Productivity and Entrepreneurial Characteristics in New Japanese Firms

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ABSTRACT. In this paper, we estimate the production function of new Japanese firms and examine whether the total factor productivity is affected by the human capital and gender of entrepreneurs. Empirical results show decreasing returns to scale of production, which verifies the assumption of production functions in many previous studies on entrepreneurship. Further, it is shown that the entrepreneur's age has a significantly negative effect on productivity, and the negative effect increases after 60 years of age. Although related business experience before startup has a significantly positive effect, the magnitude is limited and cannot overcome the negative effect of age. The results indicate the importance of starting up while young, at the latest, before 60 years of age.

1. Introduction

In empirical economics, productivity analysis has been studied for a long time. In particular, since Solow's (1957) measurement of technical change over time, using macro data in the United States, the significance of examining total factor productivity (not only labor productivity or capital productivity), defined as output per unit of total input, came to be recognized.[1] Solow's method for measuring technological progress as the shift of the production function, which became known as "Growth Accounting", has been applied to many and various issues, mainly concerning the development of the macroeconomy.[2]

However, we can alternatively measure the total factor productivity (TFP) by specifying and estimating the production function using panel data or cross-sectional data, not only by applying growth accounting to time-series data. For example, Lichtenberg and Pushner (1994) measured the index of TFP level of large Japanese manufacturing firms using panel data. They defined the TFP level e as the function

$$e = \frac{Q}{k^a l^b m^c}$$

where Q is output, k is the level of the capital input, l is the level of the labor input and m is the level of the material input, and measured the TFP index as the residuals from the estimated production function. They then examined the relationship between the TFP index and the ownership structure. Similarly, Palia and Lichtenberg (1999), using the panel dataset of manufacturing firms in United States, defined the TFP level η as the function

$$\eta = \frac{Y}{L^\alpha K^\beta}$$

where Y is output, L is the level of the labor input, and K is the level of the capital input. They further supposed that the TFP is described as

$$\ln \eta = \rho S + \varepsilon,$$

where S is an index representing the share of managerial ownership, and ε is an error term. They then examined the relationship between the TFP index and managerial ownership by estimating the integrated production function with parameters α, β and ρ.[3]

Meanwhile, in the field of entrepreneurship study, since Lucas (1978) a considerable number

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of papers have used a production function approach that explicitly includes variables for "entrepreneurial ability" in the model for the TFP and the assumption of decreasing returns to scale (e.g., Evans and Jovanovic, 1989; Holtz-Eakin, Joulfaian and Rosen, 1994; Cressy, 1996; Dunn and Holtz-Eakin, 2000; Gentry and Hubbard, 2000a; Gentry and Hubbard, 2000b). Nevertheless, as far as we know, there is no study that examines the validity of these assumptions by directly estimating the production function. Instead, several papers estimated the entrepreneurs' earnings functions. However, as stated in the next section, these studies have a problem: the earnings of entrepreneurs contain the return to capital invested by the entrepreneurs.

In this paper, we estimate the production function of new Japanese firms to examine the validity of the assumptions since Lucas (1978), and simultaneously investigate whether TFP is affected by the human capital and gender of entrepreneurs. Estimating the production function enables us to distinguish the return to entrepreneurial ability from the return to the capital invested by entrepreneurs.

The remainder of the paper is as follows. Section 2 presents the model, and Section 3 describes the data for the empirical study and their summary statistics. Section 4 reports the empirical results. Conclusions are in Section 5.

2. Model specification: Production function and its TFP

We assume the intermediate input M, the labor input L and the capital input K as the factor inputs, and $\phi(M, L, K)$ as the aggregate function. The total factor productivity (TFP) is defined as the ratio of total output to total input, hence as

$$TFP \equiv \frac{Y}{\phi(M, L, K)} \tag{1}$$

where Y is total output.

Following the previous studies mentioned above, we suppose the aggregate function has Cobb-Douglas form

$$\phi(M, L, K) = M^{\alpha}L^{\beta}K^{\gamma}, \tag{2}$$

where α, β and γ are the output elasticities of the intermediate, labor and capital inputs, respectively. Then we can write equation (1) as

$$TFP = \frac{Y}{M^{\alpha}L^{\beta}K^{\gamma}} \tag{3}$$

and transforming to

$$Y = \text{TFP} \times M^{\alpha}L^{\beta}K^{\gamma}. \tag{4}$$

This is the same form as the familiar Cobb-Douglas production function.[4] If we assume that the parameters α, β and γ and are invariant across firms, we can estimate the logarithmic form of equation (4) as

$$\begin{aligned} \ln Y &= \ln(\text{TFP}) + \alpha \ln M + \beta \ln L + \gamma \ln K \\ &= \overline{\ln(\text{TFP})} + \alpha \ln M + \beta \ln L + \gamma \ln K + u, \end{aligned} \tag{5}$$

where $\overline{\ln(\text{TFP})}$ is a constant, representing the mean value of the logarithm of the productivity. Then, we can obtain the residual

$$u = \ln Y - \overline{\ln(\text{TFP})} - \alpha \ln M - \beta \ln L + \gamma \ln K \tag{6}$$

as the TFP index, which is measured by the relative deviation from $\overline{\ln(\text{TFP})}$ (Lichtenberg and Pushner, 1994). Further, if we add the factors assumed to affect the total factor productivity in the estimating equation, we can examine the assumptions by estimating the integrated production function (Palia and Lichtenberg, 1999).

This paper adopts this approach to examine the total factor productivity of new Japanese firms. We estimate the production function of new firms using cross-sectional data, and simultaneously examine what factors affect productivity. As the production function of new firms, we adopt the form of the Lucas (1978) hypothesis.

Lucas (1978) assumed the following production function and conducted a general equilibrium analysis, each agent being endowed with a different ability to manage his or her firm, and to decide on whether to become an entrepreneur or an employee:

$$y = xg[f(n, k)], \tag{7}$$

where y is output, x is entrepreneurial ability (or management talent), n is the labor input, k is the capital input, $f(\cdot)$ is a constant-returns-to-scale production function, and $g(\cdot)$ is a strictly concave function representing the span of control of entrepreneurs. The most distinctive features of the model are the explicit assumption of entrepreneurial ability as the total factor productivity, and the decreasing returns-to-scale assumption of the production function because of the existence of the span of control of entrepreneurs.[5]

Moreover, Evans and Jovanovic (1989) and Gentry and Hubbard (2000a, b) assumed the following production function, which is based on the model of Lucas (1978):

$$y = \theta k^{\alpha}, \qquad 0 < \alpha < 1 \tag{8}$$

where θ is entrepreneurial ability, and then studied the agent's decision of the entrepreneurial choice empirically.[6]

Following these formulations and extending equation (4), we assume the production function of new firms to be

$$Y = A\theta \times M^{\alpha}L^{\beta}K^{\gamma}. \tag{9}$$

This formulation is derived by dividing TFP in (4) into θ, which is defined as entrepreneurial ability, and A, which is defined as all other factors. Similarly to equation (3), we can re-define the total factor productivity as

$$A\theta = \frac{Y}{M^{\alpha}L^{\beta}K^{\gamma}} \tag{10}$$

In this paper, we define the labor input L to include the entrepreneur's own labor, and hence L must be 1 or more. The reason is that our data set contains new firms being in business without any employees.[7] If we assume only "employees" as the labor input, the outputs of these firms are undefined under the formulation of equation (9), although these firms exist. Under this assumption, the functional form (9) includes that of equation (8) production function as the case of $A = 1$, $M = 1$ and $L = 1$.

Based on the production function of equation (9) and similar to Evans and Jovanovic (1989), total receipts of the entrepreneur $\pi(M, L, K; \theta)$ are described as

$$\begin{aligned}\pi(M, L, K; \theta) &= A\theta \times M^{\alpha}L^{\beta}K^{\gamma} - \kappa M - w(L-1) + r(z-K) \\ &= (A\theta \times M^{\alpha}L^{\beta}K^{\gamma} - \kappa M - wL - rK) + w + rz,\end{aligned} \tag{11}$$

where z is the capital invested by the entrepreneur (which is no longer that the value of the total capital input, K), κ is the real unit cost of the intermediate input, w is the real wage rate, and r is the real interest rate. Assuming profit-maximizing behavior by the entrepreneurs and a perfectly competitive market, we can derive the following necessary condition for the optimal amounts of the intermediate input (M^*), the labor input (L^*) and the capital input (K^*) as the marginal productivity principle:

$$\begin{aligned}&\alpha\frac{A\theta \times M^{\alpha}L^{\beta}K^{\gamma}}{M} = \kappa, \quad \beta\frac{A\theta \times M^{\alpha}L^{\beta}K^{\gamma}}{L} = w, \\ &\gamma\frac{A\theta \times M^{\alpha}L^{\beta}K^{\gamma}}{K} = r.\end{aligned} \tag{12}$$

From these equations, the optimal factor input ratios are determined as

$$\begin{aligned}&\frac{M^*}{L^*} = \frac{\alpha}{\beta} \times \frac{w}{\kappa}, \quad \frac{M^*}{K^*} = \frac{\alpha}{\gamma} \times \frac{r}{\kappa}, \\ &\frac{L^*}{K^*} = \frac{\beta}{\gamma} \times \frac{r}{w},\end{aligned} \tag{13}$$

and we can rewrite the total receipts of the entrepreneur (11) as

$$\begin{aligned}&\pi(M^*, L^*, K^*; \theta) = \\ &\quad (1 - \alpha - \beta - \gamma) \times A\theta \times M^{*\alpha}L^{*\beta}K^{*\gamma} + w + rz.\end{aligned} \tag{14}$$

As is well known, if the production function has constant returns to scale, i.e., the function is homogeneous of degree 1 ($\alpha + \beta + \gamma = 1$), the optimal factor input ratios are determined as (13), but the optimal levels of each factor input M^*, L^* and K^* are not determined, and there is no rent under the optimal factor input ratios (Euler's Theorem). From equation (14) and $\alpha + \beta + \gamma = 1$, the total receipts of the entrepreneur are rewritten as

$$\pi(M^*, L^*, K^*; \theta) = w + rz. \tag{15}$$

This equation indicates that, if the production function has constant returns to scale, the receipts for the entrepreneur consist of only the receipts for his or her standard labor and invested capital.

However, if the production function has decreasing returns to scale ($\alpha + \beta + \gamma < 1$), as assumed since Lucas (1978), equation (12) can be solved, and M^*, L^* and K^* are determined as

$$M^* = (A\theta)^{\frac{1}{1-\alpha-\beta-\gamma}} \times \left(\frac{\alpha}{\kappa}\right)^{\frac{1-\beta-\gamma}{1-\alpha-\beta-\gamma}} \times \left(\frac{\beta}{w}\right)^{\frac{\beta}{1-\alpha-\beta-\gamma}} \times \left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\alpha-\beta-\gamma}},$$

$$L^* = (A\theta)^{\frac{1}{1-\alpha-\beta-\gamma}} \times \left(\frac{\beta}{w}\right)^{\frac{1-\alpha-\gamma}{1-\alpha-\beta-\gamma}} \times \left(\frac{\alpha}{\kappa}\right)^{\frac{\alpha}{1-\alpha-\beta-\gamma}} \times \left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\alpha-\beta-\gamma}},$$

$$K^* = (A\theta)^{\frac{1}{1-\alpha-\beta-\gamma}} \times \left(\frac{\gamma}{r}\right)^{\frac{1-\alpha-\beta}{1-\alpha-\beta-\gamma}} \times \left(\frac{\alpha}{\kappa}\right)^{\frac{\alpha}{1-\alpha-\beta-\gamma}} \times \left(\frac{\beta}{w}\right)^{\frac{\beta}{1-\alpha-\beta-\gamma}}.$$

By using these results in (14), the total receipts of the entrepreneur are rewritten as

$$\pi(M^*, L^*, K^*; \theta) = (1-\alpha-\beta-\gamma) \times (A\theta)^{\frac{1}{1-\alpha-\beta-\gamma}} \times \left(\frac{\alpha}{\kappa}\right)^{\frac{\alpha}{1-\alpha-\beta-\gamma}} \times \left(\frac{\beta}{w}\right)^{\frac{\beta}{1-\alpha-\beta-\gamma}} \times \left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\alpha-\beta-\gamma}} + w + rz.^{8} \quad (16)$$

The equation indicates that, if the production function has decreasing returns to scale, then rent from entrepreneurial ability

$$(1-\alpha-\beta-\gamma) \times (A\theta)^{\frac{1}{1-\alpha-\beta-\gamma}} \times \left(\frac{\alpha}{\kappa}\right)^{\frac{\alpha}{1-\alpha-\beta-\gamma}} \times \left(\frac{\beta}{w}\right)^{\frac{\beta}{1-\alpha-\beta-\gamma}} \times \left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\alpha-\beta-\gamma}} > 0$$

exists at the optimal level of inputs.[9] Therefore, one of our main concerns is whether the production function (9) has decreasing returns to scale, as assumed since Lucas (1978), or constant returns to scale.

In fact, although many papers have assumed the production function explicitly, including variables for "entrepreneurial ability" in the model for TFP, and decreasing returns to scale, as far as we know, no paper has examined the validity of the assumptions by directly estimating the production function. Instead, there are several papers estimating the entrepreneurs' earnings functions (e.g., Evans and Leighton, 1989; Holtz-Eakin et al., 1994; Hamilton, 2000). However, in the context of this model, these approaches cannot be applied because the receipts of the entrepreneurs include receipts to the capital invested by themselves, as shown in equation (11). Thus the earnings of entrepreneurs tend to increase with their own assets invested to the businesses, because the earnings to the owned asset $r \times z$ in (11) increase. Therefore, even if we can obtain data on earnings of entrepreneurs from accounting information, we cannot distinguish between the receipts to entrepreneurial ability and the receipts to their invested assets z. By contrast, if we estimate the production function, as in this paper, we can directly examine the term $A\theta \times M^{\alpha}L^{\beta}K^{\gamma}$ in equation (11), and avoid the distinction problem, i.e., we can investigate the receipts to entrepreneurial ability θ distinguished from the receipts to their invested assets.

To estimate the production function, we take the logarithm of equation (9)

$$\ln Y = \ln(A\theta) + \alpha \ln M + \beta \ln L + \gamma \ln K. \quad (17)$$

Then, we assume that A, which is the TFP except for the entrepreneurial ability, consists of several

factors $X_1, X_2, \ldots, X_m$ representing the characteristics of the firms, such as sectoral differences, and that the relationship of A to $X_1, X_2, \ldots, X_m$ is

$$\ln A = a_0 + a_1X_1 + a_2X_2 + \ldots + a_mX_m. \quad (18)$$

By substituting (18) into (17), we obtain the first equation to be estimated as

$$\ln Y = a_0 + a_1X_1 + a_2X_2 + \ldots + a_mX_m. + \ln \theta + \alpha \ln M + \beta \ln L + \gamma \ln K. \quad (19)$$

$$= (a_0 + \overline{\ln \theta}) + a_1X_1 + a_2X_2 + \ldots + a_mX_m. + \alpha \ln M + \beta \ln L + \gamma \ln K + u, \quad (20)$$

where u is an error term representing the relative deviation of the logarithm of entrepreneurial ability θ from $\overline{\ln \theta}$, which is the mean value of $\ln \theta$. As mentioned above, one of the main purposes of this paper is to determine whether the production function has decreasing returns to scale ($\alpha + \beta + \gamma < 1$), as assumed since Lucas (1978), or constant returns to scale ($\alpha + \beta + \gamma = 1$).

Further, this paper examines whether the entrepreneurial ability θ is affected by the human capital and gender of the entrepreneurs. We assume that the factors $Z_1, Z_2, \ldots, Z_n$, representing the age, education, previous job experiences and gender of the entrepreneurs are related to entrepreneurial ability by the semi log-linear form

$$\ln \theta = b_0 + b_1Z_1 + b_2Z_2 + \ldots + b_nZ_n + \varepsilon.^{10} \quad (21)$$

From (19) and (21), we derive the following equation to be estimated:

$$\ln Y = (a_0 + b_0) + a_1X_1 + \ldots + a_mX_m. + b_1Z_1 + \ldots + b_nZ_n. + \alpha \ln M + \beta \ln L + \gamma \ln K + \varepsilon. \quad (22)$$

By estimating (22), we can investigate the form of the production function and the components of the TFP simultaneously. We estimate equations (20) and (22) by ordinary least squares.[11]

3. Data and preliminary analysis

For our empirical analysis, we use the data of new firms from the "Survey on Business Startups in Japan" in 1998.[12] We use the observations from those who responded to all questions used for the estimations, and exclude observations on the "Real Estate Lessors" sector and the "Others" sector. As a result, the whole sample size is 988.[13]

Although the survey is conducted annually, the survey in 1998 provided the most detailed information on income accounts, and only enough information to construct the variable, intermediate input M. The 1998 survey questioned the "sales", "purchasing expense", "compensation for the entrepreneur and his or her family employee", "compensation for other employees", "repayment of interest and principal of the debt", "all other expenses", and the "balance of payment" per month. From the surveyed results, we can define the total output Y as

Y = "sales",

and adopt this variable as the dependent variable in the empirical analysis.

For the explanatory variables, we define the intermediate, labor and capital inputs as

M = "purchasing expense" + "all other expenses",

L = number of all employees + 1,

K = total amount of capital at startup (million yen).[14]

The entrepreneur himself or herself is counted in the labor input L, as stated in the previous section, and the "employee" is comprised of the "family employee", "working director and full-time employee", "part-time employee" and "temporary employee" at the time of the survey. The part-time and temporary employees may be considered not to equal other employees in quantity (such as working hours) and quality (such as the skill level and morale), but the survey does not provide any further information that enables us to control for the difference, and we retain the simple definition. The capital input K is defined as the total startup capital, which means that running capital and the

capital for purchase of real estate are included. Although we should use the current capital rather than initial capital, these data are not provided in the survey and thus we must adopt the initial capital, assuming it is not drastically different from current capital because the number of months after startup is small in our sample.

As the $X_1, \ldots, X_m$ in equation (18), which are the components of A (a part of TFP), we adopt the following variables which are obtained in the survey and contain the information about the characteristics of firms: *Industrial Dummies* (comprised of dummies of Manufacturing, Wholesale Trade, Retail Trade, Foodservices and Drinking Places, Construction, Transportation, Personal Services, and Business Services),[15] the *Incorporation Dummy* (= 1 if the firm is an incorporated enterprise, = 0 if an unincorporated enterprise), and the *Length of Operation* (months after startup).

As the $Z_1, \ldots, Z_n$ in equation (21), which are assumed possible factors affecting θ (another part of TFP), we adopt the following variables: *Entrepreneur's Age* (age at startup), *Age60 Dummy* (= 1 if the *Entrepreneur's Age* is 60 or over), *University or College Education Dummy* (= 1 if the entrepreneur is university- or college-educated, including dropout), *Executive* (= 1 if the entrepreneur's previous position was as an executive), *Full-Time Employee* (= 1 if was a full-time employee), *Others* (= 1 if was a part-time worker, full-time homemaker, student, and others), *Related Business Experience* (years of the entrepreneur's business experience before startup related to his or her new business),[16] and *Female Dummy* (= 1 if the entrepreneur is female).

The specification indicates that we adopt the entrepreneur's age, educational background and previous job experiences as proxies of the entrepreneur's human capital. For the effect of age, we additionally adopt the *Age60 Dummy*, because most employees retire at 60 years of age in Japan, and thus the startup may be affected by whether the entrepreneur's age is under 60 or not.

The sample statistics of all variables used in empirical analysis are summarized in Table I, and the distributions of all variables except for the dummy variables are presented in Table II. The mean value of sales Y is 5.0 million yen per month and the median is two million yen, and 86% of the sales were less than 10 million yen, and more than half of the sales seem to be consumed as intermediate input M. The mean value of the labor input L, including the entrepreneur himself or herself and part-time workers, is 5.6, and the median is only three, and 88% of the firms have less than ten workers. Moreover, the mean value of the capital input K is 14.6 million yen, half of the firms have no more than 10 million yen of capital, and 89% have less than 30 million yen. These results indicate that a large proportion of our sample consists of small firms. This is mainly because the survey was conducted with enterprises financed by the NLFC, the institution that provides funds to small businesses, as described in the data appendix.

For firm characteristics (components of A), Table I indicates that the firms are distributed across various sectors, with firms in the personal services sector occupying the largest part, while firms in the manufacturing sector occupy the smallest. The unincorporated enterprises comprise 63% of the total, and the result also indicates that a large proportion of our sample consist of small firms. The mean value of the length of operation is 18 months, the median is only 15 months, and Table II shows that the most frequent range is approximately one year.

As for the entrepreneur's human capital and gender (components of θ), we can see the mean value of the age of the entrepreneurs at startup is 40 and those who are distributed broadly across age groups, but those 60 or over are few. The entrepreneurs whose last educational background was as high-school graduates or less comprise 69% of the total, those who were full-time employees amount to 78%, and male entrepreneurs were dominant in the sample for they comprised 88% of the sample entrepreneurs. Finally, Table II shows that a large proportion of the entrepreneurs started their business with utilizing their experience. The entrepreneurs who started up without previous related business experience comprised only 15% of the sample, while those who had accumulated their related business experience for at least ten years comprised 57% of the sample.

TABLE I
Sample statistics

Variable	Mean	Median	Std. dev.	Minimum	Maximum
Sales Y (million yen per month)	5.04	2.00	8.46	0.10	80.00
Intermediate input M (million yen per month)	3.35	1.00	6.84	0.01	65.90
Labor input L (number of all employees + 1)	5.62	3.00	8.57	1	132
Capital input K (million yen)	14.64	10.00	17.09	0.20	175
Industry					
Manufacturing	0.062	–	–	–	–
Wholesale Trade	0.098	–	–	–	–
Retail Trade	0.167	–	–	–	–
Foodservices and Drinking Places	0.177	–	–	–	–
Construction	0.097	–	–	–	–
Transportation	0.030	–	–	–	–
Personal Services	0.221	–	–	–	–
Business Services	0.148	–	–	–	–
Incorporation (= 1 incorporation)	0.373	–	–	–	–
Length of operation (months)	17.55	15.00	7.68	0	43
Entrepreneur's age	39.78	39.00	9.19	21	67
Age 60 (= 1 if 60 or over)	0.026	–	–	–	–
University or College Education	0.314	–	–	–	–
Previous occupational status					
Executive	0.135	–	–	–	–
Full-time Employee	0.782	–	–	–	–
Others	0.083	–	–	–	–
Related Business Experience (years)	11.46	10.00	9.15	0	46
Female	0.123	–	–	–	–

The sample size is 988.

4. Empirical results

The empirical results of production functions (20) and (22) are presented in Table III as Estimation I and II, respectively. The elasticities of factor inputs, which are among the most important parts in the results, are estimated to be $\hat{\alpha} = 0.635$, $\hat{\beta} = 0.274$, and $\hat{\gamma} = 0.041$, so that $\hat{\alpha} + \hat{\beta} + \hat{\gamma} = 0.950$ in Estimation I, which indicates that the production function has decreasing returns to scale. The result supports the assumptions of models on entrepreneurship since Lucas (1978), and suggests the existence of the rent for entrepreneurial ability θ. We can rewrite the estimated production function in line with the Lucas (1978) hypothesis (equation (7)) as

$$f(M, L, K) = A^{1/0.950} \times M^{0.668} L^{0.289} K^{0.043}$$
$$\text{and} \quad g(\cdot) = (\cdot)^{0.950},$$
$$Y = \theta \times (A^{1/0.950} \times M^{0.668} L^{0.289} K^{0.043})^{0.950}.$$

Estimation II also indicates similar estimates for α, β and γ. Testing the null hypothesis of constant returns to scale ($\alpha + \beta + \gamma = 1$) with the t-values from the estimates for the parameters α, β and γ, and the estimated covariance matrix, the hypothesis is statistically rejected for both estimation results (Estimation I: $t = -2.99$, Estimation II: $t = -2.89$).

Regarding firm characteristics (components of A), Retail Trade, and Foodservices and Drinking Places sectors show a significantly negative effect on productivity (in comparison with the Manufacturing sector), while the Construction and Business Services sectors show a significantly positive effect. This result means that a difference of productivity by industry exists and the effects are controlled by the dummy variables. Moreover, the Incorporation dummy demonstrates a significantly positive effect on productivity. The result

TABLE II
Distributions of variables

	< 1	[1, 2)	[2, 3)	[3, 5)	[5, 10)	[10, 20)	20+	Total
Sales *Y* (million yen per month)	0.228	0.224	0.119	0.165	0.127	0.083	0.055	1.000
	< 0.5	[0.5, 1)	[1, 2)	[2, 3)	[3, 5)	[5, 10)	10+	Total
Intermediate input *M* (million yen per month)	0.299	0.189	0.167	0.090	0.081	0.087	0.087	1.000
	1	2	3	4	5–9	10–19	20+	Total
Labor input *L* (number of all employees +1)	0.122	0.218	0.167	0.136	0.233	0.089	0.035	1.000
	< 5	[5, 10)	[10, 15)	[15, 20)	[20, 30)	[30, 50)	50+	Total
Capital input *K* (million yen)	0.211	0.271	0.203	0.111	0.094	0.070	0.039	1.000
	< 6	6–11	12–14	15–17	18–23	24–35	36+	Total
Length of operation (months)	0.025	0.107	0.281	0.269	0.115	0.160	0.041	1.000
	< 30	30–34	35–39	40–44	45–49	50–59	60+	Total
Entrepreneur's age (years)	0.145	0.191	0.191	0.160	0.151	0.136	0.026	1.000
	0	1–4	5–9	10–14	15–19	20–29	30+	Total
Related Business Experience (years)	0.150	0.115	0.164	0.226	0.127	0.174	0.045	1.000

The sample size is 988.

indicates that incorporated enterprises tend to achieve high productivity compared with unincorporated enterprises. Possible explanations of this result are that the inputs of the incorporated enterprises are of better quality than those for the unincorporated enterprises, or that the incorporated enterprises have relative advantages of business transactions and contracts with the clients, suppliers and bankers. However, no significant effect of the Length of Operation on productivity is observed.

Concerning the entrepreneur's human capital and gender (components of θ), Estimation II shows a significantly negative effect of the entrepreneur's age on productivity, and demonstrates that the negative effect increases after age 60. In fact, the negative effect after age 60 is large relative to the effects of other characteristics of entrepreneurs. These results indicate that the later the entrepreneur starts up, the lower is the productivity, which raises a doubt about the validity of the human capital hypothesis in several previous studies, assuming the age of entrepreneurs as a proxy for their human capital (e.g., Holtz-Eakin et al., 1994; Cressy, 1996).[17]

While a significantly positive effect of the length of related business experience before startup is shown, by comparing this coefficient with that for age, it is concluded that the positive effect of experience cannot overcome the negative effect of age. The result indicates the importance of starting up while young. As for experience from previous occupational status, a positive effect of *Executive* on productivity is shown. The result suggests that the experience of managing an existing firm is of use in managing new firms.[18] Further, no significant differences for an entrepreneur's gender and educational backgrounds are observed. This result suggests that persons who are female or who have no university or college education may not suffer a disadvantage as an entrepreneur, although they are generally viewed to be at a disadvantage for their compensation and promotion in existing firms. Therefore, for such persons, starting up a business may be a more attractive alternative than being an employee. Nevertheless, the number of female entrepreneurs is small in fact, as presented in Table I, and it may suggest that there is significant room for improving policy for fostering female entrepreneurship in Japan.

TABLE III
Empirical results (OLS)

	I			II		
	Coefficient	SRC	*t*-value	Coefficient	SRC	*t*-value
Constant	0.3164		4.82**	0.4489		5.33**
ln *M*	0.6345	0.8010	55.92**	0.6239	0.7875	54.17**
ln *L*	0.2741	0.1952	16.62**	0.2795	0.1991	17.11**
ln *K*	0.0410	0.0318	2.75**	0.0466	0.0361	3.11**
Industry						
Manufacturing		–			–	
Wholesale Trade	0.0336	0.0085	0.58	0.0447	0.0114	0.78
Retail Trade	–0.1743	–0.0555	–3.31**	–0.1498	–0.0477	–2.87**
Foodservices and Drinking Places	–0.2977	–0.0971	–5.64**	–0.2987	–0.0974	–5.72**
Construction	0.1549	0.0392	2.71**	0.1319	0.0334	2.34*
Transportation	0.0831	0.0122	1.08	0.0809	0.0119	1.05
Personal Services	–0.0498	–0.0176	–0.96	–0.0677	–0.0240	–1.32
Business Services	0.1498	0.0454	2.86**	0.1528	0.0463	2.95**
Incorporation	0.0969	0.0400	3.22**	0.1025	0.0424	3.40**
Length of Operation	0.0026	0.0171	1.69	0.0026	0.0168	1.68
Entrepreneur's Age		–		–0.0046	–0.0362	–3.06**
Age 60 (= 1 if 60 or over)		–		–0.2023	–0.0277	–2.72*
University or College Education		–		–0.0407	–0.0161	–1.62
Previous occupational status						
Executive		–		0.0643	0.0188	1.85*
Full-time Employee		–			–	
Others		–		–0.0154	–0.0036	–0.38
Related Business Experience		–		0.0043	0.0336	3.29**
Female		–		–0.0518	–0.0146	–1.43
Adj-R^2	0.9167			0.9201		
S.E.	0.3381			0.3311		

The sample size is 988.
SRC means "standardized regression coefficient".
** Significant at the 1% level.
* Significant at the 5% level.

5. Conclusions

This paper estimated the production function of new Japanese firms using cross-sectional data from the "Survey on Business Startups in Japan" in 1998, and investigated whether the total factor productivity of new firms is affected by the human capital and gender of entrepreneurs. For estimation, we adopted a production function that explicitly assumes entrepreneurial ability as the total factor productivity and decreasing returns to scale. Although such a production function has been assumed in many previous studies on entrepreneurship since Lucas (1978), as far as we know, there is no study that estimates the production function directly and examines its validity.

The empirical results demonstrate that the output elasticity of intermediate, labor and capital inputs are 0.635, 0.274 and 0.041, respectively, and the hypothesis of constant returns to scale is statistically rejected. Therefore, we conclude that the production function has decreasing returns to scale. This result suggests the existence of rent from entrepreneurial ability, and supports the assumptions of the models on entrepreneurship since Lucas (1978).

Concerning the components of TFP, a difference of productivity by industry is observed: the Retail Trade and Foodservices and Drinking Places sectors show a significantly negative effect on productivity (in comparison with the Manufacturing sector), while the Construction and Business Services sectors show a significantly positive effect. Moreover, the superiority of incorporated enterprises is presented.

Further, it is shown that the entrepreneur's age has a significantly negative effect on productivity, and the negative effect increases after age 60. Although related business experience before startup indicates a significantly positive effect, the magnitude is limited and cannot overcome the negative effect of age. The results imply the importance of starting up while young, at the latest, before 60 years of age. Meanwhile, significant differences of the entrepreneur's gender and educational background are not observed, which may indicate the relative attraction of starting up for persons who are female or do not have university or college education.

In the low- or almost zero-growth economy of Japan for more than ten years, the fostering of entrepreneurship has been one of the most important policy issues in Japan. Nevertheless, the rate of entrepreneurial activities has continued to decline and there seems to be no clear sign of a reversal. Under these circumstances, the results in this paper will contribute to the determination of policy, not only for fostering the extent of entrepreneurial activities, but more for fostering entrepreneurship through encouraging "productive" entrepreneurial activities. To retain, and preferably improve, the quality of entrepreneurship is more important than simply seeking to increase the number of entrepreneurs.

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Data appendix

The "Survey on Business Startups in Japan" ("*Shinki Kaigyou Jittai Chousa*" in Japanese) is a questionnaire-based survey, conducted annually by the National Life Finance Corporation (NLFC; "*Kokumin Seikatsu Kinyuu Kouko*" in Japanese), which is a Japanese government financial institution established to provide loans mainly to small businesses in Japan. The survey covers new business enterprises financed by the NLFC and which have been in operation for no more than one year at the time of applying for the loan. The aggregative results of the survey are annually published by NLFC as "*Sinki Kaigyou Hakusyo*" in Japanese, and "Trend of Business Startups in Japan" as the English summary.

This is the largest survey of new firms in Japan, and has a number of advantages, although there is a possible problem of sample selection. First, the survey provides detailed information on personal characteristics of entrepreneurs, such as age, gender, educational background, and previous job experience. Second, it provides financial data of new firms, such as sales, items of income accounts, and startup capital. Third, it provides data on the performance of new firms, which is usually unpublished and hard to obtain: the sample mean of the time period after startup is only 17.6 months. Fourth, the survey covers various industries, not only the manufacturing sectors but also service sectors. As Audretsch, Klomp and Thurik (1997) pointed out, less is known about post-entry performance in non-manufacturing sectors, such as the service sector, even though these sectors are increasing rapidly in developed countries.

Notes

[1] Before Solow (1957), there were several pioneering researches concerning total factor productivity such as Copeland (1937) and Tinbergen (1942). See the survey by Griliches (1996).

[2] For recent studies applying the growth accounting for Japan, see Kuroda and Nomura (1999), Sonobe and Otsuka (2001), Miyagawa, Ito and Harada (2002), and Urata and Kawai (2002). See also the survey by Hulten (2000).

[3] We should note that both studies do not a priori impose the assumption of constant returns to scale of production. For other recent studies on the direct measurement of TFP, see Lichtenberg (1992) and Coe and Helpman (1995).

[4] As Palia and Lichtenberg (1999) also noted, the Cobb-Douglas production function is considered as a local first-order approximation for any arbitrary production functions.

[5] For contemporary theoretical studies based on assumptions similar to Lucas (1978), see Beckman (1977) and Rosen (1982).

[6] The reason that they supposed only the capital input as the factor input is probably to simplify the modeling and the estimation.

[7] Such observations are 121 of 988 (12.2%) as shown in

Table II. The observations are distributed from 8 to 31 in each industry. Although we cannot exclude the possibility that missing data are included in the observations, we consider that the cases are few and can be ignored, because the distribution, as shown in Table II, is quite reasonable and thus it is relatively inadequate if we remove all of the "no-employee" observations.

[8] Here we can see that all four equations are increasing functions of entrepreneurial ability θ.

[9] See also Hoch (1955) and Hoch (1962, pp. 49–50) for such an interpretation of the rent.

[10] The semi-loglinearity is assumed in line with Lichtenberg and Pushner (1994) and Palia and Lichtenberg (1999).

[11] For the endogeneity problem of factor inputs, this paper simply assumes that entrepreneurs maximize expected profits, following Zellner, Kmenta, and Dreze (1966), although it may not perfectly solve the problem. See also the detailed discussion by Griliches and Mairesse (1995).

[12] For more detailed information on this survey, see the Data Appendix.

[13] The 'Real Estate Lessors' sector is excluded because the business is quite different from other sectors. The 'Others' sector is excluded because the sector consists of too diverse firms, and we consider that the diversity cannot be well controlled in our empirical analysis.

[14] We use responses for Y, M and K as they are without deflation, because our observations of new firms are not distributed so widely across years, as shown in Table II, and hence we consider that it is more important to avoid the arbitrariness imposed by the deflator, which is not actually observed.

[15] The eight sector divisions are the same as the divisions used in the survey. Although, conceptually, to estimate production functions by each industry may be preferable, to do so we must divide our dataset into rather small samples. Thus, in this paper, we alternatively adopt the approach to estimate the production function with industrial dummies across industries. Attempts to enhance the dataset and extend the estimation are left for further research.

[16] *Related Business Experience* = 0 means the entrepreneur has no related business experience before start-up.

[17] The negative result for the entrepreneur's age as a proxy for human capital is also presented by Harada (2002), who examined the entrepreneur's success probability using data from the 'Survey on Business Startups in Japan' from 1992 to 1996, and Honjo (2001), who examined the sales growth of new Japanese manufacturing firms using data from Tokyo Shoko Research Inc.

[18] However, the positive effect does not overcome the negative effect of age 60 or over.

References

Audretsch, David B., Luuk Klomp, and A. Roy Thurik, 1997, 'Do Service Differ From Manufacturing? The Post-Entry Performance of Firms in Dutch Services', *CEPR Discussion Paper* 1718.

Beckman, Martin J., 1977, 'Management Production Functions and the Theory of the Firm', *Journal of Economic Theory* **14**(1), 1–18.

Coe, David T. and Elhanan Helpman, 1995, 'International R&D Spillovers', *European Economic Review* **39**(5), 859–887.

Copeland, Morris A., 1937, 'Concepts of National Income', in *Studies in Income and Wealth*, Vol. 1, New York: NBER, pp. 3–63.

Cressy, Robert, 1996, 'Are Business Startups Debt-Rationed?', *Economic Journal* **106**, 1253–1270.

Dunn, Thomas and Douglas Holtz-Eakin, 2000, 'Financial Capital, Human Capital, and the Transition to Self-Employment: Evidence from Intergenerational Links', *Journal of Labor Economics* **18**(2), 282–305.

Evans, David S. and Boyan Jovanovic, 1989, 'An Estimated Model of Entrepreneurial Choice under Liquidity Constraints', *Journal of Political Economy* **97**(4), 808–827.

Evans, David S. and Linda S. Leighton, 1989, 'Some Empirical Aspects of Entrepreneurship', *American Economic Review* **79**(3), 519–535.

Gentry, William M. and R. Glenn Hubbard, 2000a, 'Tax Policy and Entrepreneurial Entry', *American Economic Review* **90**(2), 283–287.

Gentry, William M. and R. Glenn Hubbard, 2000b, 'Entrepreneurship and Household Saving', *NBER Working Paper* 7894.

Griliches, Zvi, 1996, 'The Discovery of the Residual: A Historical Note', *Journal of Economic Literature* **34**, 1324–1330.

Griliches, Zvi and Jacques Mairesse, 1995, 'Production Functions: the Search for Identification', *NBER Working Paper* 5067.

Harada, Nobuyuki, 2002, 'Who Succeeds as an Entrepreneur? An Analysis of the Post-Entry Performance of New Firms in Japan', *Japan and the World Economy*, forthcoming.

Hamilton, Barton, H., 2000, 'Does Entrepreneurship Pay? An Empirical Analysis of the Returns to Self-Employment', *Journal of Political Economy* **108**(3), 604–631.

Hoch, Irving, 1955, 'Estimation of Production Function Parameters and Testing for Efficiency', *Econometrica* **23**(3), 325–326.

Hoch, Irving, 1962, 'Estimation of Production Function Parameters Combining Time-Series and Cross-Section Data', *Econometrica* **30**(1), 34–53.

Honjo, Yuji, 2001, 'Growth of Start-up Firms: Evidence from the Japanese Manufacturing Industry', Institute of Business Research, Chuo University, Working Paper.

Holtz-Eakin, Douglas, David Joulfaian and Harvey S. Rosen, 1994, 'Sticking It Out: Entrepreneurial Survival and Liquidity Constraints', *Journal of Political Economy* **102**(1), 53–75.

Hulten, Charles R., 2000, 'Total Factor Productivity: A Short Biography', *NBER Working Paper* 7471.

Kuroda, Masahiro and Koji Nomura, 1999, 'An Explanation of the Productivity Paradox: TFP Spillover through Capital Accumulation', Bank of Japan, IMES Discussion Paper 99-E-10.

Lichtenberg, Frank R., 1992, *Corporate Takeovers and Productivity*, Cambridge and London: MIT Press.

Lichtenberg, Frank R. and George M. Pushner, 1994, 'Ownership Structure and Corporate Performance in Japan', *Japan and the World Economy* **6**(3), 239–261.

Lucas, Robert E., Jr., 1978, 'On the Size Distribution of Business Firms', *Bell Journal of Economics* **9**(2), 508–523.

Miyagawa, Tsutomu, Yukiko Ito, and Nobuyuki Harada, 2002, 'Does IT Revolution Contribute to Japanese Economic Growth?', Japan Center for Economic Research Discussion Paper 75.

Palia, Darius and Frank R. Lichtenberg, 1999, 'Managerial Ownership and Firm Performance: A Re-Examination Using Productivity Measurement', *Journal of Corporate Finance* **5**(4), 323–339.

Rosen, Sherwin, 1982, 'Authority, Control, and the Distribution of Earnings', *Bell Journal of Economics* **13**(2), 311–323.

Solow, Robert, 1957, 'Technical Change and the Aggregate Production Function', *Review of Economics and Statistics* **39**(3), 312–320.

Sonobe, Tetsushi and Keijiro Otsuka, 2001, 'A New Decomposition Approach to Growth Accounting: Derivation of the Formula and its Application to Prewar Japan', *Japan and the World Economy* **13**(1), 1–14.

Tinbergen, Jan, 1942, 'Zur Theorie der Langfirstigen Wirtschaftsentwicklung', *Weltwirts Archiv* 1, Amsterdam: North-Holland, pp. 511–549; reprinted in English translation in Jan Tinbergen, 1959, *Selected Papers*, North-Holland, pp. 182–221.

Urata, Shujiro and Hiroki Kawai, 2002, 'Technological Progress by Small and Medium Enterprises in Japan', *Small Business Economics* **18**(1–3), 53–67.

Zellner, Arnold, Jan Kmenta and Jacques Dreze, 1966, 'Specification and Estimation of Cobb-Douglas Production Function Models', *Econometrica* **34**(4), 784–795.