Assessing Nuclear Proliferation by Using System Dynamics Modeling

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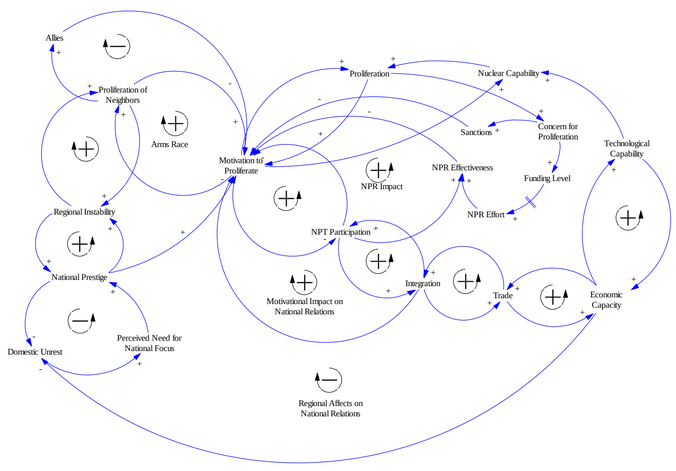
Building the Models

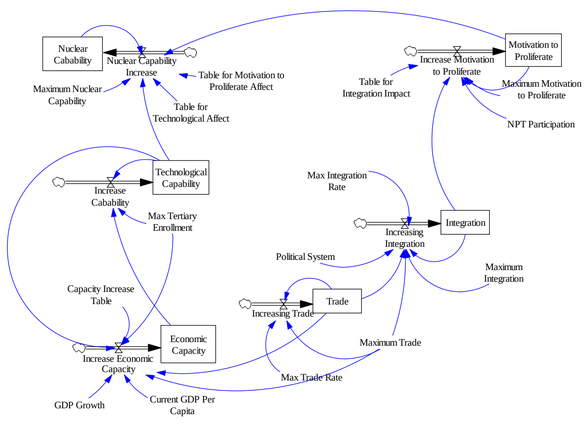
A country's decision to go nuclear depends on a number of elements. We have identified the more salient elements and created a System Dynamics model to better understand their impact on proliferation. It is our goal to study how these elements interact to affect the overall behavior of the system and gain a better understanding of the underlying causes of its behavior. This allows us to increase our knowledge of the role each element has on the system in order to assess the impacts of different actions on a countries' decision to proliferate.

Causal Loop Diagram



The causal loop diagram shows the cause and effect relationships between the individual elements that contribute to nuclear proliferation. An arrow indicates that the element at its tail has a causal impact on the element at its head. A positive sign represents a direct relationship and a minus sign represents an indirect or inverse relationship. A positive loop represents a reinforcing relationship in which the elements increase or decrease together. A negative loop is a balancing loop in which the elements maintain a specific level.

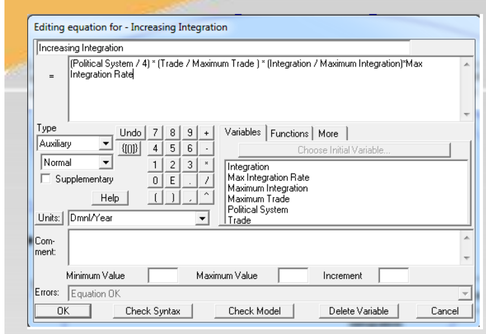
Partial Stock and Flow Diagram



The stock and flow diagram is a translation of the causal loop diagram. We expand upon the elements that are used in the causal loop diagram to get a more realistic sense of what is happening to the dynamic system. This stock and flow model is quantified with equations that capture the relationships amongst the elements of the system.

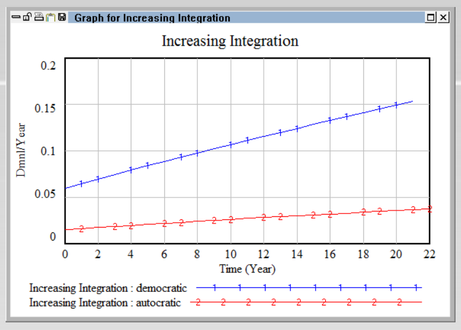
Results

Increasing Integration Equation



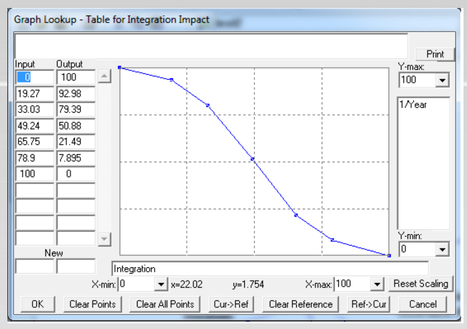
We quantified the variables that effect Increasing Integration and created the above algorithm.

Graph of Increasing Integration



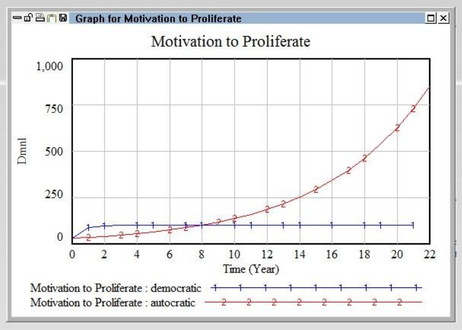
We ran a simulation for democratic and autocratic states. The graph shows that with time the democratic state becomes increasingly integrated as a result of economic trade while the autocratic state will only integrate marginally.

Table of Integration Impact on Motivation



This table shows our hypothesized relationship of the effects of integration on motivation. As shown by the table, the less integrated a state is, the more motivation it could be to proliferate. Inversely, the more integrated a state is the less motivated it is proliferate.

Graph of Motivation to Proliferate



These results show the level of motivation to proliferate for democratic and autocratic states. We see that the democratic state rises slightly during the first year and then stays at a constant low level of motivation. The results also show the motivation for an autocratic state to proliferate grows over time.

References

[1] Brothers, Alan; Coles, Garill; Gastelum, Zoe; Thompson, Sandy; "The Utility of Social Modeling for Proliferation Assessment Preliminary Findings", Pacific Northwest National Laboratory

[2] Brothers, Alan; Coles; Garill; Olson, Jarrod; Whitney, Paul; "The Utility of Social Modeling for Proliferation Assessment", Pacific Northwest National Laboratory

[3] Meyer, Steven. The Dynamics of Nuclear Proliferation. London: The University of Chicago Press, 1984

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