Trojan Horse or Trojan Course: The Turning Point of the Trojan War

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The Trojan Horse is one of the most famous examples of military deception in history. It was a strategic master plan that ended the ten-year-long siege, which resulted in the collapse of Troy. Yet the legendary nature of this war often obscures a deeper question: Did the Trojans hold a statistically superior defensive position that they simply failed to support, or was their defeat a mathematical inevitability? By stripping away the poetry and modelling the underlying mechanics of the war, we will be investigating whether the Trojans ever stood a chance of winning, and the series of events that could have led to a potential Trojan victory.

To begin with, we need to establish the key variables that will influence the trajectory of the war. Firstly, we need to consider the number of Greek and Trojan soldiers fighting in the war. While Homeric accounts suggest that the Greeks outnumbered the Trojans 10:1, this ratio has likely been exaggerated for storytelling purposes, and with little known about the exact number of soldiers fighting on each side, I decided to scale down the Greek-to-Trojan ratio to 1.5:1 which is based on the "canonical" break-even point of theatre level warfare[i] which will be discussed in further detail later on. The next major variable in this system is the role of named heroes. In the poems, named heroes are significantly stronger, smarter, and/or more skilful than the average soldier while also being charismatic leaders who aid in boosting the morale of other soldiers. Hence, I ranked both the Greek and Trojan heroes based on their relative strength and assigned each of them a percentage increase to the overall military power accordingly.

Hero	Allegiance	Tier	Increase in Power
Achilles	Greek	1	0.5
Hector	Trojan	2	0.4
Ajax	Greek	3	0.3
Diomedes			
Aeneas	Trojan	4	0.2
Odysseus	Greek		
Paris	Trojan	5	0.1

Lastly, we also need to account for the fortification strength of the Trojan Wall and the supply decay for both parties. The summarised list of variables used can be seen below.

Variable	Symbol	Value	Description
Greek force scale	N_g	1.5	Ratio of Greek to Trojan foot soldiers
Trojan force scale	N_t	1	
Trojan wall	W	1.79	Calibrated fortification strength of Trojan Wall

Active Greek heroes' power	H_g	Sum of active heroes' increase in power + 1	Multiplier to determine total power of troops after active heroes' power has been applied
Active Trojan heroes' power	H_t		
Annual rate of decay for Greek supplies	r_g	0.03	Naval transportation and foraging enabled continued access to supplies; but suffered irreplaceable losses from diseases, rusted armour, etc.
Annual rate of decay for Trojan supplies	r_t	0.05	Geographical isolation limited Trojan access to external supplies while internal supplies were depleted
Greek supply factor	S_g	$1 - r_g \times t$	Multiplier to determine total power of troops after supply decay has been considered
Trojan supply factor	S_t	$1 - r_t \times t$	

Now that we have identified the primary variables the shape the course of the war, we can keep track of the military power of both sides as the war progresses. To do this, we will be looking at a simplified timeline that divides the war into four main phases: Years 1 to 9 when all heroes were active, Early Year 10 when Achilles refused to fight, Mid-Year 10 when Hector died, and Late Year 10 when the Trojan Horse was deployed. By tracking the changes in the variables across these distinct phases, taking Phase 4 as the fixed endpoint of the war, we can obtain the military power of the Greeks and the Trojans using the general formula below.

$$P = N \times H \times S \times W$$

This enables us to compare the force ratio $\frac{P_g}{P_t}$ as the war progresses, allowing us to investigate the outcomes of four different scenarios as shown below.

Timeline of active heroes for Scenarios 1, 3 and 4

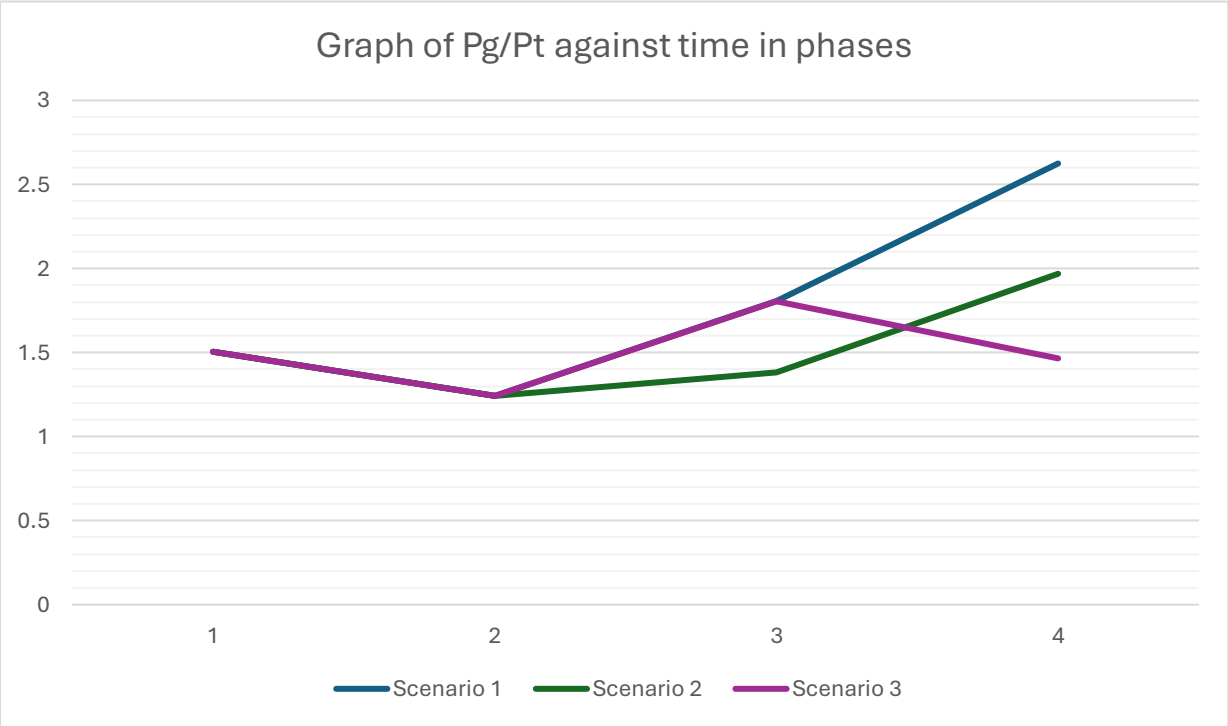
Phase	Active Greek heroes	Active Trojan heroes
Year 1-9	Achilles, Ajax, Diomedes, Odysseus	Hector, Aeneas, Paris
Year 10	Ajax, Diomedes, Odysseus	Hector, Aeneas, Paris
Death of Hector (Year 10)	Achilles, Ajax, Odysseus	Aeneas, Paris

Trojan Horse (Year 10)	Odysseus, Diomedes	Aeneas

Timeline of active heroes for Scenario 2

Phase	Active Greek heroes	Active Trojan heroes
Year 1-9	Achilles, Ajax, Diomedes, Odysseus	Hector, Aeneas, Paris
Year 10	Ajax, Diomedes, Odysseus	Hector, Aeneas, Paris
Death of Hector (Year 10)	Achilles, Ajax, Odysseus	Hector, Aeneas, Paris
Trojan Horse (Year 10)	Odysseus, Diomedes	Hector, Aeneas

After calculating the $\frac{P_g}{P_t}$ ratio in each of the four phases for the first three scenarios[ii], we can then plot a graph to visualise the shifting balance of power.



Subsequently, we will be comparing $\frac{P_g}{P_t}$ to three break-even points: 1.5, 1.2 and 2.1 for canonical, defence-conservative, and attack-conservative wars at the theatre level, respectively[i]. Note that "canonical" refers to a state of war in which neither side is particularly advantaged due to environmental or other factors. Correspondingly, "defence-conservative" assumes that these factors favour the offensive party, while "attack-conservative" assumes that

these factors favour the defensive party. However, for the purpose of this essay, we define these break-even points as thresholds for Trojan victory when $\frac{P_g}{P_t} < 1.2$, Greek victory when $\frac{P_g}{P_t} > 2.1$, and perfect stalemate when $\frac{P_g}{P_t} = 1.5$. Using these thresholds, we can find the probability of Greek victory using a logistic function as shown below.

$$P(V_g) = \frac{1}{1 + e^{-4(R-1.5)}}$$

$where\ P(V_g)\ represents\ probibilty\ of\ Greek\ victory,$

$and\ R\ represents\ \frac{P_g}{P_t}$

R	1.2	1.5	2.1
$P(V_g)$	23%	50%	92%

Scenario 1 is a simplified version of the Homeric accounts of the Trojan War. Crucially, it acts as a control to ensure that our model works as expected. During the first nine years (Phase 1) of the war, the Greeks and Trojans were locked in a stalemate, i.e. $\frac{P_g}{P_t} = 1.5$. With this knowledge, we can then calibrate the strength of the Trojan Wall for more accurate results in subsequent analyses. The first major event we will be considering occurs in the beginning of Year 10 (Phase 2), when Achilles refused to fight in the war due to a personal dispute. As a result, we see a dip in the force ratio, where $1.2 < \frac{P_g}{P_t} < 2.1$, favouring Trojan victory (74%). Phase 3 is marked by Achilles' return to the battlefield and the death of Hector, causing $\frac{P_g}{P_t}$ to rise such that $1.5 < \frac{P_g}{P_t} < 2.1$, which favours Greek victory (77%). Lastly, Phase 4 is categorised by the use of the Trojan Horse, allowing the Greeks to bypass the Trojan Wall and secure a 99% likelihood Greek victory (as shown by $\frac{P_g}{P_t}$ rising well above the 2.1 threshold)[iii].

Moving on from the historical baseline in Scenario 1, we can now experiment with different variables in isolation to analyse the probability of Trojan victory in hypothetical scenarios. To begin with, Scenario 2 isolates the impact of Hector's leadership by testing the probability of Trojan victory when Hector survives. This targets one of the main turning points in Phase 3, which led to the trend of Trojan defeat. Hence, we will be able to confirm and conclude the significance of Hector's death in the original timeline. Following the graph, we see that $\frac{P_g}{P_t}$ stays between 1.2 and 1.5 from Phase 2 to Phase 3 (probability of Trojan victory drops slightly from 74% to 62%). However, $\frac{P_g}{P_t}$ rises significantly in Phase 4, until it is just below the 2.1 threshold, with 13% probability of Trojan victory. While chances of success may seem small, it is still a significant increase from the 1% probability of Trojan victory in Scenario 1, showing that Hector is an important contributor to Trojan defence.

The next factor we will be investigating is the role of the Trojan Wall. In Phase 4, the Greeks' use of the Trojan Horse to bypass the Trojan Wall was the decisive factor which catalysed an overwhelming Greek victory. This might suggest that the failure of the Trojan Horse could lead to a definitive win for the Trojans. However, closer inspection will reveal a different story. Due to the lack of drastic systematic changes in the state of war, a prolonged stalemate is maintained throughout the four phases. Looking at the graph of Scenario 3, this test of endurance is confirmed by $\frac{P_g}{P_t}$ which consistently hovers about the 1.5 threshold, showing a 53% chance of

Trojan victory by the end of Phase 4. Hence, we can conclude that the Trojan Wall acts as an equalising force in the war.

In contrast to earlier stress-testing, our final scenario examines a version of the war that nearly transpired. Centred around the Trojans' attempt to burn Greek ships in Year 10, Scenario 4 explores how a supply deficit influences $\frac{P_g}{P_t}$. To mimic this logistical failure, we can add a $k\%$ decrease to Greek supplies on top of the pre-existing 3% yearly decrease. Based on calculations, the minimum k for which $\frac{P_g}{P_t} < 1.5$ (higher probability of Trojan victory) is $\frac{46}{155}$ or approximately 30%. In a military context, this 30% margin of error is highly significant, revealing that the Greeks' expedition was one of high performance but low tolerance.

Ultimately, the fall of Troy was not dictated by overwhelming Greek power, but by Trojan failure in strategic exploitation. While the Trojans failed to leverage the fragility of Greek dominance, the Greeks were successful in neutralising Trojan fortification. Hence, the ability to recognise and exploit the opposition's key weaknesses was the true hero that would have led to victory for either party.

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[i] https://www.rand.org/content/dam/rand/pubs/monograph_reports/2007/MR638.pdf

[ii] The fourth scenario has been excluded from this calculation to allow for flexibility in the changed variable

[iii] At this point in time, both Achilles and Ajax the Greater have died in battle and are thus excluded from the calculation