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100 Horsemen and the Empty City: A Game Theoretic Examination of Deception in Chinese Military Legend

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Abstract:

We present game theoretic models of two of the most famous military bluffs from history. These include the legend of Li Guang and his 100 horsemen (144 BC), and the legend of Zhuge Liang and the Empty City (228 A.D.). In both legends, the military commander faces a much stronger opposing army, but instead of ordering his men to retreat, he orders them to act in a matter consistent with baiting the enemy into an ambush. The stronger opposing army, uncertain whether it is facing a weak opponent or an ambush, then decides to flee and avoid battle. Military scholars refer to both stories to illustrate the importance of deception in warfare, often highlighting the creativity of the generals' strategies. We model both situations as signaling games in which the opponent is uncertain whether the general is weak (i.e., has few soldiers) or strong (i.e., has a larger army waiting to ambush his opponent if they engage in combat). We then derive the unique Perfect Bayesian Equilibrium of the games. When the probability of a weak general is high enough, the equilibrium involves mixed strategies, with weak generals sometimes fleeing and sometimes bluffing about their strength. The equilibrium always involves the generals and their opponents acting as they did in the historical examples with at least a positive probability. When the probability of a weak general is lower (which is reasonable given the reputations of Li Guang and Zhuge Liang), then the unique equilibrium always involves bluffing by the general and retreat by his opponent.

Keywords: *game theory, signaling game, bluffing, deterrence, deception*

"All warfare is based on deception"

"The enemy cannot engage me in combat:
I distract him, in a different direction"

– *Sun-tzu, The Art of War*

Introduction

War has always presented the opportunity for deception. Some examples, such as the Trojan Horse used by the Greeks in the 12th or 11th century BC and the Allied misinformation effort during World War II, were direct attempts to trick one's enemy into lowering its guard or exposing vulnerabilities. In other examples, deception (by bluffing about one's own strength) allowed military commanders to avoid conflict with a more powerful enemy. We are concerned with this later category of deception, the military bluff.

This article presents simple game-theoretic models of two of the most famous examples of military bluffs from all of history. These include the legend of Li Guang and his 100 horsemen during the Han Dynasty (144 BC) and the legend of Zhuge Liang and the Empty City during the Three Kingdom period of China (228 A.D.). In both legends, the military commander faces a much stronger opposing army, and instead of ordering his men to retreat, he orders them to act in a matter consistent with baiting his enemy into an ambush. The stronger opposing army, uncertain whether it is in fact facing a weak opponent or an ambush, then decides to flee and avoid battle. That is, the weak military commander bluffs, and the stronger opponent falls for the bluff.

Since their occurrence two millennia ago, military scholars have often referred to these legends as examples of masterful strategy. For example, the story of the 100 horsemen is used in the traditional Chinese commentary on Sun-tzu's *The Art of War* to illustrate what Sun-tzu meant by deception.[1] In referring to the story, eighth-century military strategist and original *Art of War* commentator Li Quan explains: "Puzzle [the enemy] by strange and unusual dispositions, and so make it impossible for him to engage in battle."[2] The legend of the Empty City is the basis of the "Stratagem of Open City Gates" described in the ancient Chinese military treatise *Thirty-Six Stratagems*.[3] It is also depicted in *Romance of the Three Kingdoms*, which is widely regarded by scholars as the first of the Four Great Classical Novels of Chinese History (Luo Guanzhong, 14th cent./2004).

In this article, we present the two legendary situations as games, and show that bluffing arises as a part of any rational equilibrium strategy. In game-theoretic terms, the generals play a signaling game against an opponent who is uncertain whether the general is weak (i.e., has few soldiers) or strong (i.e., has a larger army waiting to ambush his opponent if they engage in combat). The general may order his soldiers to flee, or to stand firm. A strong general

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[1] For discussion and translation of the *Art of War* and its commentary, we refer the reader to the modern John Minford translation (Sun-tzu, 6th cent. BC/2003).

[2] See Sun-tzu (6th cent. BC/2003: 184). Li Quan is one of 11 ancient scholars on The Art of War whose comments can be found in modern day translations of Sun-tzu's text. Li Quan uses the story of Li Guang to illustrate the second Sun-tzu quote that we include at the beginning of this article. Two of the other commentators—Du Mu during the Tang Dynasty and Zhang Yu during the Song Dynasty—use the story of Zhuge Liang to illustrate the same point.

[3] The open city gates stratagem states: "When the enemy is superior in numbers and your situation is such that you expect to be overrun at any moment, then drop all pretence of military preparedness and act casually. Unless the enemy has an accurate description of your situation this unusual behavior will arouse suspicion. With luck he will be dissuaded from attacking" (Verstappen, 1999: 169)

always prefers to stand firm, while a weak general prefers to stand firm only if he is not attacked by his opponent. In this setting, we show that there exists a unique Perfect Bayesian Equilibrium (PBE) of the game.[4] When the probability of a strong general is large enough, the PBE involves the general always standing firm even when he is weak. Otherwise the PBE involves the general playing a mixed strategy in which he stands firm with positive probability. Under no parameter values does there exist an equilibrium in which the general always retreats.

Such signaling models are common in the applied game theory literature, famously including Spense's (1974) job market signaling, and Ackerlof's (1970) market for lemons. Most notably, however, are the similarities between the generals' situations and Cho & Kreps' (1987) beer-quiche game, in which a weak player acts as if he is tough (by drinking beer which he dislikes, instead of ordering quiche which he enjoys) in order to avoid a fight with a bully.[5] As far as we know, ours is the first article to apply a signaling framework to the legends of the 100 horsemen and the Empty City, or to *The Art of War* commentary or the *Thirty-Six Stratagems* more generally.[6]

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[4] For details regarding PBE see Fudenberg & Tirole (1991).

[5] The concept of bluffing employed here also has similarities to the treatment of bluffing in von Neumann and Morgenstern (1944). See for example the section on poker and bluffing. However, von Neumann and Morgenstern's analysis took place before the development of Nash Equilibrium and Bayesian games.

[6] Niou & Ordeshook (1994) consider whether *The Art of War* (without commentary) fully captures the idea of equilibrium strategies. The authors find that portions of Sun-tzu's reasoning, specifically that involving incomplete information, is "vulnerable to a more complete strategic analysis" (1994: 161). This should not be surprising, as Sun-tzu's writing dates back two and a half millennia, well before Thomas Bayes showed us how to rationally update beliefs (Bayes, 1764). We show, however, that the reasoning of Li Guang and Zhuge Liang do not necessarily suffer the same shortcomings, as their strategies are consistent with the equilibrium concepts under incomplete information.

Our analysis does more than just provide commentary on two of the most famous bluffs in military history. Three additional contributions are relevant to modern day strategists and game theorists. First, the article adds to the growing literature in which game theory is used to gain a better understanding of historic events (for an overview see Greif, 2002). While it is widely recognized (and has been for a long time) that the bluffs employed by Li Guang and Zhuge Liang were creative and ultimately successful, our analysis provides a more formal understanding of why such tactics are successful. Unlike other types of deception, bluffing does not require one's opponent to be susceptible to cheap talk, lies, or other misinformation. Rather, bluffing allows for a fully rational opponent with fully rational beliefs. Bluffing prevents conflict not because the enemy is deceived into thinking his opponent is strong, but because the enemy remains uncertain of his opponent's strength and this uncertainty makes attacking too risky.

Second, the article contributes to a larger literature on deception for strategic advantage, specifically in military and defense situations (e.g., Crawford, 2003; Zhuang, Bier & Alagoz, 2010; Zhuang & Bier, forthcoming). Other articles on these topics often model deception as costless lying or cheap talk. In our model, deception comes from a weak player taking actions to act as if they are stronger than they actually are (e.g., equilibrium pooling). This framework allows for deception even when there is no explicit communication between the players. Although the theoretical framework we employ is not new (see Cho & Kreps, 1987), we are unaware of other applications directly to military strategy.

Third, the results bring to light another setting in which professionals (in our case military commanders) intuitively play game-theoretic equilibrium strategies. Although Li Guang and Zhuge Liang lacked formal training in probability theory, their familiarity with military interactions allowed them to engage in the "if he knows that I know that he knows…" logic necessary to choose equilibrium strategies. Haywood (1954) presents examples from World War II in which generals benefited from game theoretic reasoning in complete information environments. Others consider more modern-day evidence in this vein. See for example related evidence that professional soccer players play equilibrium strategies during penalty kicks (i.e., Palacios-Huerta, 2003) and in laboratory experiments (i.e., Palacios-Huerta & Volij, 2008).[7]

The article proceeds as follows. In section 2, we model the story of Li Guang and his 100 horsemen. Section 3 considers the story of Zhuge Liang and the Empty City. The 100 horsemen model is presented in more detail than the Empty City model, as there is much overlap between the two of them. Section 4 concludes the article with a discussion of our results.

Legend of Li Guang and the 100 horsemen

In 144 BC China, legendary Han general Li Guang ran into a bit of trouble. The general and 100 of his men were out riding in the countryside. Far from the main assembly of their army, they were come upon by several-thousand Xiongnu forces. The Xiongnu could easily kill the 100 riders if the two groups engaged in battle. However, the Xiongnu were uncertain if the one hundred

[7] Other research presents evidence that even the most experienced players do not optimally mix between actions when playing mixed strategies. See for example Walker & Wooders (2001) and Kovash & Levitt (2009). However, violations of equilibrium often involve violations of serial independence between actions that make up mixed strategies (e.g., football teams switch between running and passing too often). This is not applicable to our analysis, as we simply show that the one observed action taken by the generals in our examples is consistent with the unique PBEs of their situations.

riders were traveling alone, or if they were part of a larger group of Han soldiers hiding nearby.

Li Guang had to choose whether to order his troops to retreat, or order them to prepare for battle. If the 100 Han retreated, the Xiongnu soldiers could chase them down and Li Guang's group would suffer casualties. If the Han soldiers engaged in battle directly they would almost surely all be killed. Li Guang, knowing full well that his men would be killed if they engaged in battle, nevertheless ordered his men to dismount, send away their horses, and ready themselves for combat. Upon seeing the actions of the outnumbered Han soldiers, the Xiongnu forces fled, worried that the Han were trying to bait them into an ambush.

Formal model

We adapt a classic signaling game framework with two player types and two available actions per player, to model the story of Li Guang (we do the same again with the story of Zhuge Liang in Section 3).[8]

There are two players, Li Guang (i.e. LG) and an unknown Xiongnu general (i.e., GenX). LG is one of two types; either he has support of the larger Han army (i.e., he is strong) or he does not (i.e., he is weak). He knows his own type, but GenX only knows the ex ante probability he is strong, denoted by $\lambda \in (0,1)$.

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[8] Although one could envision a more complex framework to represent the military interactions, the simple model we use has its advantages. The simple framework captures the most important aspects of the situations, and allows for us to develop the most intuition about behavior in the games. Larger type spaces or action spaces will do little to increase our understanding of the situation. Also, given the similarities to classic signaling games (e.g., Spense 1974, Cho & Kreps 1987), most game theorists will be familiar with the underlying structure.

The sequential-move game takes place in the following order. (1) LG chooses whether to retreat, or to prepare for battle. (2) GenX, upon observing LG's action, decides whether his own forces retreat or engage in battle. If LG retreats, then GenX engaging in battle involves chasing down the fleeing Han.

Figure 1 shows the extensive form representation of the game, and depicts the payoffs, listing first the payoff for LG then for GenX. We assume that the Han and Xiongnu are playing a zero sum game, with payoffs equal to the casualties on the other side minus one's own casualties.[9] The parameters α and β denote the expected portion of Han soldiers who will be killed as they retreat; both values are on (0,1).[10] The parameter w is positive.

[Insert Figure 1 about here]

Equilibrium

The analysis solves for the Perfect Bayesian Equilibrium (PBE) of the game, which allows us to focus on subgame perfect solutions to a Bayesian game of incomplete information. In a PBE, neither player may have an incentive to deviate from their strategy given the strategy played by the other player and their beliefs about the other player's type. Belief's about the other player's type must be consistent with Bayes' Rule given the ex ante probabilities and their opponent's strategies. Proposition 1 summarizes equilibrium behavior.

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[9] Assuming a zero sum game with linear payoff functions is not essential for the analysis. The intuition continues to hold in more general settings, as long as the ranking of the different outcomes are unchanged for each player.

[10] The game assumes that even a strong LG will suffer casualties as he retreats, since he is vulnerable to attack while retreating. Although it makes sense that $\alpha>\beta$, such an assumption is not necessary for the results.

Proposition 1: *When* $\lambda \geq 100/(100 + w)$*, the unique PBE is a pooling equilibrium in which LG always prepares for battle, and GenX retreats when LG prepares and engages if LG retreats.*

When $\lambda < 100/(100 + w)$*, the unique PBE is in mixed-strategies, in which LG prepares for battle with probability 1 when he is strong and with probability* $w\lambda/(100\ (1 - \lambda))$ *when he is weak; GenX engages with probability 1 when LG retreats and with probability* α *when LG prepares for battle.*

Proof: First, we show that GenX always engages a fleeing Han army, and that a strong LG always prepares for battle. Since both $100\alpha > 0$ and $100\beta > 0$, engaging a retreating army is a strictly dominate strategy for GenX. Therefore, if a strong LG retreats, he earns -100 β. If he prepares for battle, he earns either zero or w, both of which are greater than -100 β. Thus, a strong LG always prepares for battle.

This means there are three possible types of equilibrium: (i) a separating equilibrium in which a strong LG always prepares and a weak LG always retreats, (ii) a pooling equilibrium in which both a strong and weak LG always prepares for battle, and (iii) a mixed-strategy equilibrium in which a strong LG always prepares, and a weak LG mixes between preparation and retreat.

We rule out possibility (i) by contradiction. Suppose that a weak LG always retreats. Consistency (a requirement of PBE) requires that GenX's beliefs put probability one on LG being strong when he prepares for battle. Knowing this, a weak LG also prefers to prepare for battle (payoff 0) rather than flee (payoff –100 α). This contradiction rules out possibility (i).

Consider now possibility (ii). If a weak LG always prepares for battle, then consistency implies that GenX's beliefs must reflect the true probabilities. That is, he must believe that a prepared opponent is strong with probability λ and weak with probability $(1 - \lambda)$. When $-w\lambda + 100\,(1 - \lambda) > 0$, or equivalently $\lambda < 100/(100 + w)$, GenX attacks a prepared opponent, in which case a weak LG prefers to flee—a contradiction. Alternatively, when $\lambda \geq 100/(100 + w)$, GenX does not attack a prepared opponent, in which case neither LG or GenX has an incentive to deviate. Thus, when $\lambda \geq 100/(100 + w)$, there exists an equilibrium in which both strong and weak LG prepares, and GenX retreats when LG prepares and engages when LG retreats.

Consider now possibility (iii). Suppose that a weak LG plays a mixed strategy in which he prepares for battle with probability q and he flees with probability $(1 - q)$. At the same time, suppose that if GenX observes preparation, he attacks with probability r and retreats with probability $(1 - r)$. Since LG mixes, he must be indifferent between both preparation and retreat, which is true if and only if $r = \alpha$. Similarly, GenX must be indifferent between engaging a prepared candidate and retreating, which is true if and only if $-w\lambda/(\lambda + (1 - \lambda)\,q) + 100\,(1 - \lambda)\,q/(\lambda + (1 - \lambda)\,q) = 0$, which simplifies to $q = w\lambda/(100\,(1 - \lambda))$.

Notice that the equilibrium value q is always positive, and whenever $\lambda < 100/(100 + w)$ it is a feasible value less than one. Thus, when $\lambda < 100/(100 + w)$, there exists a PBE in which a strong LG always prepares, a weak LG prepares with probability q, and GenX always engages a retreating army and engages a prepared army with probability $r = \alpha$.

Uniqueness of equilibrium follows from the ranges of λ under which the possible equilibria exist. *QED*

Given the historical context in which Li Guang had a reputation for being a skilled general, it is likely that λ was relatively large. Given a sufficiently large λ, the unique equilibrium involves LG always preparing for battle, even when he is weak. In this case, GenX will never engage in battle against a prepared opponent since there is a large-enough possibility that that opponent is strong.

If alternatively λ is sufficiently small, the unique equilibrium is in mixed strategies with a weak LG mixing between preparing and retreating. The probability that a weak LG prepares for battle is just enough to make GenX indifferent between attacking and retreating when he observes his opponent preparing. Similarly, GenX attacks a prepared opponent with a probability that is just enough to make a weak LG indifferent between preparing for battle and fleeing. Even when LG is very likely weak (as λ approaches zero), the equilibrium still involves him preparing for battle with positive probability.

Corollary 2 highlights the key take-away points from the proposition. A proof is omitted since it follows immediately from Proposition 1.

Corollary 2: *If the probability that LG is strong is sufficiently high, then the unique PBE is in pure strategies: LG always prepares for battle, and GenX always retreats. Otherwise, the unique PBE is in mixed strategies: a strong LG always prepares for battle, a weak LG sometimes prepares for battle, and GenX sometimes retreats. Under no parameter values does a weak LG always retreat.*

A weak LG preparing for battle is always consistent with the unique PBE of the game. To be successful, Li Guang's strategy of preparing for battle did not require that the opposing general believe he must be strong. It only required that the opposing general recognize that there was a high enough probability of Li Guang being strong to make it not worthwhile to attack Li Guang's troops. Thus, preparing for battle when weak works best when the general has a reputation for usually being strong. However, even if the probably of being strong, λ, is low, we still observe (with positive probability) Li Guang preparing for battle and the opposing general retreating as an equilibrium outcome.

Legend of Zhuge Liang and the empty city

During the Three Kingdom period of Chinese history (228 A.D.), General Zhuge Liang was faced with defending the city of Xicheng from impending attack by a much larger and more powerful army.[11] The general, famous amongst his contemporaries for his careful strategy, knew that he would surely face defeat in battle.

In response, Zhuge Liang ordered his men to open the gates to the city and to remain out of sight. He then went up into a watchtower on the city walls from which, in view of anyone approaching the city, he began composing music on his zither (traditional musical instrument). Upon seeing Zhuge Liang composing music in the watchtower, the approaching army was uncertain whether the general was trying to lure them into an ambush, or whether he was bluffing. Given Zhuge Liang's reputation for careful strategy, the chance

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[11] In addition to appearing in the commentaries for *The Art of War* and *Thirty-Six Stratagems*, the legend of Zhuge Liang also appears in the ancient Chinese novel *Three Kingdoms* (Luo Guanzhong 14th century/2004).

of an ambush was significant enough that the enemy army chose to bypass the city without engaging in battle. Zhuge Liang held onto the city, and strengthened his reputation for cunning military strategy.

The similarities between the stories of Zhuge Liang and Li Guang are obvious. It is straightforward to apply the framework from Section 2 to model the Empty City. Figure 2 provides an extensive form interpretation of the game, listing the payoffs first for Zhuge Liang (i.e., ZL) then for the approaching army.

[Insert Figure 2 about here.]

If ZL orders his soldiers to flee, the approaching army captures the city (of value c) without a fight.[12] If he remains in the city and the approaching army retreats, neither player experiences any gains or losses. If he remains in the city and the approaching army attacks, then the payoffs depend on whether ZL's forces are strong or weak. If his forces are strong (i.e., sizable and prepared to fight), then he earns payoff $w > 0$ from a fight and the approaching army experiences a similar loss. If, on the other hand, his forces are weak, then ZL faces loss $-y$ from battle, where $y > c$ since he will lose both the city and his troops. He prefers to keep the city rather than flee; however, fleeing is preferred to remaining in a city that is attacked.

The equilibrium of the game is similar to the one identified in Section 3 for the story of the 100 horsemen.

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[12] Unlike in the previous example, fleeing results in the loss of the city, but does not necessarily involve the opposing army chasing ZL's troops down. This is because ZL may flee from the city before the approaching army arrives.

Proposition 3: *When $\lambda \geq y/(y + w)$, the unique PBE is a pooling equilibrium in which ZL always stays in the city, and the approaching army retreats.*

When $\lambda < y/(y + w)$, the unique PBE is in mixed-strategies, in which ZL stays with probability 1 when he is strong and stays with probability $w\lambda/(y\,(1 - \lambda))$ when he is weak; the approaching army attacks with probability c/y.

Proof: The proof is almost identical to the proof to Proposition 1, substituting (y,-y) for payoffs (100,-100), and without having to establish that it is a strictly dominant strategy for the opposing general to engage when ZL flees Here, when ZL flees the opposing general always captures the city resulting in payoffs (-z,z) rather than (-100β, 100β) or (-100α, 100α) as was the case in the earlier game. The method for solving the equilibrium is unchanged from above, and is not repeated here. *QED*

Corollary 4 follows immediately from Proposition 3.

Corollary 4: *If the probability that ZL is strong is sufficiently high, then the unique PBE is in pure strategies: ZL always stays, and the approaching army always retreats. Otherwise, the unique PBE is in mixed strategies: a strong ZL always stays, a weak ZL sometimes stays, and the approaching army sometimes retreats. Under no parameter values does a weak ZL always flee.*

Given Zhuge Liu's reputation as a masterful strategist, it is likely that λ was large enough that the unique equilibrium involves the general always staying in the city. However, even if λ was small, the mixed-strategy equilibrium still involves general sometimes staying in the city when he is weak. Here again, the legendary behavior is consistent with the unique equilibrium of the game.

Conclusion

We develop simple, game-theoretic models of two legendary examples of military deception from Chinese history. In both examples, a general leading a small force is able to avoid conflict with a larger army (preventing the slaughter of his soldiers and the loss of a city) by acting as if his soldiers were part of a larger force attempting to bait their opponent into an ambush.

Both stories have been widely cited through history (since their occurrence two-thousand years ago) as illustrating creative solutions to dire situations on the battlefield. We show that the generals' tactics and the retreat of their opponents are consistent with the unique equilibrium of their situations. In fact, the equilibrium always involves the generals and their opponents acting as they did with at least a positive probability.

This suggests that what's remarkable about the behavior of Li Guang and Zhuge Liang was not their "unusual" approach, but rather that they could engage in the circular reasoning necessary to derive optimal strategy under incomplete information. They did so without having an advanced understanding of probability theory and having never read Harsanyi (1967)'s seminal work on modeling incomplete information.

As discussed in the introduction, the game-theoretic analysis provides a more careful understanding of these famous examples from military history. The article contributes to the literatures in which game theory is used to develop a better understanding of historic events, on the use of deception to gain strategic advantage, and on the ability of experienced professionals to intuitively play equilibrium strategies.

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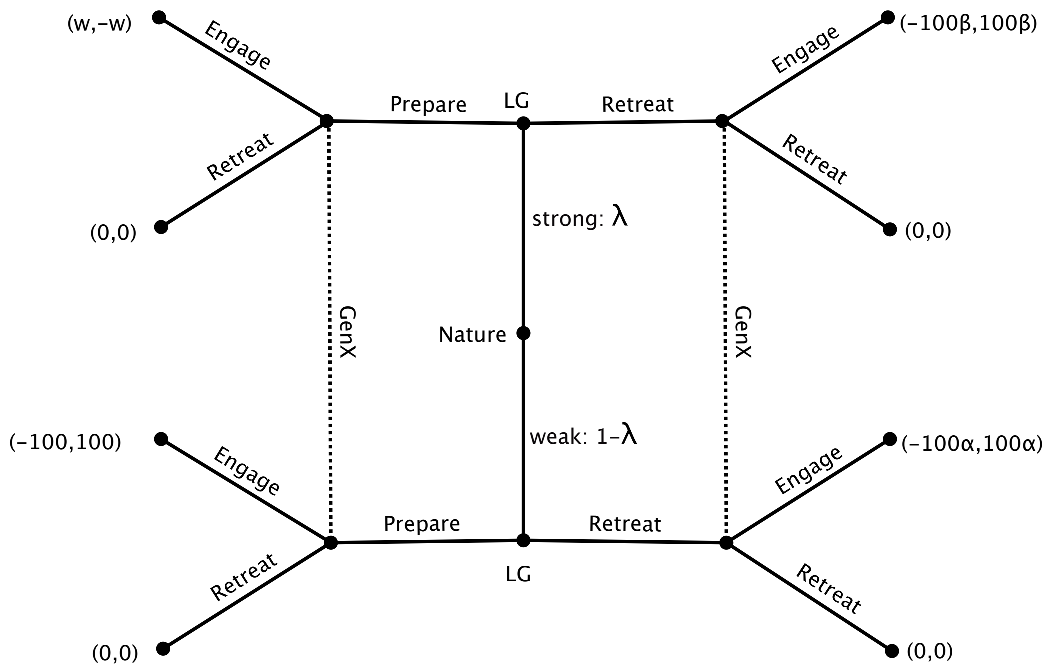

Figure 1: Li Guang, Extensive Form Game

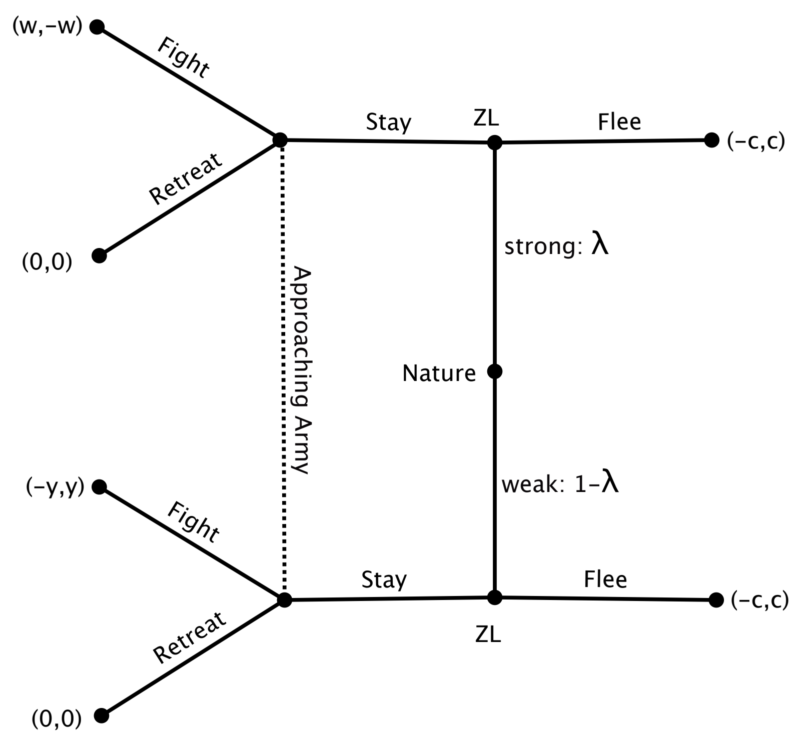

Figure 2: Zhuge Liang, Extensive Form Game