Home Bias in Multimarket Cournot Games

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Abstract
This paper consists of a laboratory experiment of Brander and Krugman (1983). In this model players compete à la Cournot in two segmented markets, a domestic and a foreign one, and incur trade costs to export to the foreign market. We find qualitative support for the model’s main predictions: (i) there is two-way trade in identical products, (ii) each player has the majority market share in his own market, (iii) a decrease in trade costs increases trade and lowers players’ sales in their own markets, and (iv) trade is welfare improving if trade costs are not too large. However, players’ sales to their own markets are higher than the equilibrium prediction, and there is less trade than the theory predicts. We also find that many players are able to sustain collusive outcomes. The findings indicate that gains from trade in oligopolistic markets are hampered by collusive division of geographic markets.

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1 Introduction

Brander (1981) and Brander and Krugman (1983) provide the first model of international trade with oligopolistic competition. There are two identical

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countries, one domestic and one foreign, and each country has one firm producing the same homogeneous good. Each firm incurs a constant marginal cost to serve its own market and an additional trade cost to cross-haul the product to the foreign market. Each firm regards each country as a separate spatial market and therefore chooses the profit maximizing quantity for each country separately. Moreover, each firm has a Cournot perspective: it assumes the other firm will hold output fixed in each country.

This model carried dramatic new implications for the theory of international trade. First, there is no comparative advantage and no product differentiation but still trade occurs. Second, there is two-way trade in identical products. Third, such trade can be mutually beneficial to the two countries since the shift from autarky, monopoly in each country, to trade, duopoly in each country, brings prices closer to marginal cost. This benefit remains even though some resources are being lost due to trade costs, so long as the trade costs are not too large.¹

In this paper, we test Brander and Krugman’s (1983) model experimentally. We use a between-subjects design with three treatments: high, low, and no trade cost. By manipulating trade costs we are able to test one of the main qualitative predictions of the model: a decrease in trade costs increases trade and lowers firms’ sales in their own markets.

We use a fixed matching scheme, i.e., fixed pairs of participants play Brander and Krugman’s (1983) one-shot game for 20 periods. The 20 periods allow us to see if subjects are able to learn to play the Nash predictions or not. One market is displayed in blue color and the other market in red color. Each player is assigned to either the blue or the red color. The colors stay the same during the 20 periods and are observed by the two players. At the end of each period, the players are informed about their profits earned in each market and the market shares of the two firms in the two markets. For the entire experiment communication is not allowed.

The main results of the paper are as follows. First, we find qualitative support for the main predictions of the model: (i) there is two-way trade in identical products, (ii) each player has the majority market share in his own market, (iii) a decrease in trade costs increases trade and lowers players’ sales in their own markets, and (iv) welfare in the low and no trade cost treatments is higher than welfare under autarky. Second, we find that players’ sales to their own markets are higher than the equilibrium prediction and that there is less trade than what the theory predicts. Third, we find that welfare is

¹According to Neary (2010) there are three main theories of international trade. The theory of comparative advantage and constant returns to scale based on perfect competition. The theory of product differentiation and increasing returns to scale based on monopolistic competition. The theory of trade under oligopolistic competition.
lower than the Nash prediction. Fourth, we find that many players are able to sustain collusive outcomes.

Our paper contributes to the experimental literature on international trade (see e.g. Nousair et al. (1995)). It also contributes to the experimental literature on Cournot duopoly. Holt (1985) and Mason et al. (1991) find that in multi-period duopoly games, the quantity choices of players fall between the Cournot and collusive levels. Our findings for multimarket Cournot duopolies are consistent with these findings.

The remainder of the paper is structured as follows. Section 2 sets-up the model. Section 3 describes the experimental design and procedures. Section 4 presents the results. Section 5 discusses the findings. Section 6 concludes the paper.

2 The Model

The domestic firm produces output $x$ for domestic consumption and output $x^*$ for foreign consumption. Marginal cost in the domestic market is a constant, $c \geq 0$, and marginal cost of export is $c/g$, where $0 \leq g \leq 1$. Similarly, the foreign firm produces output $y$ for export to the domestic country and output $y^*$ for its own market, and faces a symmetric cost structure. Using $p$ and $p^*$ to denote domestic and foreign prices and assuming linear demand, we have

\begin{align*}
p &= a - b(x + y) \\
p^* &= a - b(x^* + y^*),
\end{align*}

where $a > 0$ and $b > 0$.\(^2\) Hence, the profits of the domestic and foreign firms are given by

\begin{align*}
\pi &= [a - b(x + y)]x - cx + [a - b(x^* + y^*)]x^* - cx^*/g - F \\
&= \pi(x, y) + \pi(x^*, y^*) - F
\end{align*}

and

\begin{align*}
\pi^* &= [a - b(x + y)]y - cy/g + [a - b(x^* + y^*)]y^* - cy^* - F^* \\
&= \pi^*(x, y) + \pi^*(x^*, y^*) - F^*
\end{align*}

respectively, where asterisks generally denote variables associated with the foreign country and $F$ denotes fixed costs. The profit maximizing choice

of $x$ is independent of $x^*$ and similarly for $y$ and $y^*$: each country can be considered separately. By symmetry we need to consider only the domestic country.

Each firm maximizes profit with respect to own output in the domestic country, which yields the first-order conditions:

$$
\pi_x = a - 2bx - by - c = 0 \\
\pi_y^* = a - 2by - bx - c/g = 0.
$$

Solving this system with respect to $x$ and $y$ we obtain

$$
x^N = \frac{a - 2c + c/g}{3b} \\
y^N = \frac{a - 2c/g + c}{3b}.
$$

It follows from these two equations that $x^N \geq y^N$, i.e., the Nash-equilibrium output of the domestic firm in the domestic market is greater than or equal to the Nash-equilibrium exports of the foreign firm to the domestic market. Similarly, we have

$$
(x^*)^N = \frac{a - 2c/g + c}{3b} \\
(y^*)^N = \frac{a - 2c + c/g}{3b}.
$$

An important assumption is that output $y^N$ is strictly positive, otherwise, the foreign firm does not export to the domestic market. For that to be the case we must have

$$
g > \frac{2c}{a + c}.
$$

This inequality means that trade costs must be below a certain threshold before two-way trade in identical products takes place (trade costs fall as $g$ rises). Note that when $g = 1$ (trade costs are zero) the equilibrium is

$$
x^N = y^N = (x^*)^N = (y^*)^N = \frac{a - c}{3b}.
$$

Thus, as trade costs fall, goods produced abroad make up a greater and greater share of domestic consumption, with the share being equal to $1/2$ when $g = 1$. 

4
3 Experimental Design and Procedures

In the experiment we consider three trade cost treatments: HighTC, LowTC, and NoTC. Each treatment consists of 20 periods of the basic game in which two symmetric firms can produce in two equal-sized markets. In each market, firms face a linear demand and produce at constant marginal cost. The firms simultaneously and independently choose the quantities for the domestic and foreign markets. In each market, their action sets are numbers between 0 and 74 with 0.1 as the smallest increment. Producing 0 is equivalent to not entering the market. The price in the domestic and foreign market, respectively, are determined by the market demand functions:

\[ p = \max\{74 - (x + y), 0\} \]
\[ p^* = \max\{74 - (x^* + y^*), 0\}. \]

The marginal cost of production is equal to 2. There are no fixed costs, i.e., \( F = F^* = 0 \). Hence, the profits of the domestic firm and foreign firm are given by

\[ \pi = \max\{74 - (x + y), 0\} x + \max\{74 - (x^* + y^*), 0\} x^* - 2(x + x^*/g) \]
\[ \pi^* = \max\{74 - (x + y), 0\} y + \max\{74 - (x^* + y^*), 0\} y^* - 2(y/g + y^*), \]

respectively. In HighTC the trade cost is 10 \((g = 0.2)\), in LowTC the trade cost is 4 \((g = 0.5)\), and in NoTC the trade cost is zero \((g = 1)\).

The Nash equilibrium of the continuous version of the HighTC game is each firm offering 26.7 units in the domestic market and exporting 18.7 units. The Nash equilibrium of the continuous version of the LowTC game is each firm offering 24.7 units in the domestic market and exporting 22.7 units. Finally, the Nash equilibrium of the continuous version of the NoTC game is each firm offering 24 units in the domestic market and exporting 24 units.

At the end of each period, the players are informed about their profits earned in each market and the market shares of the two players in the two markets. Each market is displayed in a different color (blue, red) and each player is assigned one of these two colors. The colors are exogenously involved and do not have any other function than the one of giving a clear representation of the market shares in each market. The colors stay the same during the 20 periods and are observed by the two players. For the entire experiment, communication is not allowed.

All game parameters and the number of periods are commonly known. Players have access to a what-if-calculator allowing them to calculate the

\[^3\text{When } a = 74 \text{ and } c = 2 \text{ we have } g > \frac{2c}{a+c} = \frac{1}{19}. \text{ This condition is satisfied in the three treatments.}\]
payoff of hypothetical combinations of their quantity and the quantity produced by their competitor. The payments consist of a 10 CHF show-up fee plus the sum of the profits over the course of the experiment. The average earnings were about 36 CHF.

4 Results

In this section we report the findings of our experiment. We start by describing the main findings. Next, we report the dynamics. The section concludes with an analysis of heterogeneity in behavior.

4.1 Main Findings

We observe 108 subjects (36 per treatment). Figure 1 shows the average quantities chosen by players for the domestic and foreign markets for the three treatments. Horizontal lines indicate the quantities predicted by the Nash equilibrium. The left panel displays the results in HighTC, the middle panel the results in LowTC, and the right panel the results in NoTC. In all treatments there is two-way trade in identical products, and each player has the majority market share in his own market. We also see that a reduction in trade costs increases trade and lowers players’ sales in their own markets. However, there is less trade than what is predicted by theory: exports are clearly lower than Nash prediction. In addition, players’ sales in their own markets are clearly higher than the Nash prediction.

The first two lines in Table 1 show the observed quantities (obs) and the predicted quantities (ne). We also show $p$-values of exact Wilcoxon signed-rank test (independent group averages as observations) comparing the observed and predicted quantities. The deviations are highly significant in HighTC. The difference between the quantities become somewhat smaller in LowTC, but the deviations from the predicted quantities are still significant both for domestic and export quantities. Thus, while we find qualitative support for the Nash-equilibrium prediction the asymmetry in the data is much stronger than predicted. Our third treatment (NoTC) allows us to test whether the asymmetry between domestic and export quantities relies on the differences in trade costs. The results clearly indicate that this is not the case. Even without trade costs we observe an asymmetry between the domestic and export quantities.

The third line in Table 1 reports summary statistics on the home bias defined as the difference between average domestic and export quantities. For each treatment, we report the residual home bias and the $p$-values of
Wilcoxon signed-rank tests. We denote by residual home bias the difference between the observed home bias and the predicted one. In all cases, the observed home bias is significantly higher than the predicted one. The residual home bias is between 10.5 and 12.4 and seems to be relatively constant across treatments.

While we observe overproduction in the domestic market and underproduction for the export market, it could be that a player’s total quantity is in line with the prediction. On the fourth line in Table 1, we show that the total quantity is always lower than predicted. All differences are at least marginally significant.

The fact that we observe both lower total quantities per player and a shift towards the home market suggests that players managed to collude to some degree. Much to our surprise, this is not reflected in the average profits. The middle part of Table 1 shows that average profits tend to be higher than predicted on the home market and lower than predicted on the export market. The latter effect dominates the first leading to the result that in all treatments players’ average profits are lower than the Nash prediction (significant in LowTC and NoTC).

The bottom part of the table shows the effects on producer surplus, consumer surplus, and welfare. Here we use the group as a unit of observation, i.e., we sum up the profits of both firms and the consumer surplus on domestic and foreign markets. Under autarky, i.e., there is a monopoly in each country, profits and consumer surplus in each market are 1296 and 648, respectively. Hence, welfare under autarky is 3888 (2592 + 1296). On average,
Table 1: Observed (obs) and predicted (ne) values in the three treatments. Variables shown are firm's average quantity on their home \((q_h)\) and export market \((q_e)\). Residual home bias is calculated as the difference between the observed and predicted spread in the two quantities, i.e., \(q_h - q_e - (q_{hn} - q_{en})\). The middle section shows the firm’s average profit in the two markets and overall. The bottom section shows welfare measures. Here the group is the unit of observation, and we sum up the profits of both firms and the consumer surplus on both markets.

<table>
<thead>
<tr>
<th></th>
<th>HighTC</th>
<th></th>
<th></th>
<th>LowTC</th>
<th></th>
<th></th>
<th>NoTC</th>
<th></th>
<th></th>
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<tr>
<td></td>
<td>obs</td>
<td>ne</td>
<td>(p)</td>
<td>obs</td>
<td>ne</td>
<td>(p)</td>
<td>obs</td>
<td>ne</td>
<td>(p)</td>
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<td>Quantity home</td>
<td>30.8</td>
<td>26.7</td>
<td>.003</td>
<td>29.2</td>
<td>24.7</td>
<td>.001</td>
<td>27.3</td>
<td>24</td>
<td>.006</td>
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<tr>
<td>Quantity export</td>
<td>12.3</td>
<td>18.7</td>
<td>.000</td>
<td>14.8</td>
<td>22.7</td>
<td>.001</td>
<td>16.0</td>
<td>24</td>
<td>.008</td>
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<tr>
<td>Residual home bias</td>
<td>10.5</td>
<td>12.4</td>
<td></td>
<td>11.3</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>43.1</td>
<td>45.3</td>
<td>.074</td>
<td>44.0</td>
<td>47.3</td>
<td>.067</td>
<td>43.4</td>
<td>48</td>
<td>.027</td>
</tr>
<tr>
<td>Profit home</td>
<td>803.3</td>
<td>711.1</td>
<td>.060</td>
<td>779.3</td>
<td>608.4</td>
<td>.003</td>
<td>737.4</td>
<td>576</td>
<td>.074</td>
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<td>181.6</td>
<td>348.4</td>
<td>.000</td>
<td>292.4</td>
<td>513.8</td>
<td>.000</td>
<td>349.8</td>
<td>576</td>
<td>.002</td>
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<td>Profit</td>
<td>984.8</td>
<td>1060</td>
<td>.229</td>
<td>1072</td>
<td>1122</td>
<td>.030</td>
<td>1087</td>
<td>1152</td>
<td>.060</td>
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<tr>
<td>Producer surplus</td>
<td>1970</td>
<td>2119</td>
<td>.229</td>
<td>2143</td>
<td>2244</td>
<td>.030</td>
<td>2175</td>
<td>2304</td>
<td>.060</td>
</tr>
<tr>
<td>Consumer surplus</td>
<td>2014</td>
<td>2055</td>
<td>.369</td>
<td>2062</td>
<td>2240</td>
<td>.212</td>
<td>2030</td>
<td>2304</td>
<td>.090</td>
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<tr>
<td>Welfare</td>
<td>3984</td>
<td>4174</td>
<td>.012</td>
<td>4205</td>
<td>4485</td>
<td>.003</td>
<td>4205</td>
<td>4608</td>
<td>.001</td>
</tr>
</tbody>
</table>

welfare in each treatment is higher than welfare under autarky; the difference is significant for LowTC and NoTC \((p = .002 and p = .010)\), but not for HighTC \((p = .167)\). The fact that players’ quantities are lower than predicted has the consequence that the same holds for the consumer surplus. While the differences between observation and prediction are not always significant for consumer and producer surplus we find that welfare in each treatment is significantly lower relative to the Nash prediction.

4.2 Dynamics

We find clear indication for overproduction in the home market and underproduction in the foreign market over the course of the 20 periods. In a next step we investigate whether there is convergence towards the Nash equilibrium over time. Figure 2 shows the average home and export quantities over time and for the three treatments. The solid lines in the middle indicate the respective Nash-equilibrium quantities. After some adjustments in the first five periods we observe very stable patterns over time. In particular, there is no indication for convergence towards the Nash-equilibrium quantities.\(^4\)

\(^4\)We also ran OLS regressions with our measure for home bias as dependent variable and period and treatment dummies as independent variables. The point estimate for period is basically zero and insignificant \((p = .934)\). The treatment dummies are also insignificant.
The lack of convergence to the Nash-equilibrium quantities in our multi-market Cournot duopoly is consistent with experiments involving finite repetition of Cournot duopolies. While a random matching scheme results in play converging to the Nash equilibrium, incidence of collusion arises in repeated Cournot duopolies with fixed pairs of participants. See Cox and Walker (1998), Huck et al. (1999), and Huck et al. (2001).

We also see from Figure 2 that there is a starting period effect in each treatment. In HighTC and NoTC, the quantity produced for sale in the home market starts at a very low level and raises sharply from the first to the second period. In LowTC, the quantity produced for sale in the export market starts at a very low level and raises sharply from the first to the second period.

Finally, we see that there is no end period effect. This stands in contrast with experiments involving finite repetition of prisoners’ dilemma and Cournot duopoly games. A common pattern in these experiments is that many pairs of players manage to cooperate or collude for some time but move to playing Nash a few periods before the end of the game.\footnote{Kreps et al. (1982) rationalize this dynamic behavior by invoking incomplete information about one or both players’ types.}

Figure 2: Average quantities in home and export market for the three treatments across the 20 periods. Horizontal lines indicate Nash-equilibrium quantities.
4.3 Heterogeneity in Behavior

It is possible that the deviations we observe from the Cournot-Nash predictions are due to collusion. Pinto (1986) extends Brander and Krugman (1983) in a natural way by assuming that firms interact repeatedly. He shows that no trade can be a subgame perfect equilibrium of the infinitely repeated version of Brander and Krugman’s (1983) one-shot game. The intuition behind this result is clear. Firms cannot maximize joint profits when they engage in two-way trade in identical products as such trade induces trade costs. Hence, colluding firms that maximize joint profits will not deliver to foreign markets. Moreover, if firms are sufficiently patient they can sustain the joint profit maximum as a subgame perfect equilibrium of the infinitely repeated game.6

Figure 3 displays the histogram of the sum of profits of all pairs of players for all periods of play. The histogram shows that there is substantial heterogeneity in behavior. In a large percentage of cases the observed sum of profits is less than the Nash-equilibrium one and in some cases it is even negative. In HighTC, LowTC and NoTC players attained a higher joint profit than the Nash-equilibrium one in approximately 50%, 44% and 53% of cases, respectively. Hence, there is evidence that for a similar number of more and less competitive outcomes than the Cournot-Nash outcome which suggests that at least some of the groups managed to systematically collude.

![Histogram of the sum of the profits of each pair of firms in a period.](image)

Figure 3: Histogram of the sum of the profits of each pair of firms in a period.

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6Baake and Normann (2002) show that if firms are not sufficiently patient to be able to sustain the maximum joint profits as a subgame perfect equilibrium of the infinitely repeated game, they might still engage in collusive two-way trade.
5 Discussion

Our experiment provides qualitative support for Brander and Krugman’s (1983) main predictions. If firms compete à la Cournot in two segmented markets, a domestic and a foreign one, and there are trade costs, then (i) there is two-way trade in identical goods, (ii) each firm has the majority market share in its own market, (iii) a decrease in trade costs increases trade and lowers firms’ sales in their own markets, and (iv) trade is welfare improving if trade costs are not too large.

However, we also find that subjects deviate systematically from the Nash-equilibrium quantities. On average, there is overproduction in the domestic market—the quantity offered by domestic firms in domestic markets is higher than the Nash prediction—and underproduction in the export market—the quantity exported to foreign markets is lower than the Nash prediction. As a consequence, the welfare gains from trade are less than what the theory predicts.

The phenomenon that domestic products have a disproportionately high market share on many goods markets is often referred to as home bias (see Obstfeld and Rogoff, 2001). The literature has focused on two main explanations for the home bias: preferences and trade costs. The home bias might be a result of the fact that domestic consumers have a preference for buying domestic goods (see Trefler, 1995). Alternatively, the home bias might be a result of trade costs (see Hillberry and Hummels, 2003). Trade costs may lead to higher marginal costs which in turn are reflected in higher prices for imported brands. Foreign products may be distributed in a smaller set of stores and therefore fewer consumers have access to them – major domestic brands frequently have a stronger distribution network. Many foreign products may not be distributed at all due to fixed costs of being present on foreign markets.

Our experimental design rules out differences in consumer preferences as an explanation for the home bias. More importantly, our design allows us to manipulate trade costs while keeping everything else constant.\footnote{It is very hard to distinguish the effects of trade costs from differences in preferences using aggregate data. Anderson and van Wincoop (2004, pp. 734) note that “Differences in preferences are [in a standard gravity framework], however, empirically indistinguishable from trade costs.”} We find that higher trade costs lead to a higher observed home bias. However, changes in trade costs have no impact on the difference between the observed home bias and the predicted home bias. In addition, the home bias is present even in the absence of trade costs. These results show that trade costs alone are not enough to explain the home bias observed in our data.
We find suggestive evidence of players being able to sustain collusive quantities. These results provide support for an alternative explanation for the home bias: collusive division of geographic markets.\(^8\)

6 Conclusion

Our experiment provides qualitative support for Brander and Krugman’s (1983) main predictions: (i) there is two-way trade in identical products, (ii) each player has the majority market share in his own market, (iii) a decrease in trade costs increases trade and lowers players’ sales in their own markets, and (iv) trade is welfare improving if trade costs are not too high. However, the amount of trade is less than what is predicted by theory and players’ sales to their own markets are higher than the Nash prediction. As a consequence, the gains from trade are less than what the theory predicts.

We find that this form of home bias is also present in the absence of trade costs. Typically, the international trade literature assumes that the home bias is either due to trade costs or differences in consumer preferences. We find that many players are able to sustain collusive quantities. We interpret our findings as evidence in favor of an alternative explanation for the home bias: collusion in geographically segmented markets.

7 References


\(^8\)Based on an empirical analysis of the Brazilian cement industry, Salvo (2010) provides a similar suggestion.


