The Game Theory of Protective Governments and Airplane Manufacturers Introduction

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As the USA leans increasingly toward a protectionist stance, trade disputes have become an increasingly pressing issue. In this essay India Healy O'Connor analyses the strategic interactions of a trade dispute through the real-world example of the Bombardier-Boeing dispute. India clearly lays out each countries pay-offs from all possible outcomes and then deciphers the optimal strategy each should take. She then compares these strategies with the outcome which was observed in reality and analyses the policy implications of her results.

Introduction

The airplane manufacturing industry is an example of a high-technology industry that receives significant support from governments due to the fact that it produces positive externalities for the economy. There are multiple desirable spill-over effects from the industry, including high value add manufacturing, employment for a range of skill levels and production which is export orientated. This induces governments to provide state aid, which can give a strategic advantage to export firms operating in an imperfectly competitive market. The single-aisle plane market within this industry is dominated by Boeing and Airbus. However, the struggling Bombardier C series programme recently secured a $5.6 billion deal with Delta for 75 jets (Hollinger and Donnan, 2017). As can be inferred from Figure 1, Bombardier is a very small player in the industry.

The deal resulted in Boeing bringing a trade case to the US Department of Commerce, who decided to impose a 300% tariff on Bombardier jets imported

into the US (Hollinger and Donnan, 2017).

Figure 1: A comparison of Bombardier, Airbus and Boeing

The Department believed that Bombardier sold under-priced jets and received unfair state subsidies from the British and Canadian governments (Hollinger and Donnan, 2017). This is an accusation that Bombardier has strongly disputed and is ironic given that Boeing 'is among the top recipients of both federal, state and local subsidies in the U.S' (Alini, 2017). While the subject of the trade case is company-related, due to the evident investment and aid received from governments, the situation becomes a trade dispute between countries. In this paper, game theory is used to examine the decisions of the American and British governments during the development of this trade dispute. The model is presented below.

Figure 2: The double U trade dispute and negotiation process
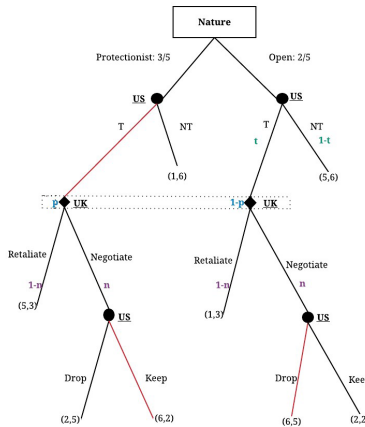
Outline

The model above represents a Bayesian game in strategic form. The game has two players - the American government (US) and the British government (UK).

The US can be one of two types- Open or Protectionist. The US is Protectionist with a probability of $^3/_5$ and Open with a probability of $^2/_5$. In order to model this random variable, Nature moves first and determines the US type. After Nature moves, only the US is aware of its type. The US must choose between playing impose tariffs (T) or do not impose tariffs (NT). If the US plays NT, the game ends. If the US plays T, then the UK must choose to either retaliate or negotiate. If the UK retaliates, the game ends and both countries are embroiled in a trade war. If the UK plays negotiate then the US may decide to keep the tariffs (Keep) or drop them (Drop). If the US plays Drop, positive trade relations are maintained and if it plays Keep, a trade dispute ensues.

Assumptions

Several assumptions govern this sequential game with imperfect information. Firstly, it is assumed that the US is more protectionist than open. Research carried out on US trade policies revealed that the US has implemented $1,297$ protectionist measures since the financial crisis compared to 206 liberalising policies (Figure 3) (Kirk, 2017). The protectionist stance adopted by the US has only been further exacerbated by President Trump (Kirk, 2017).

The US is by far the most protectionist when it comes to global trade
Net protectionist measures implemented (number of 'liberalising' measures, minus number of 'restrictive' measures)
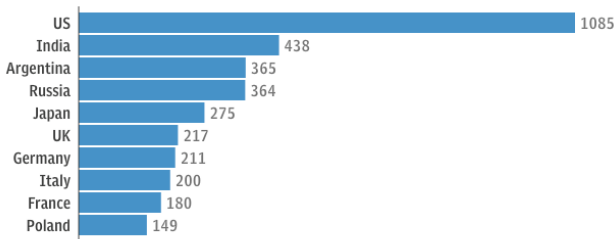

Figure 3: A ranking of countries in terms of level of protectionism

Secondly, this model assumes that there are only two players involved in this trade dispute. This is a simplification of the dispute as the Canadian government, who provided Bombardier with significant state aid, have already retaliated by stating that they won't buy Boeing jets while the tariffs are upheld (Wingrove, 2017). This assumption is not-overly constraining as the UK and Canada are on the same side of the argument and the UK are better off adopting a similar approach rather than diverge, as is reflected in the payoffs.

Finally, there are assumptions regarding the preferences of the US and the UK. The US is the most powerful nation in the world, thus while a trade dispute

with the UK is for the most part undesirable, it is a nation that can withstand such a battle. The UK is in a more vulnerable position as it attempts to navigate the country through Brexit. The UK want to punish the US for imposing these tariffs, yet they can't afford to lose the US as an alley in terms of negotiating post-Brexit trade deals. However, Prime Minister May relies on the votes of the DUP for her government majority. The DUP are dependent on many votes from the area in Northern Ireland where Bombardier employs over 4000 people. Thus the British government is under pressure to either negotiate a deal or alternatively, retaliate and align with Canada, who have already taken a hard line. The UK defence secretary has threatened that this case may prevent Boeing from winning lucrative British defence contracts in the future (Hollinger and Donnan, 2017). Furthermore, the UK would rather not reveal weakness in a negotiation process if the tariffs would ultimately be upheld.

U(a, b, c) can be defined as the case where the US chooses action a at its initial stage, the UK chooses action b and the US chooses action c at the final stage. Where b or c are missing, the game ends before reaching subsequent stages.

The outcomes of the Protectionist US are ranked as follows:

U(T, Negotiate, Keep) > U(T, Retaliate) > U(T, Negotiate, Drop) > U(NT)

Regardless of the actions of the UK, the Protectionist US will always prefer to impose tariffs. It has no regard for international relations and perceives a UK that will initially negotiate rather than retaliate as a weaker opponent.

The outcomes of the Open US are ranked as follows:

U(T, Negotiate, Drop) > U(NT) > U(T, Negotiate, Keep) > U(T, Retaliate)

The Open US is mindful of maintaining international relations, however it would still rather negotiate an attractive deal rather than impose no tariffs in the first place. If the UK chooses to retaliate, then the Open US has failed to negotiate a deal and caused further international upset. It would have been better off imposing no tariffs at all. The outcomes for the UK are ranked as follows:

U(NT) > U(T, Negotiate, Drop) > U(T, Retaliate) > U(T, Negotiate, Keep)

The best outcome for the UK involves no tariffs from the outset. It would rather not immediately engage in a war with a country that it needs to keep onside and will try to negotiate a deal. However, if the UK believes that the negotiations would ultimately be fruitless and the tariffs kept in place, they would be better off to retaliate immediately.

Equilibria

The extensive game yields three equilibria (Appendix 1). Starting at the end of the game, it is evident that the Protectionist US will choose Keep and the open

US will choose Drop (denoted by red lines). In addition, the Protectionist type has a pure strategy. The Protectionist US will always prefer to play T regardless of what the UK does later in the game. The Open US will randomize at its first information set, where it decides between T and NT.

t: represents the probability that the Open type chooses T

n: represents the probability that the UK chooses Negotiate

p: represents the probability that (US is Protectionist|T)

Equilibrium 1: Pooling PBE (Perfect Bayes Equilibrium)

o US strategy:

- Open US (T, Drop)
- Protectionist US (T, Keep)

o UK strategy: (Negotiate)

o UK beliefs:

- US is Protectionist with probability 0.6 and Open with probability 0.4

The UK's beliefs are consistent. Their posterior beliefs are equal to their prior beliefs as the actions of the US do not reveal any additional information. The UK strategy is optimal because the expected utility from negotiating is greater than that for retaliating when $p < 66.7\%$. The US strategy is also optimal. Since the UK always negotiates, the Protectionist US will play Keep and earn its highest payoff of 6. For the Open US, it will play Drop and similarly earn their highest payoff of 6.

Equilibrium 2: Separating PBE

o US strategy:

- Open US (NT)
- Protectionist US (T, Keep)

o UK strategy: (Retaliate)

o UK Beliefs:

- If US chooses T it is Protectionist with probability 1. If US chooses NT, it is Protectionist with probability 0.

The UK's beliefs are consistent because only a Protectionist US would play T, while only an Open US would play NT. Therefore, the UK adopts its optimal strategy of playing Retaliate. The US strategy is optimal because the Protectionist US adheres to its pure strategy of imposing tariffs. The Open US wants to avoid retaliation as this would result in its lowest payoff and thus will choose NT from the get go.

Equilibrium 3: Semi-separating PBE

o US strategy:

- Open US (T with probability 75%, NT with probability 25%, Drop)

- Protectionist US (T, Keep)

o UK strategy: (Negotiate with probability 80%, Retaliate with probability 20%)

o UK beliefs:

- Using Bayes' Rule the probability (US is Protectionist | T) = 66.7%

The US must play T with a probability of 75% for the UK to be willing to randomize. For this to be optimal for the US, there must be an 80% chance that the UK will negotiate. If the US plays T, the UK believes that there is a 66.7% chance that it is Protectionist. The PBE requires that both governments mix strategies.

It is also interesting to evaluate the game when the probabilities of the US types are changed. Perhaps 60% and 40% were too conservative and it would be more appropriate to assign an 80% probability to the US being Protectionist and 20% to the US being Open. When the game is recalculated with these probabilities one separating equilibrium is found (Appendix 2). As always, the Protectionist US will play (T, Keep). The Open US will choose (NT). The UK will always play (Retaliate). If the UK observes T it believes with certainty that it is facing the Protectionist type and will retaliate. If it observes NT it knows with certainty that it is facing the Open type and there is no need to do anything. The actions of the US perfectly reveal their type.

Analysis

The two separating equilibria, are interesting to consider. The separating PBE is becoming more of a reality under the Trump administration. The US is increasingly becoming more protectionist than open. So much so that WTO director general, Roberto Azevedo, stressed that trade wars were responsible for the destruction rather than the creation of jobs (Reuters, 2017). The only way that that the US can increase the value of p (as perceived by the UK) is by imposing tariffs less often when Open. This implies that as t tends to 0, p tends to 1. Under Trump, in order for other countries to credibly believe that the US is open, the US can't impose protectionist policies. With the US becoming increasingly closed and unlikely to negotiate any acceptable deal with the UK, immediate retaliation would be the best move for the UK government. The semi-separating equilibrium describes a situation whereby both governments are mixing strategies. In the real world, if the US does ultimately drop the tariffs then both governments achieve favourable payoffs. However, given how the situation has progressed this is unlikely.

The pooling equilibrium is the best indicator of what in fact occurred. While it is impossible to know UKs true beliefs regarding the US, it did try to negotiate.

However, the lobbying and pleas have thus far proved to be fruitless. The US has not dropped the tariffs although a final decision won't be made until February. The UK appears to be facing a Protectionist US and one would assume it will receive its worst payoff. However, an unexpected development occurred. This couldn't have been anticipated by either government and thus does not appear in the initial payoffs of the game. Airbus announced in October that it would be taking a majority stake in the C series. This venture provides Bombardier with the marketing expertise, distribution channels and seal of approval it was previously lacking. Airbus has a manufacturing plant in Alabama which means the partnership should be able to circumvent the high tariffs. The jobs in Northern Ireland are safe and the US has received a major blow. While this has not been modelled, a further possible extension would be to consider how the US and UK strategies change in light of this new information.

Policy Implications

Boeing is left in an even more vulnerable position with the prospect of its greatest competitor, Airbus gaining even more market share with its now superior jets. Furthermore, Boeing and the US government have damaged international relations. The US could still hopefully salvage their international relations by dropping the tariffs. Policy implications? Tariffs of 300% are the nail in the coffin for small companies and cause major international upset. No competitive industry can develop if entrants are constantly faced with this insurmountable hurdle. There ought to be stringent regulation which caps the level of tariff a government can place on such companies along with better implementation of the rules surrounding government aid. This would hopefully prevent the US from having to impose tariffs in the first place.

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6. Source taken from Hollinger and Donnan (2017) US move against Bombardier risks reprisals

7. Source taken from Kirk (2017) Mapped: Protectionism is on the rise as US and EU implement thousands of restrictive trade measures.

Appendix 1

Model 1:Probabilities 60% and 40%

Let t represent the probability that the Open US chooses Impose Tariffs (T). Let n represent the probability that the UK chooses Negotiate. Let p denote the probability that (US is Protectionist|T):

EU_{uk} (Negotiate|p) = 2p + 5(1−p) = 5−3p

EU_{uk} (Retaliate|p) = 3p + 3(1−p) = 3

UK will prefer to negotiate if:

$$5-3p > 3$$
$$-3p > -2$$
$$p < {}^2/_3$$

o If $p < {}^2/_3$, UK will play Negotiate.

o If $p > {}^2/_3$, UK will play Retaliate.

o If $p = {}^2/_3$, UK indifferent between playing Negotiate and Retaliate.

UK's beliefs have to be consistent with US strategy and Bayes' rule:

p = Probability (US is Protectionist | T) =

$$\frac{\text{Prob (T | US is Protectionist)*Prob (Protectionist)}}{\text{Prob(T | US is Protectionist)*Prob(Protectionist) + Prob(T | US is Open)*Prob(Open)}}$$

$$= [(1) * (3/5)] / [(1) * (3/5) + (t) * (2/5)]$$

$$= 3 / (3+2t)$$

Values of t where $p < {}^2/_3$:

$$p = 3 / (3+2t)$$
$$3 / (3 +2t) < {}^2/_3$$
$${}^3/_4 < t$$
$$t > {}^3/_4$$

Case 1 : t > ${}^3/_4$ $\Rightarrow$ p < ${}^2/_3$

- Since p < ${}^2/_3$, UK will always play Negotiate
- If UK always plays Negotiate, then the Open US should play T.
- Therefore, t= 1.
- Both players are playing the best response to one another, so this is an equilibrium.
- This is a pooling equilibrium where no information is revealed. The posterior beliefs are equal to the prior beliefs.

Equilibrium

- Protectionist US: (T, Keep)
- Open US: (T, Drop)
- UK: (Negotiate)
- Beliefs: Prob (US is Protectionist | T) = ${}^3/_5$

Case 2 : t < ${}^3/_4$ $\Rightarrow$ p > ${}^2/_3$

o Since p > 2/3, UK will always play Retaliate

o If the UK always plays Retaliate, then the Open US should play NT

o Therefore, t = 0

o Both players are playing the best response to one another, so this is an equilibrium.

Equilibrium

- Protectionist US: (T, Keep)
- Open US: (NT)
- UK: (Retaliate)
- Beliefs: Prob (US is Protectionist | T) = 1

Case 3 : t = ${}^3/_4$ $\Rightarrow$ p= ${}^2/_3$

o Since p = ${}^2/_3$, the UK is indifferent between playing Retaliate and Negotiate o If t= ${}^3/_4$, the Open US is mixing between T and NT.

o For the US to mix between these two strategies, the US must be indifferent between them. This can only happen if the UK is also mixing:

$$EU_{us} (T \mid n) = 6n + 1(1−n) = 5n +1$$
$$EU_{us} (NT \mid n) = 5$$
$$5n + 1 = 5$$
$$5n = 4 \ n = {}^4/_5$$

Equilibrium

Protectionist US: (T, Keep)

Open US: (T with probability $3/4$, NT with probability $1/4$, Drop)

UK: (Negotiate with probability $4/5$, Retaliate with probability $1/5$)

Beliefs: Prob (US is Protectionist | T) $= 2/3$

Appendix 2

Model 2 – Probabilities 80% and 20%

The payoffs for the UK at the information set are the same as before. Therefore, the UK optimal strategy given beliefs remains the same.

o If $p < 2/3$, UK will play Negotiate.

o If $p > 2/3$, UK will play Retaliate.

o If $p = 2/3$, UK indifferent between playing Negotiate and Retaliate.

UKs belief has to be consistent with US strategy and Bayes' rule

$p =$ Prob (US is Protectionist | T) $=$

$$\frac{\text{Prob (T | US is Protectionist) * Prob (Protectionist)}}{\text{Prob (T | Protectionist) * Prob (Protectionist) + Prob (T| Open) * Prob (Open)}}$$

$$= [(1) * (4/5)] / [(1) * (4/5) + (t) * (1/5)]$$

$$= 4 / (4+t)$$

Values of t where $p < 2/3$:

$$p = 4 / (4+t)$$
$$4 / (4 +t) < 2/3$$
$$t > 2$$

o This is not possible and therefore no value of t will result in p T $2/3$.

o This means that the only possibility is for $p > 2/3$.

o Therefore, since $p > 2/3$, the UK will always play Retaliate.

o If the UK always plays Retaliate, then the Open US should always play NT.

o Therefore, t=0

If t $= 0$

$$p = 4 / (4+t)$$
$$p = 4/4$$
$$p = 1$$

Separating Equilibrium

Protectionist US: (T, Keep)

Open US: (NT)

UK: (Retaliate)

Beliefs: Prob (US is Protectionist | T) $= 1$