disposing any of its low quality as derived in section (A.1), even if destruction costs are zero, a firm without the ability to commit to observably destroy its output, may not. To this, modify the previous model so that the products are sold sequentially by type: in the first stage the firm first puts the high quality on the market, and in the second stage the firm

puts the low quality on the market. This seems a natural extension as firms are observed putting their best product out first. In the second stage, the firm chooses the amount of low quality, q_d^L, to maximize

$$\pi_d^L(q_d^L) = s_d^L[1 - ((1 - z_d)q_d + q_d^L)])q_d^L, \tag{22}$$

subject to its choice being less than or equal to the amount of low quality goods available: $q_d^L \leq z_d q_d$. Differentiating 22 with respect to q_d^L yields

$$- s_d^L q_d^L + s_d^L[1 - ((1 - z_d)q_d + q_d^L)]. \tag{23}$$

Noting that (22) is concave in q_d^L and evaluating (23) at q_d^A, the expression (23) is positive so long as

$$c \geq \frac{(1 - z_d)((3z_d - 1)s_d^H - 3z_d s_d^L)}{1 + z_d}.$$

Obviously, then, for all $z_d \leq 1/3$, the firm would want to put all of its low quality on the market for any $c \geq 0$. Further, if $s_d^H \leq 3s_d^L$, then this holds for all $z_d \leq 1/2$. That is, the firm would be unable to dispose of any of its low quality under these conditions because it cannot commit to it. Specifically, even if $c < z_d(1 - z_d)(s_d^H - s_d^L)$ from the previous section (A.1), the firm would not dispose of any of its low quality product. (To be complete, the first stage must be checked, but not surprisingly, the derivative of high and low quality profit (8), with respect to high quality output is positive for any $c \geq 0$.)[19]

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[19]The purpose of this subsection was to show that with a lack of commitment a firm would sell all of its low quality when with commitment it would not (section A.1). If the condition on z_d does not hold then the problem becomes more complicated as the firm in choosing its original production must take this into account.

References

Alchian, A. and Allen, W., 1964, University Economics. Belmont, CA: Wadsworth Publishing Company.

Beijing Review, 2015. What's behind the lowly status of Sold in China? No. 12., 19 March.

Boom, A. 1995, Asymmetric International Minimum Quality Standards and Vertical Differentiation. The Journal of Industrial Economics, 43(1), 101-119. doi:10.2307/2950427

Thomas E. Borcherding and Eugene Silberberg, 1978, Shipping the Good Apples Out: The Alchian and Allen Theorem Reconsidered, Journal of Political Economy 86:1, 131-138

Brander, J. and Krugman, P., 1983. A reciprocal dumpingmodel of international trade. Journal of international economics, 15(3-4), pp.313-321.

Brander, J.A. and Spencer, B.J., 1985. Export subsidies and international market share rivalry. Journal of international Economics, 18(1-2), pp.83-100.

Chisholm, Darlene C.; Norman, George, 2012, Market Access and Competition in Product Lines, International Journal of Industrial Organization, 30, 5 Pages: 429-435

Costinot, Arnaud, 2009, On the origins of comparative advantage, Journal of International Economics, 77, pp. 255-264.

Crampes, Claude, and Abraham Hollanderb. Duopoly and quality standards, European Economic Review, Volume 39, Issue 1, January 1995, Pages 7182.

Creane, A., and TJ Jeitschko, Exporting to Bypass Weak Institutions: Shipping the good apples out under asymmetric information, European Economic Review, April 2016, Vol. 85(2), pp. 246-262.

De Fraja, G., 1996, Product Line Competition in Vertically Differentiated Markets. International Journal of Industrial Organization, Vol. 14, pp. 389-414

Carsten Eckel, J. Peter Neary; 2010. Multi-Product Firms and Flexible Manufacturing in the Global Economy, 2010, Review of Economic Studies; 77 (1): 188-217.

Gal-Or, E., 1983, Quality and Quantity Competition, Bell Journal of Economics, 14, pp. 590-600.

Gould, John P., and Segall, Joel, 1968, The Substitution Effects of Transportation Costs, Journal of Political Economy, 77(1), 130-37.

Hummels, D. and Skiba, A., 2004, Shipping the Good Apples Out? An Empirical Confirmation of the Alchian-Allen Conjecture. Journal of Political Economy, 112(6), 1384–1402.

Justin P. Johnson and David P. Myatt, Multiproduct Cournot Oligopoly, The RAND Journal of Economics, Vol. 37, No. 3 (Autumn, 2006), pp. 583-601.

Johnson, Justin P.; Myatt, David P., 2015, The properties of product line prices, International Journal of Industrial Organization, 43, 182-188

Mussa, Michael and Rosen, Sherwin, 1978, Monopoly and product quality, Journal of Economic Theory, Volume 18, Issue 2, Pages 301-317.

Norton, Michael I., and Jeremy Dann. "Juan Valdez: Innovation in Caffeination." Harvard Business School Case 513-090, February 2013.

Park, JH, The Canadian Journal of Economics, 34 Issue: 4 Pages: 967-987 Published: NOV 2001.

Rico, RJ, 2015, What happens to the losing team's Super Bowl championship shirts? The Guardian, Tuesday 3 February 2015 06.00 EST.

Ries, J., 1993, Voluntary Export Restraints, Profits, and Quality Adjustment. The Canadian Journal of Economics, 26(3), 688-706.

Ronnen, U., 1991, Minimum quality standard, fixed costs, and competition, Rand Journal of Economics 22, no. 4, 490-504

Tirole, J., 1988, Theory of Industrial Organization, MIT Press.

Wikipedia, 2017, Second Wine, https://en.wikipedia.org/wiki/Second_wine.

Zhou, DS; Spencer, BJ; Vertinsky, I, 2002, Journal of International Economics, 56 Issue: 1
Pages: 205-232