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Estimating entrants' productivity when prices are unobserved☆

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ABSTRACT

Entrant firms are constrained to set lower price–cost markups than incumbents due to idiosyncratic demand shocks faced in the startup phase. Productivity indices suffer from micro-level markup variation and underestimate entrants' productivity, when productivity is measured by nominal sales and expenditures but not quantities. This study makes the first attempt to estimate entrants' productivity by controlling for their markup difference, when prices or quantities are unobserved at the firm-level. The econometric methodology introduces demand side into a structural model of production to account for the price variation. The estimation routine deals with the endogeneity due to unobserved productivity using a control function approach, and retrieves average markups for entrants and incumbents together with a markup-adjusted productivity index. My findings show that entrants set on average lower markups than incumbents in Japanese manufacturing. When productivity is adjusted to markups, entrants are as productive as incumbents, while the standard measures of labor and total factor productivity indicate low productivity for entrant firms.

1. Introduction

The entry of new producers is widely thought to be a key source of productivity growth. Entrants can introduce new products and processes, up-to-date production technologies, managerial and organizational structures that may be costly to adopt by existing producers. Entrant firms have higher incentives to innovate and also tend to influence aggregate productivity growth through the dynamic process of creative destruction.[1] One, however, rarely finds highly productive entrants in data especially by examining firm-level productivity indices.

Despite the advantages of being new, entrants' productivity performance has been shown to be poor in their first years.[2] This is often attributed to the necessary tasks to be undertaken in the start-up phase such as the analysis of demand conditions, advertising new products to attract customers and learning-by-doing type activities. Thus, new firms are argued to exploit their productivity advantage, and catch up with the size and profitability scale of incumbents only after a start-up period.

Recent empirical findings show that the adverse demand shocks faced in the start-up phase cause entrants to lag behind incumbents in terms of size and profits, but productivity as the technical efficiency in production is not necessarily affected by these demand side factors. Eslava et al. (2004) and Foster et al. (2008) compare two productivity indices that are based on revenues and quantities of outputs using a rare type micro-level production data that contains nominal and quantity-based indicators. Their findings show that entrant firms' productivity performance is poor according to revenue–productivity, but entrants are as productive as incumbents with respect to quantity–productivity. The difference between the revenue and quantity based productivity is attributed to firm-level price effects. Demand shocks faced in the start-up phase prevent entrants from charging

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[1] Theoretical models of industrial evolution bring an explanation to the static feature of mature firms. Older incumbents may suffer from low input quality and out-of-date production technology, and exhibit smooth or declining productivity performance throughout the life time unless hit by random shocks (e.g. Cooper et al., 1999; Doms and Dunne, 1998; Jovanovic, 1998). Incumbents may incur additional burden in the form of, for instance, liquidation costs, severance payments or labor training expenses while replacing the existing combination of production factors. Caballero and Hammour (1998) point out that production factors are generally specific to the existing match and the production technology which creates additional costs in the liquidation phase of the separated factors of production. Acemoglu and Cao (2010) argue that entrants engage in more radical innovations to replace incumbents.

[2] Bartelsman and Doms (2000), Foster et al. (2001) and Bartelsman et al. (2005) provide empirical support that entrants require some time to exploit their productivity advantage. Olley and Pakes (1996) show that entrants have initially poor productivity performance, but the ones that survive experience higher productivity growth than incumbents.

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price–cost markups as high as incumbents, so that entrants' revenue–productivity is lower. In contrast, entrants are as productive as incumbents even in the start-up phase according to the quantity–productivity.

The empirical evidence stresses that analyzing entrants' productivity requires disentangling price effects from productivity indices. Firm-level prices or quantities, however, are generally unobservable, so that productivity is calculated by revenues and input expenditures that are price-adjusted by, at best, industry-level deflators. This may not constitute a vital issue, if the aim is to analyze aggregate productivity, since the distorting effects of unobserved price variation can be eliminated in the phase of aggregation. Price effects, however, could bias the productivity comparisons across firms within the same industry. For instance, if a particular firm group has a significantly different pricing behavior, within-industry comparisons based on nominal productivity indices would be misleading.

This paper makes the first attempt to assess entrants' productivity performance by taking into account their possible price–cost markup variation, when prices or quantities are unobservable. My methodology consists of the structural estimation of a production relation, where the theoretical setup relies on Hall (1987, 1988) that introduces the demand side into a model of production to control for unobserved markups. The estimation method borrows from Levinsohn and Petrin (2003), so that the model is estimated by taking into account the endogeneity of inputs to productivity using a control function approach. The estimation routine retrieves markups individually for entrants and incumbents jointly with a productivity index that is adjusted to entrants' markup variation. In the empirical application, I use plant-level data from manufacturing industries of Japan.

Recently, a considerable amount of research has been directed toward controlling for unobserved markups while estimating productivity. Griliches and Mairesse (1995) address the problems in the estimation of production functions due to the unobserved heterogeneity in firms' output prices. Griliches and Klette (1996) introduce demand side into the structural model of production to take into account the price variation. Katayama et al. (2003) point out that the implications derived from revenue-based productivity measures are misleading, and offer a structural approach to impute quantities from nominal data. Levinsohn and Melitz (2004) construct an empirical model of production that accounts for unobserved prices. Their model introduces a demand shifter into a production function, and factor elasticity parameters are estimated together with an average markup that is not necessarily equal to one but still the same for all firms in the sample. The structural model drawn in Griliches and Klette (1996) and modified in Levinsohn and Melitz (2004) is applied with various extensions. For instance, Dobbelaere (2004) takes into account labor market imperfections in the joint estimation of productivity and markups. Martin (2005) develops an alternative control function approach to take into account endogeneity as well as firm-level variation in factor elasticity parameters while controlling for imperfect competition. DeLoecker (2011) modifies the estimation methodology of Levinsohn and Melitz (2004) to account for multi-product firms. DeLoecker and Warzynski (2012) estimate production functions by allowing for internationally-trading firms to have markups different than the industry average.

The econometric methodology described in the following section is developed to test the importance of demand side factors in the measurement of entrants' productivity performance. In the empirical application, the Japanese manufacturing sector is divided into two groups as high-and low-tech industries for which start-up conditions may differ, and the estimation results are interpreted comparatively. The next section presents the structural model with heterogeneous firms producing differentiated products and facing different demand conditions. The third chapter describes the data and provides preliminary evidence on the entrant plants' markup variation. The fourth section constructs the control function approach to deal with the endogeneity of inputs to unobserved productivity. In addition, the robustness of alternative production function estimation methods is discussed in the fourth section. The fifth section elaborates the relative productivity performance of entrants in manufacturing industries of Japan. The fifth section also derives implications for firm-level productivity estimation by evaluating the results comparatively among alternative econometric approaches.

2. Structural model

This section presents a structural model of production based on Hall (1987, 1988). Unlike Hall's original approach, the model in this part is formulated at the plant-level, and a reduced-form production relation is derived to estimate the within industry variation in price–cost markups. The model industry is populated by heterogeneous plants that operate under imperfect competition and produce according to a Cobb–Douglas type production function.

$$Q_{it} = \Theta_{it} M_{it}^{\alpha_{it}^M} L_{it}^{\alpha_{it}^L} K_{it}^{\alpha_{it}^K}. \tag{1}$$

Eq. (1) represents plant i's production function that is homogenous of degree $\lambda_{it} = \alpha_{it}^M + \alpha_{it}^L + \alpha_{it}^K$. t is the time index and α_{it} stands for the factor elasticity that is variable over time and across plants. Q_{it}, M_{it}, L_{it} and K_{it} are the output, intermediate inputs, labor and capital respectively. Θ_{it} is the total factor productivity.

In the model industry, plants are assumed to produce differentiated products, and $P_{it}(Q_{it})$ represents the plant-level inverse demand function. Assuming $-\eta_{it}$ is the price elasticity of demand, and C_{it} is the price of intermediate inputs, the first order condition of plant i's static maximization problem for intermediate inputs is given as follows.

$$\frac{\partial P_{it}}{\partial Q_{it}} \frac{\partial Q_{it}}{\partial M_{it}} Q_{it} + P_{it} \frac{\partial Q_{it}}{\partial M_{it}} = C_{it}. \tag{2}$$

Using the identity of factor elasticity, $\alpha_{it}^M = \partial Q_{it} M_{it} / \partial M_{it} Q_{it}$, one can derive the following condition to substitute α_{it}^M in production function with a composite term that consists of markups and observables.

$$\mu_{it} \frac{C_{it} M_{it}}{P_{it} Q_{it}} = \alpha_{it}^M. \tag{3}$$

In Eq. (3), $\mu_{it} = (1 - 1/\eta_{it})^{-1}$ represents the markup and $C_{it}M_{it}/P_{it}Q_{it}$ is the intermediate input expenditures to revenue ratio. I further assume that the condition given in Eq. (3) holds for labor input. Substituting Eq. (3) into the log of the production function, the reduced-form production relation can be written as follows.

$$q_{it} = \mu_{it}\left(\frac{C_{it}M_{it}}{P_{it}Q_{it}} m_{it} + \frac{W_{it}L_{it}}{P_{it}Q_{it}} l_{it}\right) + \alpha_{it}^K k_{it} + \theta_{it}. \tag{4}$$

In Eq. (4), W_{it} represents the plant specific wage, and the lowercase letters are the variables in logarithms. In the reduced-form production function, the factor elasticity of capital is not replaced by its expenditure share, mainly because the firm-specific user cost of capital is unobservable. In the next step, however, the elasticity of capital is replaced by $\alpha_{it}^K = \lambda_{it} - \alpha_{it}^L - \alpha_{it}^M$ where λ_{it} is the degree of total returns to scale (r.t.s). To simplify the notation, s_{it}^J is used to represent the expenditure share of input $J \in \{M, L\}$ in revenues, namely that $s_{it}^M = C_{it}M_{it}/P_{it}Q_{it}$, and the production function takes the following form.

$$q_{it} = \mu_{it}\left[s_{it}^M (m_{it} - k_{it}) + s_{it}^L (l_{it} - k_{it})\right] + \lambda_{it} k_{it} + \theta_{it}. \tag{5}$$

In the derivation of the reduced form of the production function (Eq. (5)), the equilibrium identity for capital, $\mu_{it} s_{it}^K = \alpha_{it}^K$, is abandoned, mainly because the expenditure share to revenue ratio is not directly observable from data. In addition, the calculation of the user cost of capital at the firm-level has shortcomings such as the underlying assumption of fixed capital utilization rates for all firms. In the context of this paper, such a restrictive assumption on input expenditures