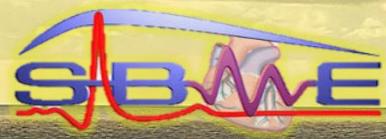
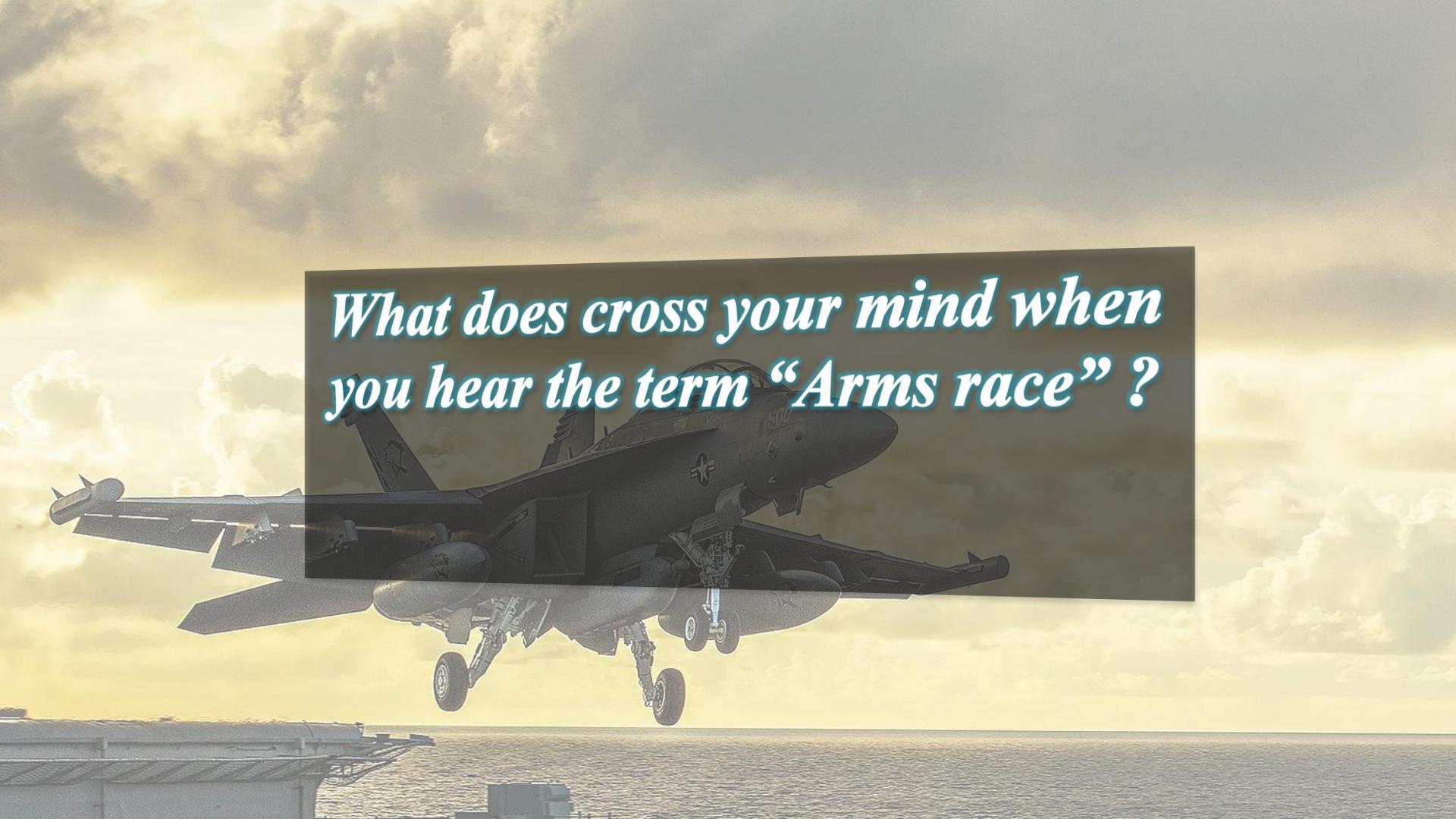




Arms Race



A fighter jet, likely an F/A-18 Hornet, is shown taking off from an aircraft carrier's deck at sunset. The sky is filled with warm, golden clouds. The jet is angled upwards, its landing gear still deployed. A large black rectangular box covers the upper portion of the image, containing the following text.

*What does cross your mind when
you hear the term “Arms race” ?*

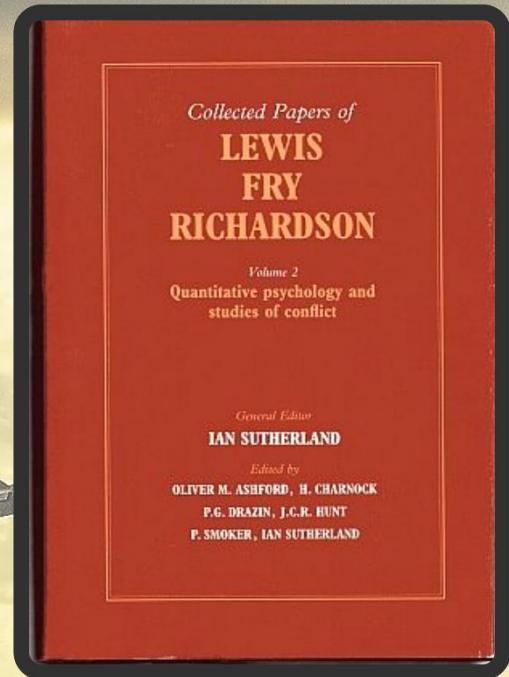
Who is Lewis Richardson ?!

- Richardson was born in 1881, was an English scientist and the pioneer in mathematical techniques and its relation in wars .
- He designed a system to analyze and predict wars between nations. That was later called the "Richardson's Arms Race Model ".



Richardson's Model of Arms race

- According to Richardson the conflict between two nations can be determined and analyzed by a set of differential equations.
- These equations state the probability of any nation in entering a war and it depends on many factors.





*Language
and color*

*Ammo
Build up*

*Religion and
Ideology*

Culture

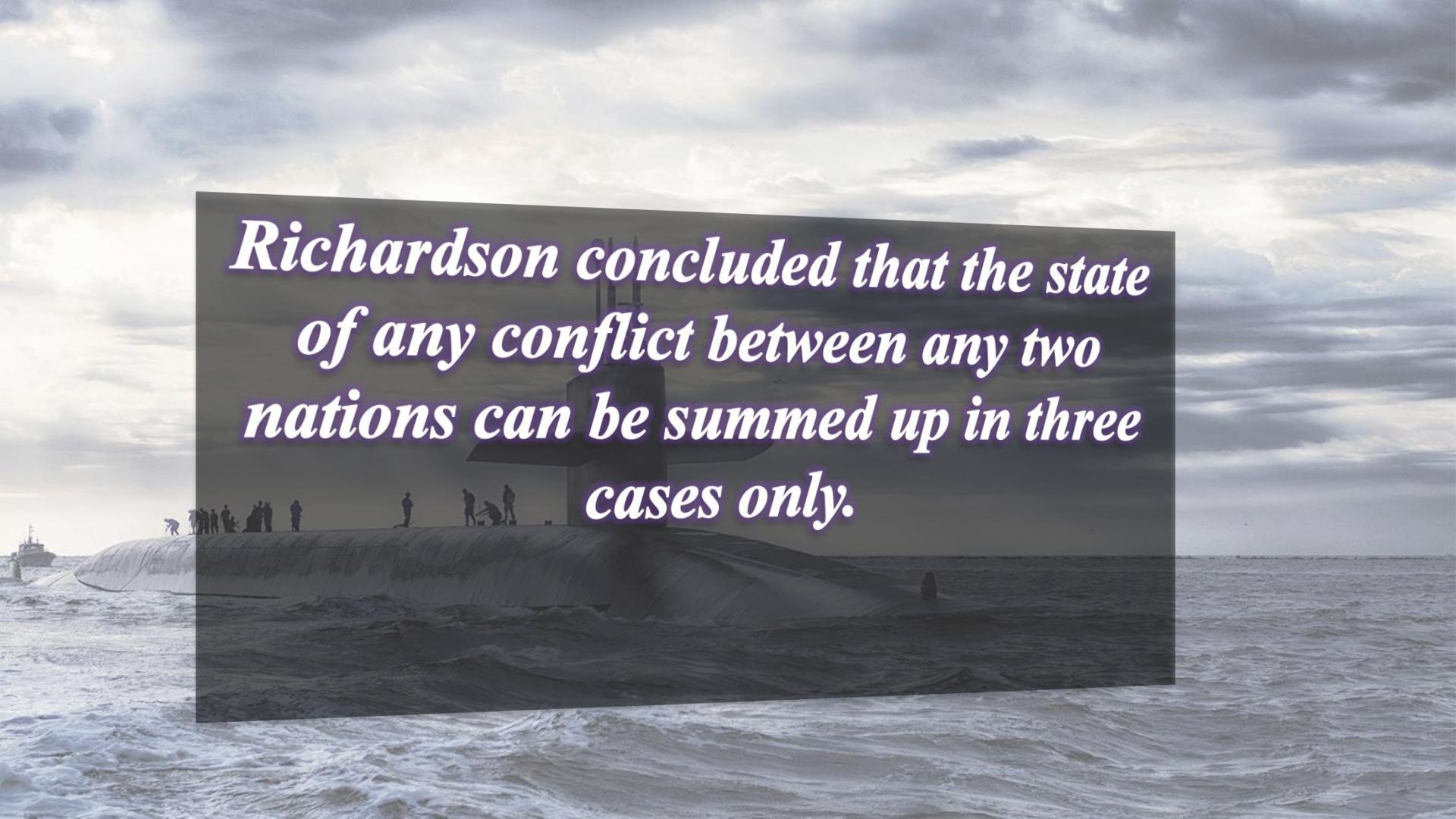
*Factors that
lead to an
arms race.*

*Economic
development*

The model analysis



*Richardson concluded that the state
of any conflict between any two
nations can be summed up in three
cases only.*



The equilibrium case

- Here in this case we simulate the situation in which every possible conditions that could lead the two nations into equilibrium point is achieved.



The runaway race case

- In this case the two nations are sufficiently hostile to each other
 - don't need more reasons to start a war so they will simply enter a runaway arms race direct .



The Friendly case

- As in this case the two nations are have enough reasons and common benefits to stay friendly towards each other so they will never enter an arms race.



Richardson's Equations

The model can be summarized into the following two equations:

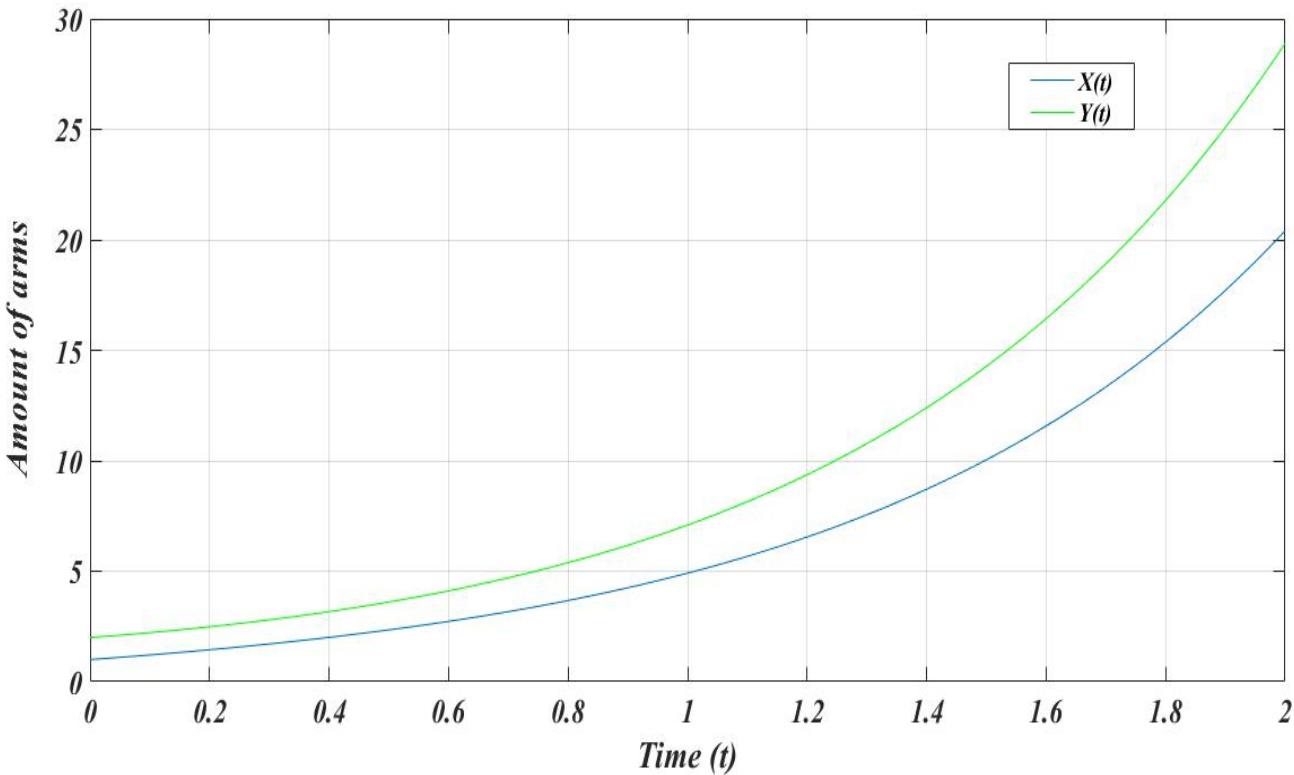
$$\frac{dx}{dt} = ay - mx + r$$

$$\frac{dy}{dt} = bx - ny + s$$

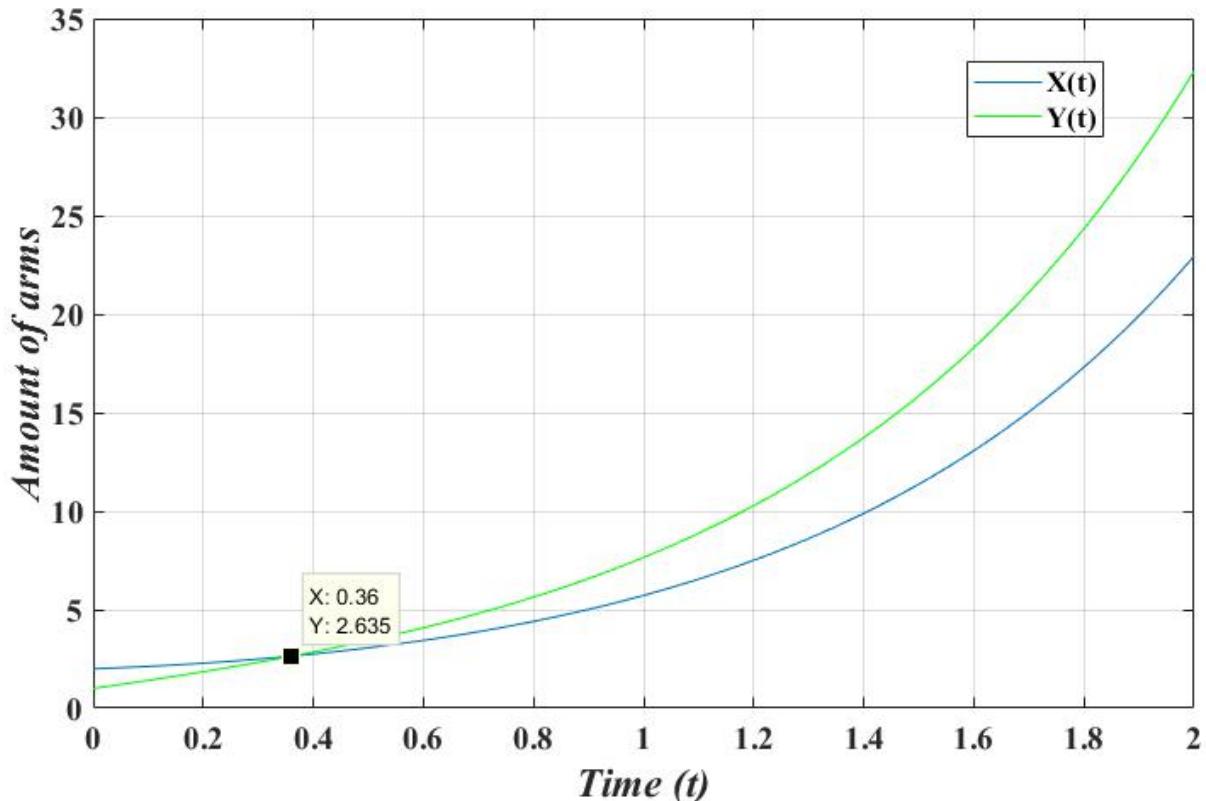
Where:

- x,y = Armament level of the country.
- a,b = Defense coefficients.
- m,n = Fatigue coefficients.
- r,s = The hostility / peace terms.

Equations Modeling



Equations Modeling

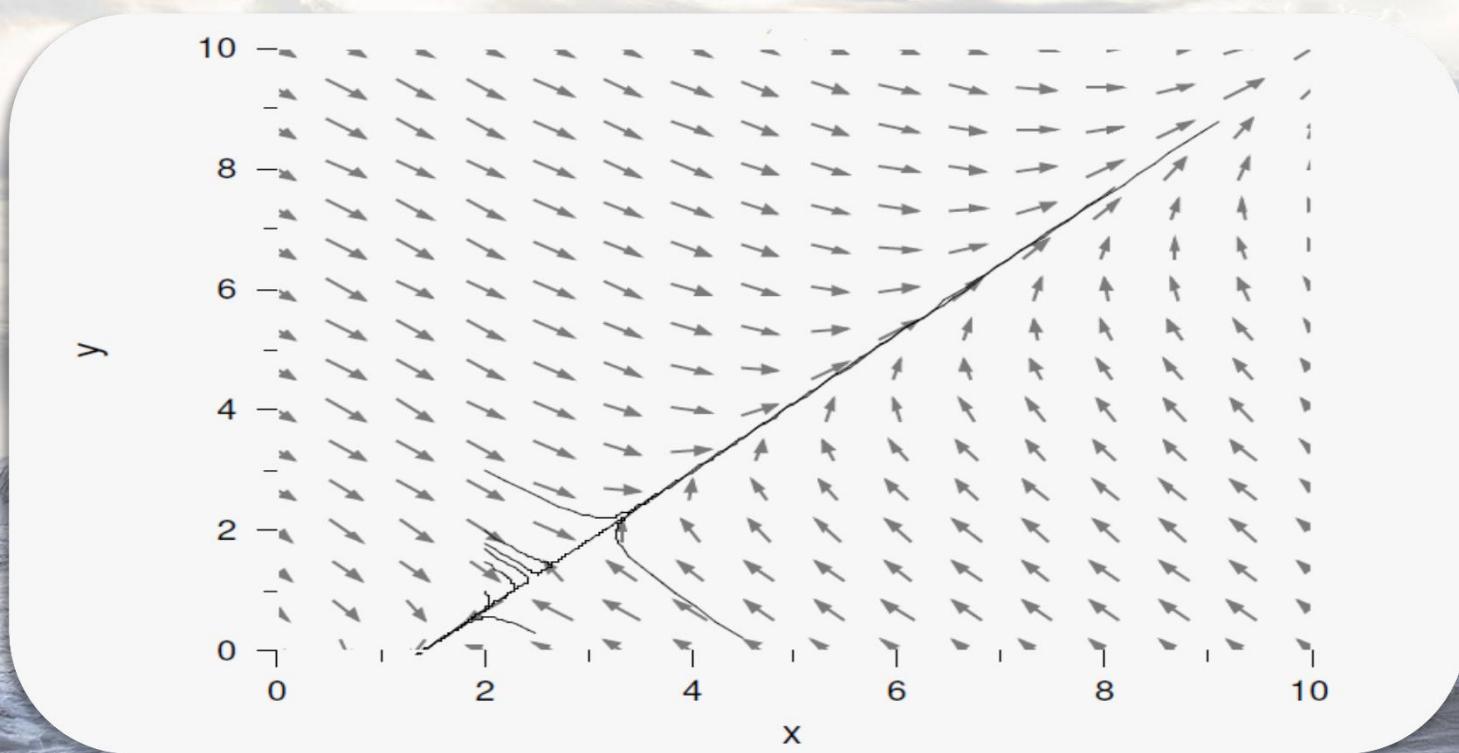


Richardson's Flaw

- The problem with the model is that Richardson didn't mention the budget constraint and doing so caused a great divert in the results causing many errors.
- Also: if the hostility/peace terms are -ve and other coefficients = 0, then it will give corrupted results.



Richardson's Results



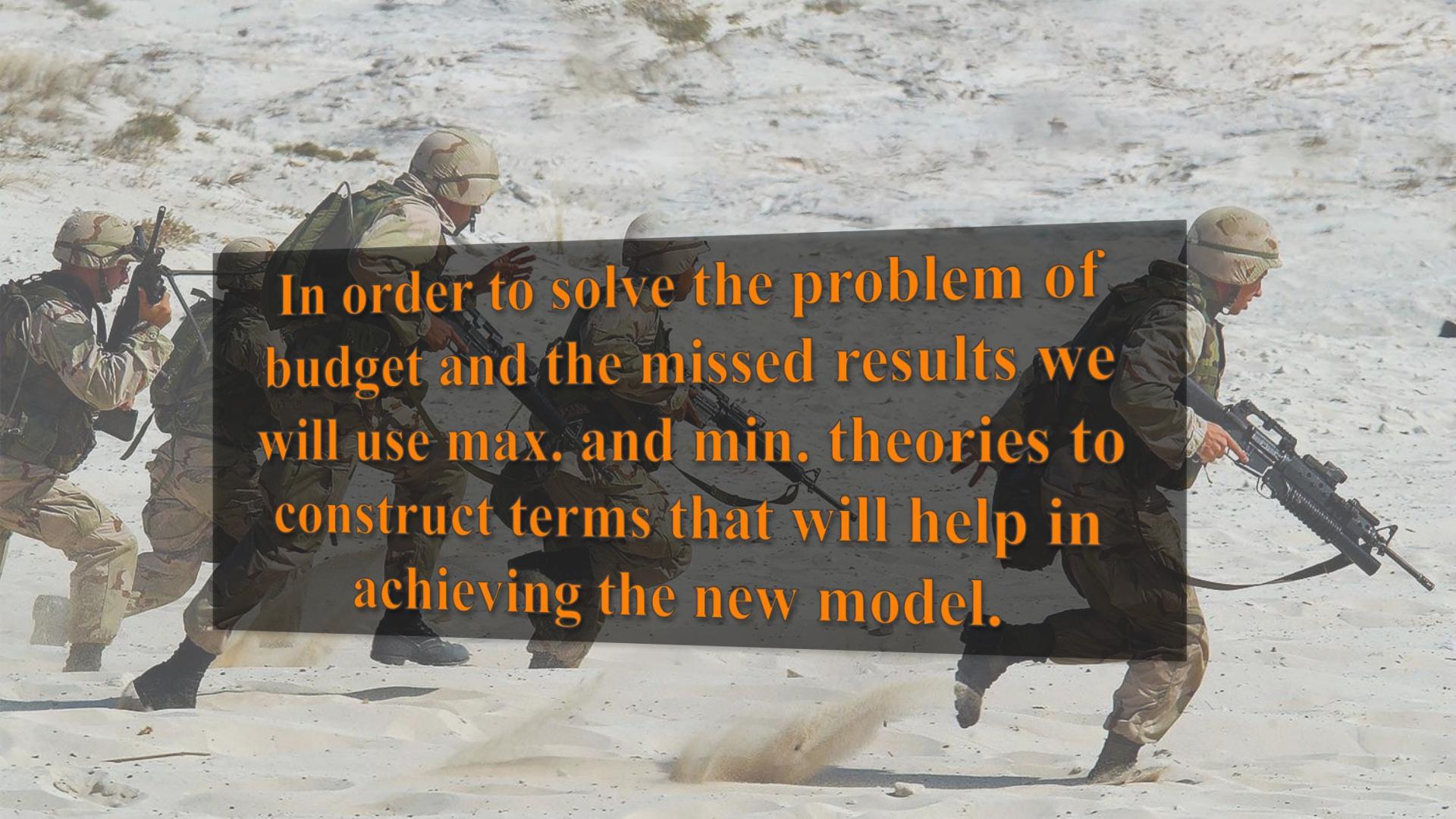


*A new Model and
Applications*

Suggested model

➤ In order to overcome the fault Richardson did, we had to work more on the model mathematically taking into consideration the variables Richardson missed.



A photograph of a group of soldiers in a desert environment. One soldier in the foreground is crouching and aiming a rifle. Behind him, other soldiers are moving through the sand dunes. The scene is set against a backdrop of light-colored sand and sparse desert vegetation.

In order to solve the problem of budget and the missed results we will use max. and min. theories to construct terms that will help in achieving the new model.

The new model's equations

By adding the new terms
the model will be:

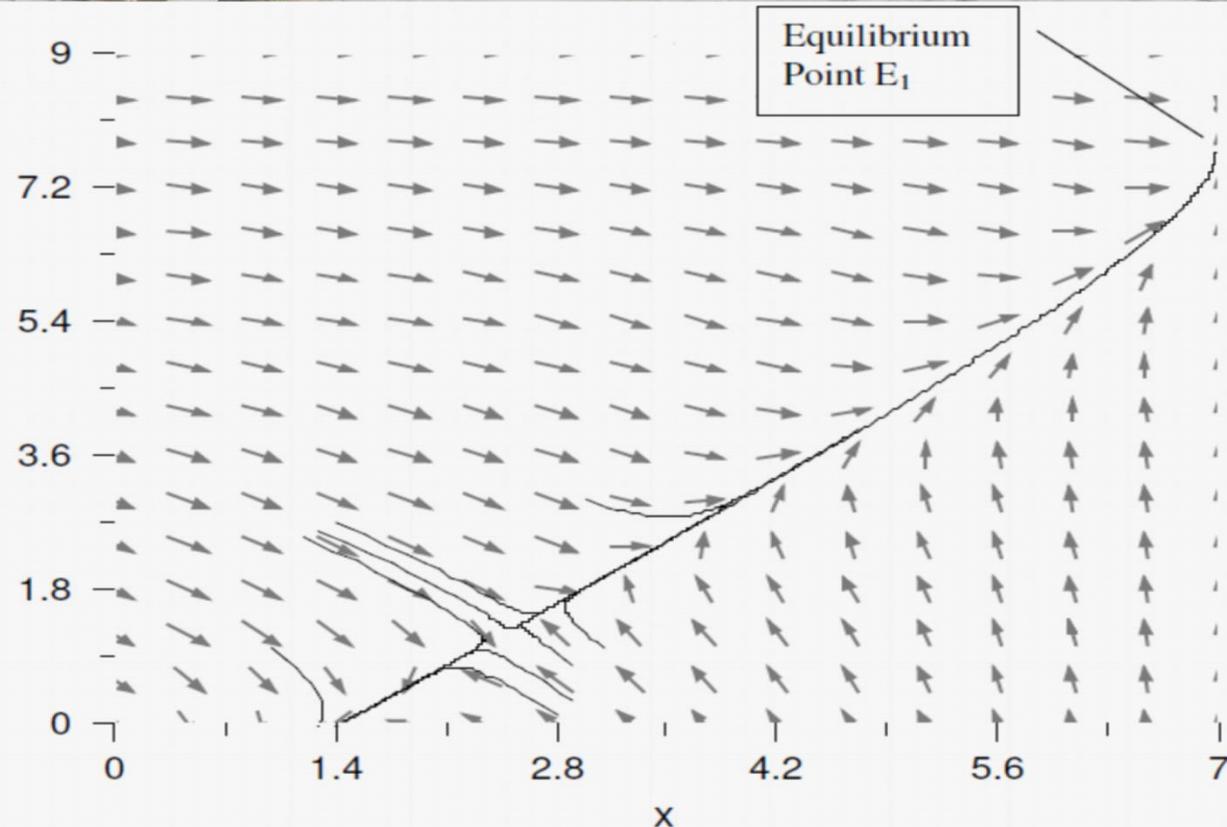
$$\frac{dx}{dt} = (1 - x/x_{max})(ay - mx + r)$$

$$\frac{dy}{dt} = (1 - y/y_{max})(bx - ny + s)$$

Where:

- x,y = *Armament level of the country.*
- a,b = *Defense coefficients.*
- m,n = *Fatigue coefficients.*
- r,s = *The hostility / peace terms.*
- x_{max}, y_{max} = *The carrying capacity terms.*

The new model's Results



Applications on arms race

- Scientists applied the classical Richardson model for the (Greece - Turkey Conflict) over the periods 1950-1986.
- But his results were very poor to proof theory of arms race.



Applications on arms race

- Unlike Greece and Turkey where the literature is ambiguous.
- previous studies of (Indian – Pakistani Conflict) have found evidence of a Richardson type arms race in the sub-continent.

The India-Pakistan War of 1965

A History

Chief Editor

SN Prasad

General Editor

UP Thapliyal



Applications on arms race

- The environment in which firms operate today is highly competitive and quite similar to that of a military conflict.
- So we use arms race to analyze and predict the market condition.



*Thanks for listening.
Any Questions ?!*