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Knowledge sourcing and firm performance in an industrializing economy: the case of Taiwan in the 1990s

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Abstract:

This paper examines the impact of R&D and technology imports on firm performance in Taiwan's manufacturing industry. Using a panel of 27,754 firms observed from 1992 to 1995, we estimate Translog production functions in twenty 2-digit industries. We implement four estimations procedures: fixed-effect regression, random-effect GLS, Hausman-Taylor estimator, and Stochastic Frontier Estimation. Our most reliable estimates, obtained with fixed effect and Hausman-Taylor models, show that knowledge inputs have a significant impact on firm sales in a small number of industries, and suggest that R&D and technology imports are more likely to be complements rather than substitutes.

JEL classification: L25, L60, O33

Keywords: Manufacturing Industries; Newly Industrialized Countries; Technology Imports.

Since the beginning of the 1990s, Taiwan has been increasingly challenged by international competition, and more specifically by competition from other Asian newly-industrialized and developing economies. A steep rise in labour costs put a heavy pressure on the economy, while the adoption of a managed floating exchange rate made exports less competitive. As a result, Taiwan had to speed up its industrial upgrading process. Technology upgrading in a newly industrialized country, however, cannot totally rely on its own R&D effort, but may also involve importing new knowledge from foreign countries. Over the 1990s, Taiwan's increasing R&D effort has thus been accompanied by an increase in technology imports.

The present research addresses two questions: first, we want to determine the respective impact of in-house R&D and of technology imports on firm performance, in the context of industrial upgrading of the early 1990s. Second, we want to know whether these two sources of knowledge act as substitutes or complements in the production process. To answer these questions, we estimate a production function in a sample of 27,754 manufacturing firms, distributed across twenty 2-digit industries. The paper is organized as follows: Section 1 states the objective of our research. Section 2 describes our data. We present our analytical framework and econometric models in Section 3, and the estimations results are given in Section 4. Conclusions are given in a final section.

1. Objective of the research

The idea that imported technology may accelerate industrial upgrading, especially in countries that are in a catching-up or industrializing phase, is not new. Studies focused on the Japanese economy in the 1960s and 1970s (e.g., Caves and Uekusa 1976; Odagiri, 1983) start from the assumption that, over this period, sales growth and/or productivity growth depended mostly on flows of new technology from abroad. They failed, however, to find statistical evidence of that assumption. More recent studies, such as that conducted by Basant and Fikkert (1996) on a panel of Indian firms observed from 1974 to 1981, suggest that technology imports may have a positive effect on productivity growth.

The present research focuses on the case of Taiwan in the early 1990s. By all accounts, the history of innovation in Taiwan is not a long one. Although the 1980s saw the emergence of Taiwan's high-tech industries (esp. electronic components), innovation activity (as measured by innovation expenditures) at the firm level really started in the 1990s. Figure 1 depicts the evolution of overall innovation expenditures (in base 100 for 1982) between 1982 and 2000, distinguishing between R&D expenditures only, and R&D expenditures plus technology imports. One can see, from 1986 on, a sharp and steady increase in both measures, with technology imports gradually taking more importance.

FIGURE 1 ABOUT HERE

This evolution may be linked to Taiwan's industrial and innovation policy, the cornerstone of which have been, since 1991, the Industrial Upgrading Statute (Hou and Gee, 1993; Luo, 2001), hereafter IUS[1]. The IUS consists in a number of incentive measures aimed at encouraging investment and technology transfers in emerging and/or strategic industries (i.e., industries that are expected to benefit economic development in a substantial way). The IUS can be seen as organized around three axes. The first axis involves taxation policy and direct public spending, for instance: tax incentives to develop investment in R&D, or preferential loans for small and medium enterprises that upgrade their technological level. The second axis concerns education policy, with the objective of upgrading the stock of human capital. The third axis consists in encouraging technology transfer and knowledge flows, through the establishment of science-based industrial parks, for instance.

In this study, we examine the impact of innovation expenditures on firms' economic performance in the early 1990s, i.e. in the years immediately following the implementation of the IUS. We are able to distinguish two types of innovation expenditures: R&D expenditures on the one hand, and disembodied technology

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[1] See http://www.moeaidb.gov.tw/portal/english/about3.jsp and http://www.environet.org.tw for more details about the IUS.

imports on the other. ‘Disembodied’ refers here to technologies that are protected by intellectual property rights, but can be purchased by a firm and used in its own production process. These include patented technologies, licensed technologies and other royalties-inducing technologies. There is some empirical evidence that, in newly industrialized countries or rapidly-industrializing countries, licensing agreements with foreign firms may be at least as important a source of knowledge as internal R&D (e.g., Caves and Uekusa, 1976; Basant and Fikkert, 1996).

In the context of our study, a firm may therefore not only do R&D in order to innovate (e.g., create a new product); it may also use a patented process from abroad (and pay royalties to the patent owner). The issue of whether these two sources of knowledge are complements or substitutes naturally comes to mind. Although economic theory generally assumes substitutability, some authors (e.g., Blumenthal, 1979; Freeman, 1991; Cassiman and Veugelers, 2006) have found evidence of complementarities between external and internal sources of knowledge. A theoretical justification for these results could be found in the seminal work of Cohen and Levinthal (1989, 1990) on R&D and firm ‘absorptive capacity’. The argument is as follows: firms which rely on technology imports must also maintain some R&D capacity, in order to know which technologies are available for purchase or copy at a given time. Firms may also build on this R&D capacity to modify and adapt foreign technologies, and tailor them to their specific needs.

The objective of the present research is therefore twofold: first, we want to estimate the effects of innovation expenditures on the economic performance of Taiwanese firms in the early 1990s. Second, we want to examine whether R&D expenditures and technology imports are substitutes or complements. Since many major Taiwanese inventions make use of patents held by foreign companies, the main purpose of R&D conducted in Taiwan in the 1990s may have been to maintain a level of *absorptive* capacity. We may thus assume R&D and technology imports to be complements; our analytical framework will allow us to test this assumption.

2. The Taiwanese MOEA Panel Data

This paper uses census data gathered by the Statistic Bureau of Taiwan's Ministry of Economic Affairs (MOEA). The Statistical Bureau of the MOEA conducts a yearly census survey, and collects data on every plant in operation that holds a registered certificate in the manufacturing sector. In Taiwan, most manufacturing firms are single-plant producers: 87% of the manufacturing firms in our database are actually single-plant producers. Therefore, distinguishing between plant and firm may not be as relevant in Taiwan as it is in industrialized countries, and we will refer to the MOEA data as 'firm-level data' hereafter.[2]

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[2] Moreover, our estimations will include a control for the nature of the firm (multi / single-plant).

Given what was said about innovation policy in Taiwan in the previous section, it makes sense, for our purpose, to focus on the 1990s. When the present research was started, post-1997 data was not available yet. Moreover, the MOEA census survey was not conducted in 1991 and 1996. For these reasons, our research will focus, in this paper, on the 1992-1995 period only, i.e. on the period immediately following the start of the IUS.

Over the 1992-1995 period, we observed a panel of 27,754 Taiwanese manufacturing firms, distributed across twenty-one 2-digit industries. Table 1 gives a breakdown of this population of 27,754 firms by industry. The MOEA panel provides information on firms' sales (deflated by a wholesale price index), total value of fixed assets in operation at the end of the year, total expenditures on raw materials (deflated by an intermediate input-output price index), and wages (deflated by a consumer price index). These variables will be used as proxies for firm output, capital input, materials input, and labour input respectively[3].

TABLE 1 ABOUT HERE

Additional information includes firms' yearly R&D expenditures, as well as the value of imported disembodied technologies (as defined in Section 1). Finally, the data includes three additional firm-specific characteristics: firm age, an indicator of whether

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[3] More information about the data and the construction of variables is available upon request from the authors.

a firm exports technologies, and an indicator of whether a firm is a single- or multi-plants producer. Table 2 gives summary statistics, by industry, for all the aforementioned variables.

TABLE 2 ABOUT HERE

Coming from a census, our population is very large, and it would not really make sense to estimate a unique econometric model on that population, as the heterogeneity across industries is too important. It is more reasonable and more relevant, in that case, to conduct a by-industry analysis. It must be noted that industry (23) 'petroleum and coal products' included only 13 firms, and was regrouped with industry (22) 'chemical products' for our empirical analysis. In other words, our estimations were performed, *in fine*, over twenty 2-digit industries rather than on the original twenty-one.

3. Theoretical framework and econometric modelling

3.1. Econometric model

Our analysis derives from a production function approach, linking firm output Q to input vector X (with X_1 = capital, X_2 = labour and X_3 = materials) and knowledge K, assuming that knowledge and inputs have distinct effects. As in Basant and Fikkert (1996), we assume an exponential link between output and knowledge. For firm i operating at time t in a given 2-digit industry, we write:

(1) $Q_{it} = F(X_{it}).\exp(K_{it})\exp(\varepsilon_{it})$,

where F is an unspecified functional form and ε_{it} a random error term. We assume that ε_{it} can be decomposed in an individual effect u_i (which depicts unobserved individual characteristics), a time effect λ_t, and a transitory error term ω_{it}:

(2) $\varepsilon_{it} = u_i + \lambda_t + \omega_{it}$.

In order to estimate Equation (1), we need to specify F, and to specify how knowledge K relates to innovation expenditures. Since we want to keep F as general as possible, we assume a translog specification, usually considered as a reasonable second-order approximation of an arbitrary production function (see for instance Berndt and Christensen, 1973; Chan and Mountain, 1983; Beason and Weinstein, 1996). We may then rewrite (1) as:

(3) $\ln Q_{it} = \beta_0 + \Sigma_j \beta_j.\ln X_{jit} + \frac{1}{2}[\Sigma_j \Sigma_k \beta_{jk.}(\ln X_{jit})(\ln X_{kit})] + K_{it} + \varepsilon_{it}$

3.2. Measurement of the stocks of R&D capital and technology imports.

As in Basant and Fikkert (1996), we assume that the stock of knowledge has a Generalized Leontief functional form of the type:

(4) $K_{it} = \alpha_0.(KO)^{½} + \alpha_1.(KP)^{½} + \alpha_2.(KO\times KP)^{½}$

where *KO* represents a firm’s own knowledge (i.e., its stock of R&D capital) and *KP* a firm’s purchased knowledge (i.e., its stock of imported technology). As stated in Basant and Fikkert (1996), the specification of Equation (4) permits *KO* and *KP* to be complements or substitutes to one another. It also avoids the problem of taking the logarithm of the knowledge inputs, which are frequently equal to zero.

The stocks of R&D capital and technology imports are measured using the perpetual inventory method (Griliches, 1979; Hall and Mairesse, 1995); i.e., if δ denote the depreciation rate of knowledge, we have :

(5.a) $KO_t = (1 - \delta)KO_{t-1} + RD_{t-1}$, where *RD* is the value of R&D expenditures

(5.b) $KP_t = (1 - \delta)KP_{t-1} + TI_{t-1}$, where *TI* is the value of technology imports

This method normally requires the use of a long history of R&D (technology imports), so that the process of computing knowledge stocks may be started presample. However, no such historical series are available at the firm-level in our case, for, as was stated in Section 1, the history of innovation in Taiwan prior to 1991 is way too short. Therefore, initial values KO_1 and KP_1 had to be calculated on the basis of our 4-year panel, taking 1992 as year 1. For this calculation, we used Hall and Mairesse's (1995) Equation (5), p. 270, which states:

(6.a) $KO_1 = RD_1 / (g + \delta)$

(6.b) $KP_1 = TI_1 / (g + \delta)$

where g denotes the growth rate of R&D and Technology Imports expenditures.

Following Basant and Fikkert (1996), we assume that both g and δ are the same for *TI* and *RD*. As usual, it is very difficult to assign a value to those parameters.

The most frequently used assumptions in the literature are a depreciation rate of 15% and a growth rate of 5%. After conducting a sensitivity analysis (taking, for instance, values of 20% to 25% for the depreciation rate and of 10% for the growth rate), we have decided to follow this set of assumption in our econometric modelling.

3.3. Estimation procedure

The econometric model to be estimated in each 2-digit industry can finally be written as:

$$(7) \quad \ln Q_{it} = \beta_0 + \Sigma_j \beta_j.\ln X_{jit} + \frac{1}{2}[\Sigma_j \Sigma_k \beta_{jk.}(\ln X_{jit})(\ln X_{kit})]$$

$$+ \alpha_0.(KO)^{½} + \alpha_1.(KP)^{½} + \alpha_2.(KO \times KP)^{½} + u_i + \lambda_t + \omega_{it},$$

where λ_t is depicted by a set of year dummy variables. To estimate Equation (7), we used four different procedures: First, we specified u_i as a fixed effect. Second, we specified u_i as a random effect, estimated Equation (7) by GLS, and conducted a Hausman specification test for each 2-digit industry. Third, we estimated a Hausman-Taylor model, which consists in specifying u_i as a random effect while assuming possible dependence between u_i and the knowledge inputs. Indeed, we only observe knowledge inputs, but do not directly observe the output of the innovation process. It may well be, nonetheless, that this innovation output has an effect on sales. If so, then this effect is captured partially by the knowledge inputs, and partially by the unobserved heterogeneity term.

The fourth and final procedure consisted in the stochastic frontier estimation (SFE) of Equation (7). This method stems from the assumption that there may be inefficiency in the production process, arising from unobserved factors such as managerial abilities (Battese and Coelli, 1992; Kumbhakar and Lovell, 2000). The principle of SFE is to decompose the stochastic error term ω_{it} into a one-sided error term v_{it}, which represents inefficiency, and a symmetric (noise) error term w_{it}:

(8) $\omega_{it} = v_{it} + w_{it},$

where the distribution of v_{it} is truncated normal, $N(\mu, \sigma_v^2)$, and were w_{it} is normally distributed and i.i.d., $N(0, \sigma_w^2)$. Both error terms are supposed to be distributed independently of each other and independently of the explanatory variables.

The one-sided error v_{it} is supposed to capture the deviation from the production frontier for firms that fall within that frontier, and are thus considered as inefficient. This leads us to rewrite Equation (7) as:

(9) $$\ln Q_{it} = \beta_0 + \Sigma_j \beta_j.\ln X_{jit} + \frac{1}{2}[\Sigma_j \Sigma_k \beta_{jk.}(\ln X_{jit})(\ln X_{kit})]$$

$$+ \alpha_0.(KO)^{½} + \alpha_1.(KP)^{½} + \alpha_2.(KO\times KP)^{½} + u_i + \lambda_t + v_{it} + w_{it},$$

and to estimate this model by Maximum Likelihood (ML).

For the random effect and Hausman-Taylor specifications of Equation (7), as well as for the SFE estimation of Equation (9), more control variables were added to the econometric model: firm age in the first year of the period (1992), a dummy variable indicating whether a firm exports technology, a dummy variable indicating whether a firm is a single- or multi-plant producer, and a set of 4-digit industry dummy variables.

4. Results

4.1. Fixed and random effects

For the sake of concision and clarity, we focus our discussion of results on our main explanatory variables, i.e. knowledge inputs. We first consider the results of the fixed-effect estimation given in Table 3. This table shows a significant impact of the knowledge inputs on firm output in four industries only: (15) "Leather and Fur Products", (21) "Basic Chemicals", (31) "Electronic" and (32) "Transportation".

TABLE 3 ABOUT HERE

In industry (15), a firm's own knowledge (R&D capital stock) has a positive impact on sales, whereas the knowledge purchased abroad (stock of technology imports) has a negative effect. The interaction of *KO* and *KP* is positive, suggesting that there is some degree of complementarity between in-house R&D and technology imports. Since industry (15) is a traditional industry, it seems logical that R&D be used in order to absorb knowledge purchased from abroad (such as licensed new production processes, for instance). In industries (21) and (32), *KP* is the only knowledge input that has an impact on sales; this impact is positive in industry (21), whereas it is negative in industry (32).

Finally, in industry (31) “Electronics”, the fixed-effect model shows a positive effect of R&D capital stock on firm sales. The effects of *KP* and of the interaction term are positive, but not significant. These results are consistent with those of the study conducted by Branstatter and Chen (2006) on Taiwan’s electronic industry: In their fixed effect regression, these authors find positive coefficients associated to R&D expenditures and technology imports. However, none of these two variable has a significant effect on firms’ output. This difference between our study and Branstatter and Chen’s (2006) study can be explained by the facts : (1) that they use a more restrictive specification of their production function (a Cobb-Douglas technology) and (2) that they do not include an interaction term in their model[4].

We now consider the results of the random-effect model, given in Table 4. In that model, we find that the knowledge inputs variables have a significant effect on firm output in a larger number of industries (fifteen out of twenty, including the ones already mentioned in the fixed-effect model). In most of those industries, we find a significant and positive effect of R&D capital.

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[4] In our analysis, restriction tests favour the Translog specification over the Cobb-Douglas in every industry: the null hypothesis of the parameters associated to the cross-log of the inputs being all equal to zero was rejected at the 1% level.

TABLE 4 ABOUT HERE

In industry (31), in particular, we find a significant and positive effect of both R&D capital and technology imports (which is again, consistent with the findings of Branstatter and Chen, 2006). Moreover, we find that the interacted term $KO \times KP$ has a significantly negative impact on firm sales: this result suggests that R&D and technology imports may be substitutes rather than complements in that industry, which is consistent with the findings of Basant and Fikkert (1996) for India. Unfortunately, the Hausman tests we conducted after estimating the random effect model led us to favour the fixed effect model in every industry[5].

4.2. Hausman-Taylor model and Stochastic Frontier estimation

Given those results, it can be informative to examine the results of the Hausman-Taylor model, presented in Table 5. This model is, in fact, a random effect model in which one relaxes the assumption of non-correlation between the unobserved individual characteristics and the other covariates. As explained in Section 3, we allowed for correlation between the knowledge inputs and the unobserved individual effect. The results of the estimation are, interestingly, quite similar to those obtained with the fixed-effect model.

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[5] The only exceptions are industries (22+23) and (28), in which the test statistic is negative. For these industries, we cannot decide between the random- and fixed- effects specifications.

Indeed, we find significant effects of the knowledge inputs in industries (11) “Agro-food”, (15) “Leather and Fur Products”, (21) “Basic Chemicals” and (32) “Transportation”. In industries (15), (21) and (32), the significances, signs, and magnitudes of the knowledge inputs are quite close to those we found in the fixed effect regression. Contrary to what we observed in the fixed effect model, however, the effect of the R&D capital stock in the electronic industry is not significant anymore. Overall, our results nevertheless suggests that the assumption of a possible correlation between knowledge inputs and unobserved individual characteristics seems to hold.

TABLE 5 ABOUT HERE

Finally, we examine the results of the SFE model, given in Table 6. As explained in Section 3, the SFE model can be considered as an extension of a random effect model, in which the error term is decomposed in an inefficiency term and a noise term. Since the Hausman tests seemed to favour the fixed effect model over the random effect model, we will not discuss the results of the SFE in details: They are, overall, very similar to those of the random effect model, in terms of sign, significance, and magnitude.

TABLE 6 ABOUT HERE

The most interesting result concerns the inefficiency term v_{it}, assumed to be i.i.d., with $v_{it} \sim N(\mu, \sigma_v^2)$. Table 6 includes an estimate of μ, the mean value of v_{it}, which is not significantly different from zero, except in industry (17) "Furniture and Fixtures". This results suggest that, overall, there is no significant inefficiency bias linked to unobserved firm characteristics, and we need not reject the assumption that firms are operating on the production frontier.

5. Conclusion

The objective of this research was to evaluate the impact of knowledge inputs on firm performance in Taiwan in the early 1990s, in the institutional context of the Industrial Upgrading Statute (IUS). To conduct our empirical analysis, we used a panel of 27,754 manufacturing firms observed over the 1992-1995 period, in twenty 2-digit industries. Using a flexible translog production function, we regressed sales (as a measure of firm output) on the usual inputs (capital, labour and materials) and on the stock of knowledge. Two knowledge inputs were taken into consideration : in-house R&D and imports of royalties-inducing disembodied technologies.

The model was estimated in each 2-digit industry, using four different procedures: fixed effect regression, GLS random effect regression, Hausman-Taylor estimation (a random effect model allowing for correlation between knowledge inputs and unobserved individual characteristics), and Stochastic Frontier Estimation.

Hausman tests led us to favour the fixed effect specification over the random effect model. The results of the Hausman-Taylor model were very similar to those of the fixed effect regression, whereas the SFE results were, unsurprisingly, quite similar to those of the random effect model.

On the basis of the fixed effect and Hausman-Taylor models, we find a significant effect of knowledge inputs in a small number of industries, with no common pattern: In some industries, such as electronic products, we find a positive effect of R&D capital stock, whereas in other industries, such as basic chemicals, the stock of technology imports is the only significant knowledge input. Finally, in the leather industry, we find evidence suggesting that R&D and technology imports may be complements. Evidence for substitutability is more difficult to find, except if we refer to the results of the less reliable random effect and SFE models.

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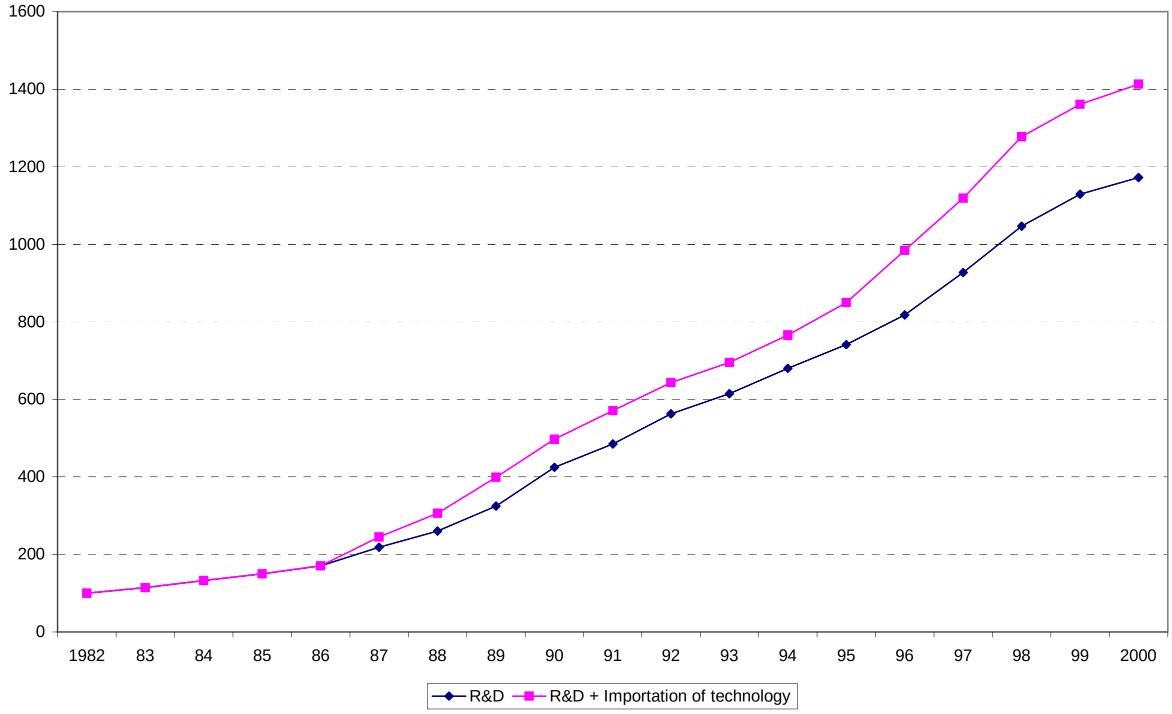
Figure 1 : evolution of innovation expenditures in Taiwan over the 1982-2000 period (1982 = 100)



Source: *Indicators of Science and Technology*, Taiwan.

Table 1: breakdown by 2-digit industries

2-digit industry		Number of firms	% of total
11	Food Manufacturing	3161	11.4
13	Textile Mill Products	1806	1.3
14	Wearing Apparel and Accessories	366	0.8
15	Leather and Fur Products	227	3.0
16	Wood and Bamboo Products	839	3.6
17	Furniture and Fixtures	994	2.8
18	Pulp, Paper and Paper Products	789	2.8
19	Printing Processing	782	2.2
21	Basic Chemical Matter Manufacturing	616	4.2
22	Chemical Products	1172	0.1
23	Petroleum and Coal Products	13	1.2
24	Rubber Products Manufacturing	335	8.5
25	Plastic Products Manufacturing	2347	5.7
26	Non-Metallic Mineral Products	1592	5.4
27	Basic Metal Industries	1493	11.9
28	Fabricated Metal Products	3313	8.4
29	Machinery and Equipment	2329	6.8
31	Electrical and Electronic Machinery	1890	6.8
32	Transportation Industry	1893	2.1
33	Precision Instruments	588	4.4
39	Miscellaneous Industrial Products	1209	1.3
	Total of manufacturing industries	*27754*	*100.0*

Table 2: summary statistics

	(11)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(21)	(22+23)	(24)	(25)	(26)	(27)	(28)	(29)	(31)	(32)	(33)	(39)
Q (sales)	110.0	175.6	72.4	224.2	31.4	39.7	133.6	25.1	548.9	119.8	92.5	71.8	105.6	216.4	48.7	54.5	404.6	177.8	62.9	44.5
	(516.9)	(732.3)	(141.1)	(469.2)	(96.0)	(100.4)	(453.2)	(86.3)	(2036.6)	(760.8)	(322.6)	(436.7)	(372.9)	(683.9)	(169.2)	(187.9)	(1846.9)	(1476.4)	(248.6)	(120.3)
Capital	68.7	151.8	23.9	80.4	18.8	21.6	132.7	22.7	499.0	81.4	70.3	37.4	96.2	115.1	28.0	24.3	158.5	76.4	25.1	20.6
	(305.9)	(764.7)	(56.4)	(154.2)	(59.9)	(70.3)	(676.6)	(100.9)	(1931.4)	(903.8)	(310.8)	(283.1)	(487.4)	(551.8)	(126.6)	(97.0)	(981.1)	(472.1)	(76.6)	(66.6)
Labour	10.6	24.8	17.6	31.1	4.5	8.5	18.6	6.6	45.2	14.6	19.2	9.8	14.6	14.9	7.4	8.3	42.4	21.0	12.1	9.2
	(43.8)	(87.2)	(36.5)	(72.0)	(11.6)	(25.6)	(62.3)	(34.7)	(164.8)	(49.5)	(66.8)	(42.5)	(36.0)	(36.8)	(20.1)	(22.4)	(153.7)	(108.4)	(39.3)	(23.6)
Material	33.0	56.7	25.1	80.9	12.7	13.7	45.7	6.9	168.4	39.3	27.1	24.4	28.0	78.8	15.4	18.6	136.0	62.4	21.3	13.8
	(186.0)	(300.5)	(64.7)	(219.2)	(46.9)	(40.2)	(201.4)	(29.0)	(807.5)	(409.0)	(124.6)	(190.2)	(106.9)	(323.8)	(69.7)	(82.2)	(939.1)	(703.2)	(125.7)	(47.9)
R&D	0.3	0.9	0.3	2.2	0.0	0.2	0.5	0.1	4.0	2.0	1.2	0.4	0.4	0.4	0.3	0.5	8.5	2.7	0.8	0.4
	(2.7)	(6.2)	(1.8)	(10.4)	(0.3)	(2.3)	(2.9)	(1.0)	(19.4)	(26.1)	(8.4)	(3.3)	(4.0)	(3.3)	(3.2)	(4.0)	(55.0)	(27.5)	(6.2)	(3.0)
TI	0.1	0.1	0.0	1.1	0.0	0.1	0.2	0.0	0.8	0.4	0.2	0.2	0.1	0.1	0.1	0.1	3.5	1.2	0.0	0.0
	(1.2)	(2.1)	(0.2)	(7.4)	(0.3)	(1.6)	(2.9)	(0.8)	(10.6)	(5.8)	(1.6)	(1.9)	(1.7)	(2.6)	(1.2)	(1.2)	(53.1)	(19.4)	(0.5)	(0.4)
Age 92	13.4	12.6	11.3	12.0	15.0	11.0	11.2	11.5	12.1	12.4	12.4	11.5	12.8	10.9	10.4	11.5	9.9	11.5	9.8	11.5
	(7.5)	(6.7)	(5.6)	(6.1)	(6.3)	(5.5)	(6.3)	(6.1)	(7.0)	(7.4)	(6.2)	(5.8)	(6.6)	(6.1)	(5.6)	(5.8)	(5.9)	(5.9)	(5.1)	(6.1)
ET	0.00	0.00	0.00	0.01	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	(0.03)	(0.02)	(0.04)	(0.11)	(0.02)	(0.02)		(0.03)	(0.06)	(0.04)	(0.06)	(0.03)	(0.04)	(0.02)	(0.03)	(0.04)	(0.09)	(0.04)	(0.04)	(0.04)
Multi-pl.	0.1	0.2	0.1	0.2	0.1	0.1	0.2	0.1	0.3	0.2	0.2	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.1
	(0.3)	(0.4)	(0.3)	(0.4)	(0.3)	(0.3)	(0.4)	(0.3)	(0.4)	(0.4)	(0.4)	(0.3)	(0.4)	(0.4)	(0.3)	(0.3)	(0.4)	(0.4)	(0.3)	(0.3)

TI: Technology Imports, ET: firm exports technology (dummy variable), Multi-pl.: Multi-plants firm (dummy variable).

Output, inputs and innovation expenditures are in thousands of constant New Taiwan Dollar.

Standard Errors in parentheses.

Note: no firm exports technology in industry 18 “Paper, Pulp and Paper Products” (ET = 0).

Table 3: fixed-effect regression by 2-digit industry

Variables	(11)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(21)	(22+23)	(24)	(25)	(26)	(27)	(28)	(29)	(31)	(32)	(33)	(39)
lnK	0.02	-0.03	-0.11	0.40	-0.14	0.03	-0.06	0.06	-0.10	0.02	-0.04	0.01	-0.06	-0.05	-0.06	-0.06	0.02	-0.06	0.16	0.06
	(0.03)	(0.04)	(0.09)	(0.12)**	(0.05)**	(0.04)	(0.05)	(0.05)	(0.07)	(0.04)	(0.07)	(0.03)	(0.04)	(0.05)	(0.03)*	(0.03)	(0.03)	(0.03)	(0.07)*	(0.05)
lnL	0.58	0.42	0.80	0.98	0.68	0.31	0.65	0.14	0.83	1.03	0.88	0.63	0.58	1.18	0.50	0.56	0.50	0.61	0.71	0.31
	(0.04)**	(0.06)**	(0.14)**	(0.15)**	(0.09)**	(0.08)**	(0.08)**	(0.09)	(0.12)**	(0.06)**	(0.14)**	(0.05)**	(0.06)**	(0.07)**	(0.05)**	(0.06)**	(0.05)**	(0.05)**	(0.11)**	(0.07)**
lnM	0.47	0.32	0.16	0.36	0.46	0.37	0.31	0.29	0.34	0.32	0.20	0.27	0.37	0.29	0.27	0.29	0.29	0.34	0.35	0.31
	(0.02)**	(0.02)**	(0.06)**	(0.06)**	(0.04)**	(0.03)**	(0.03)**	(0.03)**	(0.04)**	(0.03)**	(0.04)**	(0.02)**	(0.02)**	(0.02)**	(0.01)**	(0.02)**	(0.02)**	(0.02)**	(0.04)**	(0.03)**
$(K^2)/2$	0.03	0.02	-0.02	-0.004	0.02	0.004	0.01	0.01	0.01	0.01	0.03	0.004	0.01	0.005	0.02	0.03	0.002	0.01	0.02	-0.01
	(0.00)**	(0.01)**	(0.01)	(0.02)	(0.01)**	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)**	(0.00)	(0.00)*	(0.01)	(0.00)**	(0.00)**	(0.00)	(0.00)*	(0.01)*	(0.01)
$(L^2)/2$	0.11	0.10	0.01	0.05	0.09	0.14	0.07	0.14	0.02	0.04	0.05	0.05	0.05	-0.05	0.08	0.09	0.06	0.07	0.10	0.11
	(0.01)**	(0.01)**	(0.02)	(0.03)	(0.02)**	(0.01)**	(0.01)**	(0.02)**	(0.02)	(0.01)**	(0.02)*	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.02)**	(0.01)**
$(M^2)/2$	0.09	0.07	0.08	0.07	0.09	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.06	0.06	0.07	0.08	0.08	0.07	0.08	0.07
	(0.00)**	(0.00)**	(0.01)**	(0.01)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.01)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.01)**	(0.00)**
lnK*lnL	-0.02	-0.01	0.03	-0.02	0.005	-0.01	-0.003	-0.01	0.01	-0.01	-0.02	0.01	0.01	0.02	-0.01	-0.01	0.01	0.01	-0.03	0.005
	(0.00)**	(0.01)	(0.01)**	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)**	(0.00)	(0.01)*	(0.01)*	(0.01)	(0.01)**	(0.01)
lnK*lnM	-0.01	-0.001	0.001	-0.01	-5.E-04	0.004	0.003	-0.003	-0.004	0.002	-0.004	-0.01	-0.01	-0.02	-5.E-04	-0.004	-0.01	-0.001	-0.01	0.001
	(0.00)**	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)*	(0.00)**	(0.00)**	(0.00)	(0.00)*	(0.00)**	(0.00)	(0.01)	(0.00)
lnL*lnM	-0.10	-0.08	-0.07	-0.07	-0.12	-0.10	-0.09	-0.08	-0.08	-0.09	-0.07	-0.07	-0.07	-0.06	-0.08	-0.08	-0.07	-0.09	-0.09	-0.09
	(0.00)**	(0.00)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.01)**	(0.01)**
$KO^{1/2}$	**0.01**	**0.02**	**0.02**	**0.14**	**0.22**	**0.01**	**0.01**	**0.05**	**-0.01**	**-0.04**	**0.03**	**-0.02**	**0.03**	**0.01**	**0.01**	**0.01**	**0.03**	**-0.02**	**0.03**	**-0.02**
	(0.02)	**(0.02)**	**(0.06)**	**(0.05)****	**(0.18)**	**(0.05)**	**(0.03)**	**(0.06)**	**(0.02)**	**(0.02)**	**(0.04)**	**(0.02)**	**(0.02)**	**(0.03)**	**(0.02)**	**(0.02)**	**(0.01)****	**(0.02)**	**(0.03)**	**(0.03)**
$KP^{1/2}$	**-0.03**	**0.03**	**1.26**	**-0.14**	**-0.09**	**-0.02**	**0.004**	**-2.E-04**	**0.04**	**0.01**	**-0.09**	**0.04**	**-0.04**	**-0.03**	**0.03**	**0.04**	**0.01**	**-0.04**	**-0.12**	**0.04**
	(0.04)	**(0.04)**	**(0.99)**	**(0.05)****	**(0.28)**	**(0.05)**	**(0.04)**	**(0.05)**	**(0.02)***	**(0.02)**	**(0.18)**	**(0.02)**	**(0.06)**	**(0.05)**	**(0.04)**	**(0.06)**	**(0.01)**	**(0.02)***	**(0.09)**	**(0.13)**
$(KO.KP)^{1/2}$	**0.01**	**-0.01**	**-0.47**	**0.01**	**-0.01**	**-4.E-05**	**-0.01**	**0.03**	**-0.001**	**-2.E-04**	**0.01**	**-0.003**	**0.01**	**0.004**	**-0.01**	**-0.01**	**9.E-05**	**0.001**	**0.01**	**0.01**
	(0.01)	**(0.01)**	**(0.42)**	**(0.00)***	**(0.06)**	**(0.00)**	**(0.02)**	**(0.06)**	**(0.00)**	**(0.00)**	**(0.02)**	**(0.00)**	**(0.01)**	**(0.01)**	**(0.01)**	**(0.01)**	**(0.00)**	**(0.00)**	**(0.01)**	**(0.02)**
Constant	1.56	3.53	2.82	-1.30	2.00	3.27	2.97	4.14	2.71	0.90	1.93	2.48	2.89	0.98	3.44	2.89	2.99	2.43	1.29	3.19
	(0.19)**	(0.32)**	(0.69)**	(0.72)	(0.41)**	(0.35)**	(0.39)**	(0.38)**	(0.62)**	(0.30)**	(0.66)**	(0.23)**	(0.31)**	(0.36)**	(0.20)**	(0.26)**	(0.28)**	(0.24)**	(0.54)*	(0.31)**
R^2	0.93	0.93	0.83	0.89	0.89	0.91	0.93	0.90	0.92	0.91	0.92	0.91	0.91	0.89	0.90	0.90	0. 93	0.92	0.91	0.90
F-test	653.2**	343.7**	89.2**	82.9**	207.8**	258.6**	306.8**	130.9**	75.2**	220.4**	71.8**	524.6**	325.6**	265.4**	620.3**	461.5**	393.7**	522.5**	137.8**	269.8**

Significance: ** 1% level ; * 5% level

All models include year dummy variables

Fixed-effect u_i significantly different from zero in all industries at 1% level of significance

Table 4: GLS random-effect regression by 2-digit industry

Variables	(11)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(21)	(22+23)	(24)	(25)	(26)	(27)	(28)	(29)	(31)	(32)	(33)	(39)
lnK	-0.06	0.05	-0.02	0.15	-0.16	0.07	-0.07	0.10	-0.09	-0.12	0.01	-0.002	-0.09	-0.09	-0.08	-1.E-04	0.03	-0.01	0.09	0.07
	(0.02)**	(0.03)	(0.07)	(0.10)	(0.04)**	(0.04)	(0.04)	(0.04)*	(0.06)	(0.03)**	(0.06)	(0.03)	(0.03)**	(0.04)*	(0.02)**	(0.03)	(0.03)	(0.03)	(0.06)	(0.04)
lnL	0.40	0.56	0.44	0.85	0.59	0.38	0.47	0.30	0.77	0.81	0.83	0.47	0.60	1.03	0.44	0.52	0.60	0.63	0.55	0.30
	(0.03)**	(0.05)**	(0.11)**	(0.13)**	(0.07)**	(0.06)**	(0.06)**	(0.06)**	(0.08)**	(0.05)**	(0.10)**	(0.04)**	(0.05)**	(0.06)**	(0.04)**	(0.04)**	(0.04)**	(0.04)**	(0.08)**	(0.05)**
lnM	0.54	0.47	0.29	0.43	0.45	0.43	0.39	0.38	0.44	0.38	0.25	0.35	0.52	0.36	0.36	0.39	0.38	0.42	0.46	0.34
	(0.01)**	(0.02)**	(0.06)**	(0.06)**	(0.03)**	(0.03)**	(0.03)**	(0.03)**	(0.04)**	(0.03)**	(0.04)**	(0.02)**	(0.02)**	(0.02)**	(0.01)**	(0.02)**	(0.02)**	(0.02)**	(0.04)**	(0.03)**
$(K^2)/2$	0.02	0.03	-0.01	0.01	0.02	0.01	0.03	0.01	0.01	0.02	0.04	0.01	0.03	0.03	0.03	0.02	0.01	0.02	0.04	-0.01
	(0.00)**	(0.00)**	(0.01)	(0.02)	(0.01)**	(0.01)**	(0.01)**	(0.01)*	(0.01)	(0.01)**	(0.01)**	(0.00)*	(0.00)**	(0.01)**	(0.00)**	(0.00)**	(0.00)*	(0.00)**	(0.01)**	(0.01)
$(L^2)/2$	0.15	0.13	0.10	0.06	0.14	0.17	0.14	0.16	0.06	0.11	0.10	0.11	0.09	0.02	0.13	0.14	0.09	0.12	0.16	0.15
	(0.01)**	(0.01)**	(0.02)**	(0.02)*	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.02)**	(0.01)**	(0.02)**	(0.01)**	(0.01)**	(0.01)*	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**
$(M^2)/2$	0.11	0.10	0.10	0.10	0.13	0.10	0.11	0.11	0.10	0.10	0.10	0.11	0.09	0.11	0.10	0.11	0.11	0.10	0.11	0.11
	(0.00)**	(0.00)**	(0.01)**	(0.01)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.01)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.01)**	(0.00)**
lnK*lnL	-0.002	-0.02	0.02	0.01	0.01	-0.01	-0.01	-0.01	0.02	-0.003	-0.03	0.01	0.004	0.02	-0.01	-0.01	0.01	-0.004	-0.03	0.01
	(0.00)	(0.01)**	(0.01)	(0.02)	(0.01)	(0.01)*	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)*	(0.00)	(0.01)	(0.01)*	(0.00)	(0.00)**	(0.01)*	(0.01)	(0.01)*	(0.01)
lnK*lnM	-0.01	-0.01	-0.01	-0.02	-0.002	-0.002	-0.002	-0.01	-0.01	0.003	-0.01	-0.01	-0.02	-0.02	-0.003	-0.005	-0.02	-0.003	-0.01	0.002
	(0.00)*	(0.00)*	(0.01)	(0.01)*	(0.00)	(0.00)	(0.00)	(0.00)**	(0.01)*	(0.00)	(0.01)	(0.00)**	(0.00)**	(0.00)**	(0.00)	(0.00)*	(0.00)**	(0.00)	(0.00)*	(0.00)
lnL*lnM	-0.13	-0.11	-0.09	-0.10	-0.15	-0.12	-0.12	-0.11	-0.11	-0.12	-0.09	-0.10	-0.10	-0.09	-0.11	-0.12	-0.10	-0.11	-0.12	-0.11
	(0.00)**	(0.00)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.01)**	(0.00)**
$KO^{1/2}$	0.03	0.01	0.004	0.03	0.01	0.03	0.003	0.05	0.02	0.003	0.03	0.02	0.01	-0.004	0.01	0.02	0.01	0.01	0.03	0.02
	(0.01)**	(0.00)*	(0.01)	(0.01)*	(0.04)	(0.01)*	(0.01)	(0.02)**	(0.01)**	(0.00)	(0.01)*	(0.01)*	(0.01)	(0.01)	(0.01)*	(0.01)**	(0.00)**	(0.00)**	(0.01)**	(0.01)*
$KP^{1/2}$	0.03	0.01	0.02	-0.02	0.08	0.004	0.03	0.003	0.03	0.04	0.05	0.04	0.03	-0.01	0.01	0.03	0.01	0.01	0.03	0.02
	(0.02)	(0.01)	(0.07)	(0.03)	(0.06)	(0.03)	(0.02)	(0.03)	(0.01)*	(0.01)**	(0.03)*	(0.01)*	(0.02)	(0.03)	(0.02)	(0.02)*	(0.00)**	(0.01)*	(0.04)	(0.05)
$(KO.KP)^{1/2}$	-0.003	-0.002	0.09	9.E-05	0.01	-0.004	-0.01	-0.01	-0.002	-0.003	-0.003	-0.005	-5.E-04	0.003	-0.001	-0.003	-4.E-04	-4.E-05	-0.003	-0.002
	(0.00)	(0.00)	(0.15)	(0.00)	(0.03)	(0.00)	(0.01)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)**	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)**	(0.00)	(0.00)	(0.00)
Constant	0.60	0.76	2.27	-0.60	1.61	1.49	1.82	2.11	0.93	0.94	0.81	1.88	1.28	0.03	2.40	1.46	1.13	0.72	0.83	2.21
	(0.19)**	(0.19)**	(0.49)**	(0.57)	(0.28)**	(0.25)**	(0.27)**	(0.27)**	(0.33)**	(0.20)**	(0.40)*	(0.16)**	(0.21)**	(0.25)	(0.14)**	(0.18)**	(0.17)**	(0.17)**	(0.37)*	(0.24)**
R^2	0.94	0.94	0.91	0.92	0.90	0.92	0.95	0.91	0.94	0.94	0.93	0.92	0.93	0.91	0.91	0.91	0.94	0.94	0.92	0.91
Hausman	1814**	746**	325**	197**	812**	786**	620**	1452**	3929**	-382	209**	1611**	2531**	1913**	-5560	1291**	4546**	2707**	25437**	778**

Significance: ** 1% level ; * 5% level.

All models include the following control variables: firm age in 1992, "firm exports technology" and "multi-plant firm" dummy variables, as well as year and 4-digit industry dummy variables.

H_0: "β =0" rejected at the 1% level in all industries; random-effect u_i significantly different from zero in all industries at the 1% level of significance.

Table 5: Hausman-Taylor estimation by 2-digit industry

Variables	(11)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(21)	(22+23)	(24)	(25)	(26)	(27)	(28)	(29)	(31)	(32)	(33)	(39)
Time-varying, uncorrelated with u_i																				
lnK	0.03	0.04	-0.10	0.36	-0.14	0.05	-0.02	0.11	-0.10	0.03	-0.01	0.03	-0.03	-0.03	-0.04	-0.02	0.05	-0.03	0.17	0.08
	(0.02)	(0.04)	(0.09)	(0.11)**	(0.05)**	(0.04)	(0.04)	(0.05)*	(0.07)	(0.04)	(0.07)	(0.03)	(0.04)	(0.05)	(0.03)	(0.03)	(0.03)	(0.03)	(0.06)**	(0.05)
lnL	0.54	0.52	0.80	1.05	0.68	0.31	0.67	0.22	0.86	1.03	0.92	0.65	0.61	1.17	0.52	0.57	0.57	0.63	0.71	0.32
	(0.04)**	(0.06)**	(0.14)**	(0.13)**	(0.09)**	(0.07)**	(0.08)**	(0.08)**	(0.10)**	(0.06)**	(0.13)**	(0.05)**	(0.06)**	(0.07)**	(0.04)**	(0.05)**	(0.05)**	(0.05)**	(0.10)**	(0.06)**
lnM	0.50	0.36	0.17	0.38	0.46	0.38	0.33	0.32	0.35	0.33	0.21	0.28	0.39	0.30	0.28	0.32	0.30	0.35	0.35	0.32
	(0.01)**	(0.02)**	(0.05)**	(0.06)**	(0.03)**	(0.03)**	(0.02)**	(0.03)**	(0.03)**	(0.03)**	(0.04)**	(0.02)**	(0.02)**	(0.02)**	(0.01)**	(0.02)**	(0.02)**	(0.02)**	(0.04)**	(0.03)**
$(K^2)/2$	0.02	0.01	-0.02	-0.003	0.02	0.004	0.01	0.01	0.01	0.01	0.03	0.003	0.01	0.01	0.02	0.03	-0.001	0.01	0.02	-0.01
	(0.00)**	(0.01)*	(0.01)	(0.02)	(0.01)**	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)**	(0.00)	(0.00)**	(0.01)	(0.00)**	(0.00)**	(0.00)	(0.00)*	(0.01)*	(0.01)
$(L^2)/2$	0.12	0.10	0.01	0.04	0.10	0.14	0.08	0.14	0.02	0.04	0.05	0.06	0.06	-0.04	0.09	0.10	0.06	0.08	0.10	0.12
	(0.01)**	(0.01)**	(0.02)	(0.02)	(0.02)**	(0.01)**	(0.01)**	(0.01)**	(0.02)	(0.01)**	(0.02)*	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**
$(M^2)/2$	0.09	0.07	0.08	0.08	0.09	0.07	0.08	0.09	0.07	0.07	0.08	0.08	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.08
	(0.00)**	(0.00)**	(0.01)**	(0.01)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.01)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.01)**	(0.00)**
lnK*lnL	-0.01	-0.01	0.03	-0.01	0.01	-0.01	-0.01	-0.02	0.01	-0.01	-0.02	0.01	0.01	0.02	-0.01	-0.01	0.01	0.004	-0.03	0.005
	(0.00)**	(0.01)	(0.01)**	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)**	(0.00)*	(0.01)**	(0.01)*	(0.01)	(0.01)**	(0.01)
lnK*lnM	-0.01	-0.001	0.001	-0.02	-2.E-04	0.003	0.002	-0.005	-0.004	0.002	-0.005	-0.01	-0.01	-0.02	-0.001	-0.01	-0.01	-0.002	-0.01	2.E-05
	(0.00)**	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)**	(0.00)**	(0.00)**	(0.00)	(0.00)*	(0.00)**	(0.00)	(0.00)	(0.00)
lnL*lnM	-0.11	-0.09	-0.07	-0.08	-0.12	-0.10	-0.09	-0.09	-0.08	-0.09	-0.07	-0.08	-0.07	-0.06	-0.08	-0.09	-0.08	-0.09	-0.09	-0.09
	(0.00)**	(0.00)**	(0.01)**	(0.01)**	(0.01)**	(0.00)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.01)**	(0.00)**
Time-varying, correlated with u_i																				
$KO^{½}$	0.07	0.02	0.02	0.12	0.27	0.05	0.01	0.06	0.02	-0.04	0.04	-0.03	0.04	0.01	0.01	0.02	0.01	-0.002	0.04	-0.001
	(0.02)**	(0.02)	(0.06)	(0.04)**	(0.17)	(0.05)	(0.03)	(0.05)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.03)	(0.03)
$KP^{½}$	-0.02	0.05	1.48	-0.12	-0.13	-0.04	0.01	-0.04	0.04	0.01	-0.17	0.04	-0.05	-0.04	0.04	0.05	-0.005	-0.04	-0.13	0.06
	(0.04)	(0.04)	(0.82)	(0.04)**	(0.26)	(0.04)	(0.03)	(0.05)	(0.02)*	(0.02)	(0.15)	(0.02)	(0.06)	(0.04)	(0.03)	(0.05)	(0.01)	(0.02)*	(0.09)	(0.12)
$(KO.KP)^{½}$	0.01	-0.01	-0.55	0.01	-0.01	0.001	-0.01	0.02	-0.001	-2.E-04	0.01	-0.003	0.01	0.004	-0.01	-0.01	2.E-04	0.001	0.01	0.01
	(0.01)	(0.01)	(0.35)	(0.00)*	(0.06)	(0.00)	(0.01)	(0.06)	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.02)
Constant term																				
β_0	0.53	2.06	2.27	-1.71	1.56	2.47	2.13	3.19	1.77	0.46	1.28	1.85	2.25	0.58	2.88	2.30	2.08	1.70	0.86	2.63
	(0.52)	(0.30)**	(0.72)**	(0.67)*	(0.43)**	(0.35)**	(0.55)	(0.35)**	(0.59)**	(0.33)	(0.63)*	(0.24)**	(0.39)**	(0.40)	(0.21)**	(0.28)**	(0.28)**	(0.24)**	(0.57)	(0.33)**

Significance: ** 1% level ; * 5% level.

Models also include: "exporting technology" dummy variable (time-varying, correlated with u_i), year dummy variables (time-varying, uncorrelated with u_i); firm age in 1992 and 4-digit industry dummy variables (time-invariant, uncorrelated with u_i); "multi-plants" dummy variable (time-invariant, correlated with u_i). H_0: "β =0" rejected at the 1% level in all industries.

Table 6: stochastic frontier estimation by 2-digit industry

Variables	**(11)**	**(13)**	**(14)**	**(15)**	**(16)**	**(17)**	**(18)**	**(19)**	**(21)**	**(22+23)**	**(24)**	**(25)**	**(26)**	**(27)**	**(28)**	**(29)**	**(31)**	**(32)**	**(33)**	**(39)**
lnK	-0.08	0.04	-0.03	0.17	-0.17	0.07	-0.07	0.09	-0.10	-0.11	0.001	-0.004	-0.09	-0.11	-0.08	-0.01	0.03	-0.02	0.09	0.06
	(0.02)**	(0.03)	(0.07)	(0.10)	(0.04)**	(0.04)	(0.04)	(0.04)	(0.05)	(0.03)**	(0.06)	(0.03)	(0.03)**	(0.04)**	(0.02)**	(0.03)	(0.03)	(0.03)	(0.06)	(0.04)
lnL	0.42	0.56	0.45	0.86	0.58	0.36	0.47	0.29	0.82	0.82	0.83	0.47	0.59	1.03	0.43	0.52	0.59	0.62	0.54	0.29
	(0.03)**	(0.05)**	(0.11)**	(0.12)**	(0.07)**	(0.06)**	(0.06)**	(0.07)**	(0.08)**	(0.05)**	(0.10)**	(0.04)**	(0.05)**	(0.06)**	(0.04)**	(0.04)**	(0.04)**	(0.04)**	(0.08)**	(0.05)**
lnM	0.56	0.45	0.28	0.42	0.45	0.43	0.39	0.38	0.46	0.38	0.25	0.35	0.50	0.36	0.35	0.38	0.37	0.41	0.45	0.34
	(0.01)**	(0.02)**	(0.06)**	(0.06)**	(0.03)**	(0.03)**	(0.02)**	(0.03)**	(0.03)**	(0.03)**	(0.04)**	(0.02)**	(0.02)**	(0.02)**	(0.01)**	(0.02)**	(0.02)**	(0.02)**	(0.04)**	(0.03)**
$(K^2)/2$	0.03	0.03	-0.01	0.01	0.02	0.01	0.03	0.01	0.03	0.02	0.04	0.01	0.03	0.03	0.03	0.02	0.01	0.02	0.04	-0.01
	(0.00)**	(0.00)**	(0.01)	(0.02)	(0.01)**	(0.01)**	(0.01)**	(0.01)*	(0.01)*	(0.01)**	(0.01)**	(0.00)*	(0.00)**	(0.01)**	(0.00)**	(0.00)**	(0.00)*	(0.00)**	(0.01)**	(0.01)
$(L^2)/2$	0.16	0.13	0.09	0.06	0.14	0.17	0.14	0.16	0.07	0.10	0.10	0.11	0.09	0.02	0.13	0.14	0.09	0.11	0.16	0.15
	(0.01)**	(0.01)**	(0.02)**	(0.02)*	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.02)**	(0.01)**	(0.02)**	(0.01)**	(0.01)**	(0.01)	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**
$(M^2)/2$	0.12	0.09	0.10	0.10	0.13	0.10	0.10	0.11	0.11	0.10	0.10	0.10	0.08	0.10	0.10	0.11	0.11	0.10	0.11	0.10
	(0.00)**	(0.00)**	(0.01)**	(0.01)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.01)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.01)**	(0.00)**
lnK*lnL	-0.001	-0.02	0.02	0.01	0.01	-0.01	-0.01	-0.01	0.01	-0.004	-0.03	0.01	0.004	0.02	-0.01	-0.01	0.01	-0.004	-0.03	0.01
	(0.00)	(0.01)**	(0.01)	(0.02)	(0.01)	(0.01)*	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)*	(0.00)	(0.01)	(0.01)*	(0.00)	(0.00)**	(0.00)*	(0.01)	(0.01)**	(0.01)
lnK*lnM	-0.01	-0.004	-0.01	-0.02	-0.001	-0.001	-0.001	-0.01	-0.01	0.003	-0.01	-0.01	-0.02	-0.02	-0.003	-0.005	-0.01	-0.002	-0.01	0.002
	(0.00)**	(0.00)	(0.01)	(0.01)*	(0.00)	(0.00)	(0.00)	(0.00)*	(0.00)**	(0.00)	(0.01)	(0.00)**	(0.00)**	(0.00)**	(0.00)	(0.00)*	(0.00)**	(0.00)	(0.00)*	(0.00)
lnL*lnM	-0.14	-0.11	-0.09	-0.09	-0.15	-0.12	-0.11	-0.11	-0.11	-0.12	-0.09	-0.10	-0.09	-0.09	-0.10	-0.11	-0.10	-0.11	-0.12	-0.11
	(0.00)**	(0.00)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.01)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.00)**	(0.01)**	(0.00)**
KO$^{1/2}$	**0.03**	**0.01**	**0.01**	**0.03**	**0.02**	**0.03**	**0.01**	**0.05**	**0.01**	**0.005**	**0.03**	**0.02**	**0.01**	**0.002**	**0.02**	**0.02**	**0.01**	**0.02**	**0.03**	**0.02**
	(0.01)**	**(0.01)****	**(0.02)**	**(0.01)***	**(0.05)**	**(0.01)***	**(0.01)**	**(0.02)****	**(0.01)****	**(0.00)**	**(0.01)***	**(0.01)***	**(0.01)**	**(0.01)**	**(0.01)****	**(0.01)****	**(0.00)****	**(0.00)****	**(0.01)****	**(0.01)***
KP$^{1/2}$	**0.01**	**0.01**	**0.03**	**-0.03**	**0.08**	**0.001**	**0.03**	**0.002**	**0.03**	**0.04**	**0.05**	**0.04**	**0.03**	**-0.01**	**0.01**	**0.04**	**0.01**	**0.02**	**0.03**	**0.03**
	(0.02)	**(0.01)**	**(0.07)**	**(0.03)**	**(0.06)**	**(0.03)**	**(0.02)**	**(0.03)**	**(0.01)***	**(0.01)****	**(0.03)**	**(0.02)****	**(0.02)***	**(0.03)**	**(0.02)**	**(0.02)***	**(0.00)****	**(0.01)***	**(0.04)**	**(0.05)**
(KO.KP)$^{1/2}$	**-0.002**	**-0.002**	**0.09**	**3.E-04**	**0.01**	**-0.004**	**-0.01**	**-0.01**	**-0.003**	**-0.003**	**-0.004**	**-0.005**	**-0.001**	**0.003**	**-0.001**	**-0.003**	**-4.E-04**	**-1.E-04**	**-0.003**	**-0.003**
	(0.00)	(0.00)	(0.14)	(0.00)	(0.03)	(0.00)	(0.01)	(0.03)	(0.00)*	(0.00)	(0.00)	(0.00)**	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)**	(0.00)	(0.00)	(0.00)
Constant	0.89	2.72	3.95	1.37	3.41	2.77	3.52	3.28	0.81	2.88	2.18	3.84	2.96	2.35	4.40	3.19	2.80	3.07	2.13	3.78
	(0.19)**	(4.72)	(7.34)	(10.85)	(5.53)	(0.46)**	(5.15)	(0.66)**	(0.29)**	(11.00)	(5.80)	(13.57)	(5.67)	(8.58)	(8.29)	(11.90)	(5.96)	(13.45)	(3.18)	(4.71)
μ	-68.41	1.78	1.55	2.01	1.74	1.07	1.62	1.10	-78.86	1.94	1.30	1.87	1.54	2.11	1.84	1.66	1.58	2.21	1.25	1.47
	(117.75)	(4.72)	(7.32)	(10.83)	(5.52)	(0.38)**	(5.14)	(0.61)	(120.85)	(10.99)	(5.78)	(13.57)	(5.66)	(8.58)	(8.28)	(11.90)	(5.96)	(13.45)	(3.16)	(4.71)
σ_v^2	17.07	0.09	0.09	0.12	0.08	0.09	0.07	0.08	22.41	0.09	0.07	0.08	0.07	0.14	0.08	0.07	0.09	0.09	0.07	0.09
σ_w^2	0.23	0.15	0.15	0.16	0.16	0.13	0.10	0.12	0.20	0.16	0.12	0.14	0.14	0.21	0.14	0.15	0.16	0.12	0.13	0.17
ln L	-8063	-4061	-836	-584	-1993	-2050	-1357	-1476	-1642	-2973	-602	-5122	-3362	-4313	-7084	-5217	-4553	-3803	-1193	-2918

Significance: ** 1% level ; * 5% level. H_0: "β=0" rejected at the 1% level in all industries.

All models include the following control variables: firm age in 1992, "firm exports technology" and "multi-plant firm" dummy variables, as well as year and 4-digit industry dummy variables.

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