Analysis of Pricing Models in the Defense Industry to Support Cost Projection

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ANALYSIS OF PRICING MODELS IN THE DEFENSE INDUSTRY TO SUPPORT COST PROJECTION

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EXECUTIVE SUMMARY

Project Summary

This study aims to develop a mathematical model to describe the interactions between defense contractors and the government, in order to estimate cost and schedule for developing a technologically advanced weapon system. The research goal is twofold: (1) Explain why the development of a new weapon system is often subject to cost overrun and schedule delay; and (2) Identify market mechanisms to improve the efficiency of the bidding and contracting process in order to better manage risk.

Background

The pricing models in the defense industry cannot rely on basic economic principles such as supply and demand, since it involves advanced technology that are pertinent to national security. The cost estimation of developing a technologically advanced weapon system is typically done based on component cost, labor cost, inflation, cost to acquire new technology, and opinions of subject matter experts. Since not all necessary technologies are in place at the onset of the system development, there is a lot of uncertainty in the total program cost and completion time. If a technological hurdle cannot be overcome in time, the whole program may suffer substantial delay and cost overrun.

Besides technological uncertainty, developing a technologically advanced weapon system also involves a lot of political uncertainty. The budget needs to be approved on a yearly basis, and sometimes a program may get cancelled. This uncertainty puts pressure on defense contractors to secure sole-source contracts when competing against the other contractors. Once becoming a sole-source contractor, however, the contractor's main motivation is to complete the scheduled tasks on time in each fiscal year, but not to deliver the final product as soon as possible.

Findings and Conclusions (to include Process)

We develop a mathematical model, in which the government manages a program to develop a technologically advanced weapon system in two phases: the competition phase and the sole-source phase. Each phase consists of three steps, which are described below.

1. The government funds a few defense contractors to develop a prototype for a technologically advanced weapon system in the competition phase. At the end of the competition phase, the government selects a sole source to develop the final product.
2. Each contractor may or may not be motivated to exert extra effort in the competition phase in order to improve its chance of winning the sole-source contract.

3. At the end of the competition phase, each contractor demonstrates its product prototype. The quality of the prototype depends on the contractor's design capability and also its luck to overcome technological hurdles.
4. Based on the prototype demonstration, the government selects a sole-source contractor to develop a final product. The program enters the sole-source phase.
5. The sole-source contractor continues to develop the weapon system. The progress may be affected by fiscal-year budget constraints, as well as the contractor's capability and luck to overcome technological hurdles.
6. The payoff of the government depends on the total program cost and program completion time. The government prefers to spend less money and complete the program sooner.

By using probabilistic modeling to capture the uncertainty of developing technologically advanced weapon system, we are able to quantify the effect of several model parameters on the eventual program cost and completion time. After analyzing the model, we run a simulation study to gain insights into the entire process, and identify three main reasons why such a program often suffers cost overrun and schedule delay.

1. The selected contractor tends to be luckier than usual in the competition phase, so the government tends to overestimate its capability.
2. Once a contractor becomes the sole source, its goal is to complete the scheduled tasks within each fiscal year on time, but not to deliver the final product as soon as possible.
3. The contractors may be motivated to exert extra effort during the competition phase in order to improve its chance of getting selected as the sole source, which may result in an overly optimistic estimation on program completion time.

Based on a cost structure, our model offers recommendation on the optimal length of the competition phase, and the number of contractors to invite, in order to minimize the program completion time and total cost.

Recommendations for Further Research

Our model assumes that the government announces the length of the competition phase in advance, and selects one contractor at the conclusion of the competition phase. An alternative approach is to review each contractor's progress on a yearly basis, and decide which contractors to fund for another year. In addition, if the government has some prior knowledge about each contractor’s capability, then a Bayesian approach may produce a more reliable estimate on the program completion time. A separate study is needed to explore these issues.