MBA 211 GAME THEORY

FINAL PROJECT:
Mexican Drug War
Introduction

Mexico is one of several countries that are notorious for drug trafficking organizations. The Mexican government, led by President Vincent Fox in 2000, has waged a war with major cartels as a means to cope with international pressure and enhancing the wellness of the Mexican population. On the one hand, the government is considered to be doing the right thing for the country as drug trading usually comes with significant social costs including crime, corruption, terror, and violence which adversely affect human rights situation in Mexico. The government also experiences a significant loss in tax revenues as these activities are not legitimate businesses. On the other hand, the war and export limitation also come with tremendous social costs as more people are addicted to the substances while drugs are trapped in the country. The government budget has also been depleted while there is no sign that the war is going to end. In addition, one can argue that the overall country’s incomes are lower when the drug export is limited.

Game theory will help us evaluate whether the Mexican government has made the best decision in going into the war. Our hypothesis is that fighting may not be the best alternative that maximizes the payoff for the government and public interests. Rather, the benefits from accommodating the drug trading may outweigh the costs of having the war.

Background

The Mexican drug war is a conflict taking place between rival drug cartels and the government forces in Mexico. Although Mexican drug cartels, or drug trafficking organizations, have existed for a few decades, they have become more powerful since the demise of Colombia’s Cali and Medellín cartels in the 1990s. Mexico is used as a transshipment point from Colombia to the U.S. and Mexican drug cartels now dominate the wholesale illicit drug market in

North America.\textsuperscript{2} Drug traffickers from Mexico had established an infrastructure and collaborated with the Colombia-based traffickers. The Mexican gangs were given 35 to 50 percent of each cocaine shipment in return. Even though there are seven major cartels in Mexico, the Sinaloa Cartel and the Gulf Cartel have taken over trafficking cocaine from Colombia to the worldwide market.

Due to international pressure and commitment to stop the drug trafficking, ex-President Vincente Fox announced a war on drugs in 2000 by sending troops to the border areas between the U.S. and Mexico which led to a surge in violence. In 2006, the subsequent administration led by President Felipe Calderón sent 6,500 federal troops to retaliate against the cartel violence which is regarded as the starting point of the war between the government and cartels. As time progressed, Calderón continued to escalate his anti-drug campaign, in which there are now about 45,000 troops involved in addition of state and federal police forces. This crackdown has put the total number of deaths nationwide at 22,700 since 2006. The war has been prolonged without any sign of success from either side\textsuperscript{3}.

The drug war is not only the fight between the government and the two cartels, but it is also the fight between the two major cartels (Sinalua Cartel vs. Gulf Cartel). President Calderón claimed that cartel-on-cartel violence accounts for 90 percent of the causalities in the drug war\textsuperscript{4}. The two cartels have not achieved coordination in response to the government army forces. Instead, they each act independently in hopes of maximizing their own profits.

\textbf{Signaling from the Mexican Government}

The Mexican government has strongly signaled its stance on drugs to the cartels during the current crisis. Cartels may suspect that President Calderón is not truly committed to the war,

\textsuperscript{3} "Cuernavaca new front in Mexico drug war", \textit{Los Angeles Times}, April 22, 2010 (accessed May 12, 2010).
\textsuperscript{4} ibid.
similar to past regimes that have turned a blind eye to the cartels, President Calderón has publicly and frequently vowed to end the drug war by 2010 on numerous media sources. On top of being visible, the Mexican government’s signal is also a costly one as the government has spent about $7 billion\(^5\) on top of its normal public security since December 2006 to defeat the world’s most powerful drug gangs. Moreover, with the $1.6 billion aid package from the U.S. government over the next three years\(^6\), the Mexican government can signal to the cartels that its cost of ending the drug problem is different than those spent by the previous regimes.

Despite the strong signaling of commitment from the Mexican government, however, the cartels understand that such commitment can only last until 2012. Since Mexican presidents serve a single six-year term, the cartels have the option of enduring the crackdown until President Calderón’s term ends in 2012. As long as the cartels can ride out the current troop deployment, they will have a chance to influence the new government to forego the strict drug enforcement in two years. Therefore, it is necessary for us to look past the government’s current commitment and analyze which options the government has to address the drug war.

**Design of the Game Tree**

In order to understand the fundamental issues and to predict the outcome of the drug war using the tools of game theory, we followed the following steps:

- Identify the key players in the drug war game,
- Identify the strategies available to each player,
- Identify the factors that contribute to each player’s payoffs, and
- Formulate mathematical formulas that a player may use to determine the payoffs for different outcomes.

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\(^5\)“Mexican president: We’re not losing drug war”, *MSNBC.com*, February 26, 2009 (accessed May 11, 2010).

Key Players in the Drug War Game

Based on the background information that we collected, we identified three key players in the drug war game: the Mexican federal government, Cartel I (Sinaloa), and Cartel II (The Gulf). Even though there are around seven big cartels in Mexico, each made up of many gangs and drug pushers, we reduced the number of cartels down to two because recent law enforcement intelligence suggested that the cartels have started to organize themselves into two factions that are bounded by fragile truce.\(^7\) Having two cartels in our analysis also simplifies the dynamics of the game, making it possible for us to analyze how cartels could coordinate or engage in territorial fights with each other.

Strategies for Each Player

The drug war game that we analyzed is constituted of several sequential and simultaneous sub-games. To simulate the real-world situation, the government starts the drug war game by first deciding whether to engage in a war with the cartels. Depending on the decision of the government, the cartels then enter into a simultaneous or sequential game with each other as well as with the government and formulate their best responses. Here are the five strategies that the government can undertake, each followed by cartels' alternatives:

1) **Wage War on All Cartels:** This strategy is the option currently chosen by the government. Under this strategy, the government employs the federal troops on all cartel activities at once and does not discriminate one cartel from another. This will force the two cartels to simultaneously predict what each other would do and formulate the best response from the following alternatives: a) form a faction and fight the government together; b) fight the

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\(^7\) Roebuck, Jeremy, “Violence the result of fractured arrangement between Zetas and Gulf Cartel, authorities say”, *The Brownsville Herald*, March 9, 2010 (accessed May 11, 2010).
government individually and fight against the other cartel to gain additional territories and trade routes; or c) surrender.

2) **Wage War on Cartel I:** As opposed to fighting both cartels at once, the government can utilize the fragile truce and strong rivalry between the cartels and eliminate the cartels one at a time. Faced with discriminating attack, Cartel I has the following alternatives: a) seek help from Cartel II; b) fight the government individually and fight Cartel II to gain additional territories and trade routes, or c) surrender. If Cartel I seeks help, Cartel II can formulate the best response from the following alternatives: a) answer Cartel I’s request and fight together; b) fight Cartel I to gain additional territories and trade routes; or c) surrender. If Cartel I fights the government on its own and fights Cartel II or if Cartel I surrenders, Cartel II can formulate the best response from the following alternatives: a) fight back against Cartel I, or b) surrender.

3) **Offer safe passage:** Under this strategy, the government foregoes the federal troop deployment and returns to the status quo before 2006, allowing its local officials to take bribes and offer cartels safe passage to the U.S. However, they will continue to crack down on any cartels dealing domestically. The cartels then simultaneously decide on whether to: a) bribe together in a concerted fashion to ensure fair amounts of money spent and trade routes assigned; b) bribe individually and fight each other; c) form a faction and continue fighting against the government in order to continue dealing domestically; d) fight individually and each other; or e) surrender.

4) **Legalize trade:** The government can choose to loosen its drug policy by legalizing the cartels’ trades to the U.S. The cartels then simultaneously choose to: a) export together and act as duopoly to ensure high prices; b) export individually and engage in non-violent competitions
such as price wars; c) form a faction and continue fighting against the government in order to sell drugs domestically in Mexico; d) fight individually and each other; or e) exit.

5) Legalize trade and consumption: Under this strategy, the government legalizes all drug-related activities inside and outside of the country. In other words, the cartels are free to export drugs and sell them in Mexico for domestic consumption. The cartels are now faced with the following options: a) sell together in a duopoly; b) sell individually and engage in competitions such as price wars; or c) exit the drug market.

The game tree below summarizes the players and their strategies:

Exhibit 1: Game Tree for the Drug War
Mathematical Model to Determine the Payoffs for Each Strategy

Each player has a different payoff structure, and requires one mental model per player. For simplicity, the cartels are assumed to be of equal size and organization and have symmetrical payoffs. However, the government’s payoffs are based on an entirely different mental model.

Cartels’ Mental Model

The value of cartels’ best response to either strategy depends on two factors: (1) the importance of three variables to cartels \([y(v)]\) and (2) the utility points that each variable brings to cartels \([u(v)]\):

\[
\text{payoff}(c) = \sum_{i=1}^{3} y(v_i) * u(v_i)
\]

Consequently, cartels’ payoffs depend on three variables/potential benefits:

1. **Profit potential from drug dealing.** The utility from annual profits for cartels \([\text{payoff}(p)]\) depends on the value of annual profits from international drug operations \([v(i)]\), and the value of profits from the domestic commercialization of drugs in Mexico \([v(d)]\).

\[
\text{payoff}(p) = y(p) * [v(i) + v(d)]
\]

According to the press agency Aljazeera\(^8\), the illegal drugs market in the US alone is $40 billion per year and most of this market is supplied through Mexican cartels\(^9\). The value of the drug commercialization in Mexico is approximately $2 billion per year\(^10\). Given that the main motivation of individuals to engage in illegal activities is to generate superior profits and that

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\(^8\) Aljazeera.net, March 24, 2010.
\(^9\) "90% of the cocaine consumed in the US is supplied through Mexican Cartels", Aljazeera.net, March 24, 2010
\(^10\) In 2006 there were 361 thousand addicts in Mexico, estimated consumption per person $5,000 per year. Consejo Nacional contra las Adicciones (Conadic), Mexico 2008
the profit potential is close to 5% of the Mexican GDP\textsuperscript{11}, we assigned an importance factor $y(p)$ of 60%.

2. **Social Standing.** The utility from social standing [$payoff(s)$] comes from the fact that cartel leaders enjoy their lives the poorest communities [$v(s)$], where they are usually seen as the ‘Robin Hood’ that was able to accumulate significant wealth and who uses that wealth to develop the communities and help their relatives. This social standing is visible in ‘Narco Corridos’ which is a series of popular songs that portray cartel leaders as heroes fighting against the oppressive government.

\[
payoff(s) = y(s) * v(s)
\]

‘Narco Corridos’ are drug ballads sung by popular ‘ranchero’ singers, and are sold by millions in both sides of the border. Due to their immense success\textsuperscript{12} as proof of the ‘Robin Hood’ social phenomena, we assigned an importance factor $y(s)$ of 30%.

3. **Size of the army [$payoff(a)$].** Most cartels are a family business and the size of their army is a signal of power. The army is seen as the most credible threat which cartels can use to deter the other from invading its territory/route and the Mexican government. Consequently, the utility from having a large army depends on number of deaths avoided in cartel-cartel battles [$v(g|g)$], and in cartel-government battles [$v(c|g)$]

\[
payoff(a) = y(a) *[v(c|c) + v(c|g)]
\]

According to Univision Press Agency, during 2009 over 8,000 of people died as a result of the drug-war related violence, and slightly over 90% of these deaths are from cartels’ army. We assigned the remaining 10% of importance factor $y(a)$ to this variable.

\textsuperscript{11} Mexican GDP $875$ Billions, International Monetary Fund, 2009
\textsuperscript{12} Consistent hit in the Top 10 rankings of Mexican Music Charts; Elijah Wald, ‘Narcororrido’, October 2000
**Government’s Mental Model**

Similar to the cartels’ mental model, the governments’ payoffs depend on various factors:

(1) the importance of three variables to the government \( y(v) \) and (2) the utility points that each variable brings to the Mexican government \( u(v) \):

\[
payoff(g) = \sum_{i=1}^{4} y(v_i) * u(v_i)
\]

Government’s payoffs depend on four variables/potential benefits:

1. **Personal gain \([payoff(pg)]\).** Politicians dedicate their life to public service because they extract value from political power (i.e. either for professional fulfillment or personal creation of wealth), but they are also regular people vulnerable to the attack of cartels. Therefore, the utility from personal gain is a function of the value of political power adjusted by the probability of staying in power \([v(pw)]\) plus the value of their life (and the life of their relatives) adjusted by the probability of death due to drug-related violence \([v(pl)]\).

\[
payoff(pg) = y(pg) * [v(pw) + v(pw)]
\]

Politicians are also humans and are frequently approached by drug dealers trying to bribe and extort them, it is a common practice by ‘capos’ to give the ‘bribe or die’ ultimatum. Given that death penalty does not exist in Mexico, the value of taking the money and avoiding death is very hard for most politicians to resist. Consequently, we assigned an importance factor \([y(pg)]\) of 40% to this variable.

2. **Moral imperative \([payoff(m)]\).** The ultimate purpose of the federal government is to procure society's wellness. Consequently, the utility from government’s moral imperative is a function
of the reduction of civilian and military deaths from cartel-cartel violence \([v_{cd/cc}]\), civilian and military deaths of from government-cartel violence \([v_{cd/gc}]\) and the reduction of drug addicts per year \([v_{ad}]\).

\[
payoff (m) = y(m) \ast [v_{cd} + v_{cc} + v_{cd} + v_{gc} + v_{ad}]
\]

The number of drug addicts in Mexico increased from 203 thousand to 361 thousand in 2008, which is a 51% increase\(^{13}\), and the number of civilian and military deaths over the last 3 years is over 8,000 per year. Due to the size of the numbers and the relevant role they play in public opinion as an indicator of government success in the war, we believe this variable is second in importance and we assigned a 30% importance factor \([y(m)]\).

3. Economic development. The utility from economic development \([payoff(e)]\) depends on the value of annual exports from legalized drug trade \([v(x)]\) plus the increase in transfers to the country as a result of an increase in tourism due to the reduction of drug-related violence \([v(t)]\).

\[
payoff (e) = y(e) \ast [v(x) + v(t)]
\]

The potential value of the drug market is close to 5% of the Mexican GDP\(^{14}\), and the estimated reduction of tourism was $2 billion in 2008.\(^{15}\) We believe that moral imperative and personal gain have a greater weigh in governments’ decision making; consequently, we ranked this variable third with an importance factor \([y(e)]\) of 20%.

\(^{13}\) Consejo Nacional contra las Adicciones (Conadic), Mexico 2008
\(^{14}\) Mexican GDP $875 Billions, International Monetary Fund, 2009
4. *Government budget* \([\text{payoff}(b)]\). This potential benefit could materialize either by the value from taxes coming from legalized drug trade \([v(dtx)]\), the increase in taxes coming from tourism \([v(ttx)]\), and/or the reduction of budget for the war against cartels \([v(w)]\).

\[
\text{payoff}(b) = y(b) \times [v(dtx) + v(ttx) + v(w)]
\]

Even though the size of the budget for the drug war is close to $2.6B, we ranked this variable fourth with a 10% importance factor \([y(b)]\) as we believe that budgets are highly flexible, deficit spending is the norm, and in the light of the other variables, this subject plays the least important role in the government’s decision making.

**Determination of payoffs for each player and strategy**

The next step to analyze the game tree is to assess the payoffs to each player of each combination of strategies using the mathematical formulas detailed above. Consequently, we determined three levels of benefit (i.e. low, medium, high) for each of the variables of our mental model; where the high value is the maximum potential benefit for each variable, the medium value is half of the maximum value and the low value is zero. Subsequently, we assigned the payoffs from each outcome in the matrix according to each player’s mental model. See Appendix 1 for the detail of the payoffs.

To illustrate how the payoffs are assigned, the payoff for Cartel I in the ‘Fight Individually, Fight Individually’ outcome if the Government chooses to ‘Legalize trade and consumption’ is 31 utility points. This is based on the addition of 0 (low payoff in reduction of deaths from cartel to cartel violence) because there would still be battles against cartels; plus 0.78 (high payoff in reduction of deaths from government to cartel violence) because most of the deaths from government to cartel violence would be eliminated, plus 28.57 and 1.43 (medium payoff for potential of profits for cartels) because cartels will stay in business but will split the market; and 0
utility points for social standing (low payoffs from social standing) as cartel leaders would no longer be regarded as heroes. Following a similar rationale and assuming symmetry, we computed the payoff for Cartel II to be 31 utility points.

The payoff for the government in this outcome is 30 utility points. This payoff was calculated by adding 8.24 (high payoffs form tax revenue due to legalized drug trade), plus 0 (low payoff from increased tax revenue due to tourism) as we believe this strategy would change the face of Mexico as a tourist destination and might be damaging for this industry, plus 1.53 (high payoffs from reduction in military spending), plus 19.05 (high payoff from increase exports from legalized drug trade), plus 0 (low payoffs from increased transfers due to tourism), 0 (low payoff from reduction in deaths from cartel to cartel violence and low payoff from reducing drug addiction), plus 1.68 (medium reduction in deaths from government to cartel violence), and 0 for personal gain.

Expected Outcomes based on Optimal Strategies

The next step is to apply the principle of “look forward reason back” to predict the outcome of the game assuming each player chooses their optimal strategy.

We began by analyzing each sub-game from the perspective of the two cartels and determined the strategies they would choose in equilibrium. The following section will describe this analysis and the predicted outcomes for each of the five sub-games:

<table>
<thead>
<tr>
<th>Cartel 1 Actions</th>
<th>Cartel 2 Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fight together</td>
</tr>
<tr>
<td>Fight together</td>
<td>69</td>
</tr>
<tr>
<td>Fight individually</td>
<td>61</td>
</tr>
<tr>
<td>Surrender</td>
<td>25</td>
</tr>
</tbody>
</table>

In this sub-game, we observe the classic coordination game. Cartels could choose to fight each other, which is the status quo. However, if they cooperate together to fight the government,
they would get higher payoffs because they would avoid losing their members in cartel-cartel violence. Non-symmetrical strategies (e.g. 'Fight individually, Fight together') would not make sense in this game because the player being attacked would have a profitable deviation to defend their territories and fight the other cartel. Similarly, if you start from 'Fight together, Fight together', neither player would have an incentive to deviate to the non-symmetrical strategy because the profits taken from the other cartel's territory would not be worth the losses from cartel-cartel violence. Despite the existence of two Nash equilibria, we note that the likely outcome is 'Fight individually, Fight individually' because of the issues in coordination that are described in a later section. We also note that exit strategies are not optimal for any player because this leads to the lowest possible payoff, largely due to the lost profits from exiting the drug trade and from the loss in social standing.

In this sub-game, because the government is focusing on Cartel I, this provides Cartel I the opportunity to move before Cartel II, thereby converting the sub-game described above into a sequential game, which resolves the coordination problem. The payoffs are largely similar as before except for Cartel II not incurring any losses from government-cartel violence. Because the game is now sequential, the two cartels will find it easier to coordinate at first, though it is questionable whether this coordination will last in the long run due to the factors described below.
### III. Offer Safe Passage

<table>
<thead>
<tr>
<th>Cartel 1 Actions</th>
<th>Cartel 2 Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bribe together</td>
<td>Bribe together</td>
</tr>
<tr>
<td>Bribe individually</td>
<td>Bribe individually</td>
</tr>
<tr>
<td>Fight together</td>
<td>Fight together</td>
</tr>
<tr>
<td>Fight individually</td>
<td>Fight individually</td>
</tr>
</tbody>
</table>

In this sub-game, we note the similarities with the other simultaneous sub-game described above. The payoffs in the lower-right boxes are exactly the same as the payoffs in the sub-game faced by the cartels if the government chooses to wage war on all cartels. As before, we note that there are two Nash equilibria. However, there are now new strategies available to the cartels, which are to bribe officials in exchange for safe passage. These new strategies introduce two new equilibria. These are the outcomes where neither cartel attacks one another but one cartel chooses to fight the government to deal drugs locally while the other cartel abandons the local market and focuses on smuggling drugs to the US. These outcomes also rely on continued peace between cartels, which as will be discussed further below, are not likely. As such, the predicted outcome is still ‘Fight individually, Fight individually’.

### IV. Legalize Trade

<table>
<thead>
<tr>
<th>Cartel 1 Actions</th>
<th>Cartel 2 Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Export together</td>
<td>Export together</td>
</tr>
<tr>
<td>Export individually</td>
<td>Export individually</td>
</tr>
<tr>
<td>Fight together</td>
<td>Fight together</td>
</tr>
<tr>
<td>Fight individually</td>
<td>Fight individually</td>
</tr>
</tbody>
</table>

In this sub-game, we note that, a cartel that wants to export drugs is a business operating within the law, unlike the above where they had to bribe officials. By becoming legal entities, they lose their “Robin Hood” reputations and therefore some of their social standing payoffs. Consequently, the outcomes where one cartel chooses to export drugs legally are not equilibria -- there is always a profitable deviation to either (i) fight the other cartel and increase profits from taking territory or (ii) fight the government and increase social standing payoffs. Because of this, we have the same two equilibria as the coordination problem and the more likely equilibrium is ‘Fight individually, Fight individually’.
In this sub-game, the cartels are now faced with a standard prisoner’s dilemma in that they could share the market as a duopoly or engage in a price war. Because there is a dominant strategy for each player in this game to sell individually, the predicted outcome is ‘Sell individually, Sell individually’. The main difference between this and the sub-games where there is a cooperative Nash equilibrium is that it is now profitable to deviate from the cooperative outcome. This is because the cartels do not have to incur losses from cartel-cartel violence.

The following table summarizes the expected outcomes for each of the five sub-games described above and shows the expected payoff to government in that scenario:

<table>
<thead>
<tr>
<th>Government’s Strategic Options</th>
<th>Expected Strategy for Cartel 1</th>
<th>Expected Strategy for Cartel 2</th>
<th>Exp. Payoff to Government</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Wage war on all</td>
<td>Fight individually</td>
<td>Fight individually</td>
<td>32</td>
</tr>
<tr>
<td>II. Wage war on Cartel 1</td>
<td>Seek help</td>
<td>Fight together</td>
<td>21</td>
</tr>
<tr>
<td>III. Offer safe passage</td>
<td>Fight individually</td>
<td>Fight individually</td>
<td>35</td>
</tr>
<tr>
<td>IV. Legalize trade</td>
<td>Fight individually</td>
<td>Fight individually</td>
<td>33</td>
</tr>
<tr>
<td>V. Legalize trade and consumption</td>
<td>Sell individually</td>
<td>Sell individually</td>
<td>30</td>
</tr>
</tbody>
</table>

Based on the table above, waging war against only one cartel offers the lowest payoff to the government. This strategy essentially backfires because it only makes it easier for the cartels to coordinate, which is painful for those in government because cartels working together means higher likelihood that the government officials will be killed and spending more of the government budget to fight a multi-pronged war. While the rest of the strategies will lead to a non-cooperative outcome among the cartels, the best strategy for the government is ‘Offer safe passage’. This strategy yields a higher payoff than ‘Wage war on all’ and ‘Legalize trade’ because it prevents government-cartel violence (if not cartel-cartel violence). ‘Legalize trade and consumption’ also
prevents government-cartel violence but at the cost of higher levels of drug addiction among the population.

**Coordination Problem**

From our research, we found no evidence that coordination between the two cartels to fight against the Mexican government has ever been sustained. Fighting between rival drug cartels began in earnest after the 1989 arrest of Miguel Ángel Félix Gallardo who ran the cocaine business in Mexico\(^\text{16}\). Over time, the balance of power between the various Mexican cartels simply shifts as new ones emerge and older ones weaken and collapse.

Even though the cartels have incentives to coordinate and keep the peace (as observed in sub-games analyses above), cartels are not perfectly governed and some rogue gangs will eventually disobey or ignore orders from leadership and infringe upon other cartel's territories. Punishment mechanisms in the drug trade are severe and disproportional. Cartels have been known to use torture, beheadings and kidnappings as forms of punishment.\(^\text{17}\) Because of the lack of forgiveness and proportionality, cartels cannot sustain cooperation.

We can understand the difficulty of maintaining cooperation by imagining the game in terms of multi-round payoffs. In the current round, there may be an incentive to cooperate. However, in the next round, there is a chance that a rogue gang will violate the truce between the two cartels and if that happens, the truce unravels. As such, in the mind of each cartel, the end of the game is essentially always in sight because of the fear of a rogue gang deviating from the terms of the truce. Because the end of the game is always in sight, cooperation cannot be sustained.


Conclusion and Key Takeaways

From our analysis, it is evident that issuing the safe passage yields the optimal outcome for the government. Had the Mexican government utilized game theory principles to analyze the situation, it would have realized that the war is hopeless and unnecessarily costly because the cartels will continue to fight each other regardless. Instead, numerous deaths from government-cartel violence could have been spared if they had offered safe passage.

In terms of our key takeaways, applying game theoretic principles led to several important insights to predict the behavior of the cartels and maximize payoffs for the Mexican government. First, we analyzed the effectiveness of the Mexican government’s signaling their commitment to fight the war on drugs. Even though their signal was visible, costly and differentially costly, the signal was ultimately undermined by the term limits on the current government. Second, using a thorough game tree analysis, we were able to identify the optimal strategy for the Mexican government, which is to offer safe passage. Most of the sub-games faced by the cartels are essentially coordination games. While these would typically mean that cooperation and non-cooperation are equally likely, we used game theoretic principles to predict whether cooperation can be sustained between cartels. Because of the nature of their punishment mechanisms, lack of forgiveness and proportionality will prevent sustained cooperation. Finally, we note that the government attacking only one cartel could backfire because it turns a simultaneous coordination game into a sequential game, which would lead to cooperation as the most likely outcome.
### Appendix 1: Payoff Matrix

| Decision Variables/Criteria | Importance \(|y(v_i)\) | Levels of payoffs | 
|-----------------------------|-----------------|-------------------| 
|                             | Best \([v_i] \text{ Utility} [u(v_i)]\) | Medium \([v_i] \text{ Utility} [u(v_i)]\) | Worst \([v_i] \text{ Utility} [u(v_i)]\) |
| Cartel:                     |                 |                   |                 |
| I. Size of Army             | 10              |                   |                 |
| reduction in deaths from cartel-cartel violence per year | 3,320 9.22 1,660 4.61 0 0.00 | 280 0.78 1,660 0.39 0 0.00 | 
| reduction in deaths from gov't-cartel violence per year | 
| II. Profits                 | 60              |                   |                 |
| annual profits from international drug operations | $20B 57.14 $10B 28.57 0 0.00 | $1B 2.86 $0.5B 1.43 0 0.00 | 
| annual profits from domestic drug operations | 
| III. Social Standing        | 30              | Robin 50          |                 |
| reputation in local community | Hood 30 Legal 15 Criminal 0 Fugitive 0 | 
| Government:                 |                 |                   |                 |
| I. Government Budget        | 10              |                   |                 |
| increased taxes from legalized drug trade | $14B 8.24 $7B 4.12 0 0.00 | $0.7B 0.41 $0.35B 0.21 0 0.00 | 
| increased taxes from tourism induced by reduced crime | 
| reduction in police/military spending | $2.6B 1.53 $1.38 0.76 0 0.00 | 
| II. Economic Development    | 20              |                   |                 |
| increased annual exports from legalized drug trade | $40B 19.05 $20B 9.52 0 0.00 | $2B 0.95 $1B 0.48 0 0.00 | 
| increased annual exports from tourism induced by reduced crime | 
| III. Moral Imperative       | 30              |                   |                 |
| reduction in deaths from cartel-cartel violence per year | 6,880 20.64 3,440 10.32 0 0.00 | 1,120 3.36 560 1.68 0 0.00 | 
| reduction in deaths from gov't-cartel violence per year | 
| reduction in new drug addicts per year | 2,000 6.00 1,000 3.00 0 0.00 | 
| IV. Personal Gain           | 40              |                   |                 |
| value of political power adjusted by the probability of staying in power | high 10.00 mid 5.00 low 0.00 | high 30.00 mid 15.00 low 0.00 | 
| value of life adjusted by the probability of staying alive | 

100 100 50 0