Efficiency measurement in railway maintenance contracts

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Research question

This paper estimates the cost efficiency of railway maintenance contracts in Sweden, using stochastic frontier analysis (SFA) on an unbalanced panel stretching from 2001-2012. The estimation technique allows us to study how different contract characteristics affect cost efficiency, as well as how the characteristics of the production environment affect the location of the cost frontier.

The rail infrastructure management in Sweden was reformed in 1998 when the production unit was separated from the administrative unit. This created a client-contractor relationship, and paved the way for the decision to gradually expose the maintenance of railways to competition. The first contract was tendered in competition in 2002. Most contracts are performance based with a formalized set of requirements on track quality and train delays, while some are traditional contracts in which the entrepreneur mainly executes the activities set up by the contractor. Furthermore, contracts differ with respect to the share of contracted activities with payments dependent on the measured quantity and activities with fixed payment. We estimate the effect of competitive tendering and how the contract characteristics affect cost efficiency, while controlling for heterogeneity in the production environment.

Methodology

We estimate a cost frontier model which is represented by:

$$C_{it} = f(Q_{it}, W_{it}, N_{it}, D_{it} ; \beta) + v_{it} + u_{it}$$

where i = 1,2,...,N contracts and t = 1,2,...,T years. $Q_{it}$ is gross tonne-density (gross tonne-km/route-km), $W_{it}$ is a proxy for the input cost consisting of average hourly wage, $N_{it}$ is a vector of network characteristics, $D_{it}$ includes T-1 year dummies. $\beta$ is the vector of parameters to be estimated. The dependent variable $C_{it}$ is maintenance costs for the activities included in the contracts. The random component $v_{it}$ is assumed to be normally distributed, with zero mean and constant variance, and $u_{it}$ is a one-sided random component capturing the inefficiency of the contracts.

The model is estimated using a stochastic frontier method, first introduced by Aigner et al. (1977) and Meeusen and Van den Broeck (1977) for a cross-sectional case. With panel data, we can estimate a stochastic frontier model where the inefficiency is allowed to vary over time and between
contracts. The model proposed by Battese and Coelli (1995) is used, in which the inefficiency terms are assumed to be distributed as truncated normal, $u_t \sim N^+ (m_{it}, \sigma^2)$, with mean

$$m_{it} = Z_{it} \delta$$

Thus, the inefficiency is estimated considering a set of explanatory variables, $Z_{it}$, where $\delta$ is a vector of parameters to be estimated. Three variables in vector $Z$ are used; a dummy variable indicating when a contract is subject to competitive tendering, a dummy variable if a contract is performance based, and a variable for the share of contracted activities with fixed payments vis-à-vis payments dependent on measured quantity.

Stochastic frontier analysis requires a functional form to be specified. We start with the translog model and test the Cobb-Douglas restriction. The restriction could not be rejected based on a likelihood ratio.

**Results**

The estimates on traffic (gross tonne-density) suggest a usage elasticity of 0.24, which is in line with the usage elasticities estimated for a number of European countries (Wheat et al. 2009). The parameter estimates for track length show constant returns to scale. Turning to the effect of competitive tendering, the results show that contracts tendered in competition are closer to the cost frontier. The share of contracted activities with fixed payments does not have a significant effect on the cost efficiency. However, traditional contracts are closer to the cost frontier.

**References**


