Contracting in Medical Equipment Maintenance Services: an Empirical Investigation

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1. Research Problem

Operators of capital-intensive equipment often devote a large annual budget on maintenance so as to ensure high equipment reliability. For instance, in the medical imaging equipment industry, which forms the basis of our study, a top-of-the-line Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) equipment typically costs US $1 million each, and require annual maintenance expenses corresponding to 10\% of their price.

A key feature of maintenance services is that value is co-produced, i.e., both proper operational handling by the operator and proper maintenance and repair by the service provider have an effect on reliability and service costs—and hence collaboration between the equipment operator and the service provider is critical to create good service outcomes. This collaboration, in turn, crucially depends on the maintenance service plan that contractually determines the payment structure for the service and hence may influence both parties' behavior in their interactions with the equipment. Indeed, such plans take many forms, ranging from a pay-per-service contract where a markup for labor and parts is charged every time a repair service is required, to a fixed-price full-protection plan covering all services over an agreed period.

Few empirical studies to date have explored the relative performance of these contracts despite the key role maintenance plans plays in structuring co-production relationships. Hence, our paper aims to empirically identify the incentive distortion effects of maintenance service plans on service performance and costs.

2. Methods

We obtained a rich dataset covering the monthly service records of more than 700 medical imaging equipment (MRI and CT Scanners) from a major medical device manufacturer.

Hospitals operate the equipment, while the manufacturer provides maintenance services. This panel data records each new sale of equipment, which comes with a standard one-year warranty period. At the end of the period, operators sign on to one of the three types of maintenance plans (a pay-per-service basic plan, a hybrid partial-protection plan and a fixed-fee full-protection plan), each one of them providing the hospital and manufacturer with different incentives.

We exploit the structure of this unique dataset to account for endogenous contract selection in the estimation of the incentive distortion effects of maintenance plans. Since during the warranty period, all hospitals are incentivized by the same contract structure, any observed differences in service failures and costs among the equipment over this period of time can be attributed to differences in their innate operating conditions. Based on this, we adapt a fixed effects model to estimate the innate operating conditions of each piece of equipment, and therefore remove its confounding effects in our final estimates. This enables us to measure the impact of contract type on service cost due to incentive distortion effects, i.e., the effect on service cost due to the shifting of equipment failure risk from one party to the other.

Further, we were able to disentangle which party is contributing to the changes in service cost by examining alternative metrics of service performance (specifically, operator reported failure rates tells us how operator behavior has changed; while the propensity of the service provider to resolve problems onsite versus offsite tells us how service provider behavior has changed).

3. Major Results and Implications

The present paper establishes that, when properly controlling for contract selection, a fixed-fee full-protection plan leads to more failures (25%) and higher service costs (68% increase in labor hours and 84% increase in spares cost) compared to a time-and-materials plan in the context of medical equipment maintenance. Further, our analysis shows that both the operator and the

service provider contribute to the increase in service costs. Our results thus indicate that maintenance plan structure impacts the behavior of both the operator and the service provider.

For the equipment operator, the incentive distortion effect seems to arise from a reduced level of equipment care when she does not bear the cost of failures. Using secondary datasets, we found little evidence supporting other possible explanations—such as the operator using the equipment more heavily, or that she is simply reporting more problems of a less critical nature.

As for the service provider, we see that he expends more resources when he bears the costs of those resources. Hence, the service provider behavior seems to be driven less by cost concerns, but rather by concerns of providing differentiated levels of onsite responsiveness to operators on different plans.

Irrespective of the source of the incentive distortion effects, our results establish that the full-protection plan results in an unambiguous decrease in maintenance service chain value relative to the basic (time-and-material) plan. Hence, our results appear to speak to the teachings of the prisoners' dilemma game—while choosing the full-protection plan may individually be optimal for both the service provider and many operators, the choice locks them in a configuration that does not maximize the profit potential of the equipment.

Finally, in academic and practitioner circles the prevailing wisdom has been for manufacturers intending to move into services to assume more equipment failure risks. Our results provide a caution against this prevailing wisdom, as we observed both lower reliability and higher service costs when the service provider assumes higher responsibilities over equipment failures.