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Using the Asymptotically Ideal Model to estimate the impact of knowledge on labour productivity: An application to Taiwan in the 1990s

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Abstract:

This paper examines the impact of embodied and disembodied knowledge on labour productivity in Taiwan's manufacturing industry, using the Asymptotically Ideal Model. The model is estimated on a panel of 27,754 firms observed from 1992 to 1995, using three estimations procedures: fixed-effect regression, random-effect GLS, and Hausman-Taylor estimation. Our findings show that, in traditional industries, labour productivity is mostly driven by embodied knowledge, whereas in high-tech industries, labour productivity depends on both embodied and disembodied knowledge. The latter result may be the consequence of the Industrial Upgrading Statute implemented in Taiwan after 1991.

JEL classification: C51, J24, L60, O38

Keywords: Asymptotically Ideal Model; Disembodied Knowledge; Embodied Knowledge; Labour Productivity; Newly Industrialized Countries.

While the measurement of labour productivity is of general interest for economists, studying its determinants has a special significance in newly-industrialized economies (NIE). Indeed, compared to older industrialized countries, NIE are generally experiencing a transition from the production of labour-intensive goods to the production of more knowledge-intensive goods. This was, in particular, the case of Taiwan in the 1990s: as its economy was increasingly challenged by neighbouring Asian economies with lower labour costs, Taiwan answered by upgrading its manufacturing industry.

In the present research, we analyse the effect of this technological upgrading on labour productivity, using a production function approach – which raises the problem of selecting a functional form. We try to answer this problem by specifying our production function as the Almost Ideal Model (AIM), which tends to satisfy regularity conditions globally, while retaining a certain amount of flexibility. Our empirical model is estimated on a sample of 27,754 manufacturing firms, distributed across twenty 2-digit industries.

The paper is organized as follows: Section 1 states the objectives of our research. Section 2 describes our data. We specify our analytical framework and econometric model in Section 3, and present the estimation results in Section 4. Conclusions are given in a final section.

1. Objectives of the research

There has been a number of studies devoted to the impact of knowledge on labour productivity at the firm level, the majority of which focus on knowledge *inputs* (such as R&D expenditures)[1]. Several seminal papers (e.g., Cuneo and Mairesse, 1984; Griliches and Mairesse, 1984; Hall and Mairesse, 1995) use the stock of R&D capital as a proxy for knowledge, and estimate its impact on labour productivity. More recent studies have shown a concern for the distinction between embodied and disembodied knowledge. For instance, Greenan, Mairesse and Topiol-Bensaïd (1999) and Wacker *et al.* (2006) study the impact of knowledge embodied in non-production personnel (e.g., engineers, product designers, computer technicians, R&D personnel) on labour productivity, whereas Gera *et al.* (1999) and Goodrum and Haas (2004) focus on knowledge embodied in equipment (especially information technology-related goods).

In the present study, we focus on two measures of knowledge inputs: non-wage R&D expenditures, and imports of disembodied technology (i.e., licenses, patents, and other royalties-inducing technologies). The former is used as a proxy of knowledge embodied in equipment (R&D capital stock), and the latter is used as a

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[1] Due to data limitations, there are but few studies dedicated to the impact of knowledge output (such as patents or new products, for instance) on labour productivity. One possible exception is the research conducted by Huiban and Bouhsina (1997), who find labour productivity to be significantly affected by the type of innovation (radical / incremental, product / process) implemented in a firm.

measure of disembodied knowledge. We want to examine the impact of those two variables on labour productivity in Taiwan. Indeed, there is some empirical evidence that, in NIE 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; Odagiri, 1983; Basant and Fikkert, 1996).

Our period of analysis is the early 1990s, a period immediately following the implementation of the Industrial Upgrading Statute (hereafter IUS[2]) in 1991 (Hou and Gee, 1993; Luo, 2001). The IUS consists in a number of incentive measures aimed at encouraging investment and technology transfers, especially in emerging and/or strategic industries (i.e., industries that are expected to benefit economic development in a substantial way). Both R&D expenditures and (disembodied) technology imports grew from 1991 onwards, as can be seen in Figure 1, which depicts the evolution of R&D expenditures and technology imports in Taiwan's manufacturing industry between 1991 and 2000 (base 100 for 1991). Two periods clearly appear on this figure: from 1992 to 1995, R&D expenditures grow faster than technology imports; from 1996 to 2000, technology imports grow faster than R&D expenditures. Figure 2 depicts the evolution of the composition of R&D expenditures in Taiwan over roughly

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

the same period (1991-2001): It can be seen that the relative importance of R&D capital decreased after 1993, as the wages component of R&D increased.

FIGURE 1 ABOUT HERE

FIGURE 2 ABOUT HERE

FIGURE 3 ABOUT HERE

Over the same period, labour productivity (in base 100 for 2001) grew steadily in the manufacturing industry, as can been seen in Figure 3. To determine whether this growth in labour productivity may be related to the evolution of our measures of embodied and disembodied knowledge, we use a production function approach. As always, this raises the problem of selecting a functional form: One faces a trade-off between, on the one hand, forms that satisfy regularity conditions globally but are not very flexible, such as Cobb-Douglas and CES, and, on the other hand, flexible forms that are regular only locally, such as Translog or Leontiev (see Guilkey *et al.*, 1983). We try to solve this dilemma by specifying our production function as the Asymptotically Ideal Model (AIM), a flexible form which tends to satisfy regularity conditions globally (see for instance Barnett *et al.*, 1991; Havenner and Saha, 1999).

To our knowledge, there have been very few empirical applications using the AIM (exceptions include: Koop and Carey, 1994; Fleissig and Swofford, 1996). The objective of our research is therefore twofold: First, estimate the AIM over real data (a

4-year panel of Taiwanese firms) and second, get some substantive results regarding the impact of (embodied and disembodied) knowledge on labour productivity.

2. 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 holding a registered certificate in the manufacturing sector. In Taiwan, most manufacturing firms are single-plant producers (that is the case of 87% of the firms in our database). 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.[3]

As was said in the previous section, we 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. This period is also interesting because, as was shown in Figure 1 (Section 1), innovation in the manufacturing industry during that period seemed to be driven more by R&D than by technology imports. Therefore, if our

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

knowledge proxies have any effect on labour productivity, we may expect the effect of R&D to be stronger than the effect of technology imports.

Over the 1992-1995 period, we observe a panel of 27,754 Taiwanese manufacturing firms, distributed across twenty-one 2-digit industries. Table 1 gives a breakdown of these 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 number of employees. These variables will be used as proxies for firm output, capital input, materials input, and labour input respectively[4].

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 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

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

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. Econometric modelling

3.1. Measuring embodied and disembodied knowledge

For this research, we assume that knowledge K consist in two components: embodied knowledge KE and disembodied knowledge KD:

(1) $K = K(KE, KD)$.

We use the stock of non-wage R&D as a proxy for KE, and the stock of disembodied technology imports as a proxy for KD. Our first problem with this approach is that wages paid to R&D personnel represent a significant proportion of our ‘R&D expenditures’ variable. In other words, taken “as is”, R&D expenditures measure knowledge embodied not only in technical equipment, but also in personnel. Double counting problems with the labour input may therefore arise, which can lead to spurious correlation between our measures of embodied knowledge and labour productivity. We try to solve this problem by taking the share of R&D wages out of R&D expenditures; we call the resulting variable ‘non-wage R&D’. Unfortunately, information on the share of R&D wages is available at the industry level only, which means that our measure is a poor proxy of actual non-wage R&D expenditures at the firm-level. The share of R&D wages in total R&D expenditures is presented at the 2-digit level in Table 1 for an average year.

KE and *KD* are then measured using the perpetual inventory method (Griliches, 1979; Hall and Mairesse, 1995); i.e., if δ denote the depreciation rate of knowledge, we have :

(2.a) $KE_t = (1 - \delta)KE_{t-1} + RD_{t-1}$,

(2.b) $KD_t = (1 - \delta)KD_{t-1} + TI_{t-1}$,

where *RD* is the value of non-wage R&D expenditures and *TI* is the value of disembodied 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 the history of innovation in Taiwan prior to 1991 is way too short. Therefore, initial values KE_1 and KD_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:

(3) $KE_1 = RD_1 / (g + \delta)$ and $KD_1 = TI_1 / (g + \delta)$

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

Following the literature (for instance, 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.

3.2. Specification of the model

Our analysis derives from a production function approach, linking firm output Q to various inputs including knowledge K:

(4) $Q = F(C, L, M, K(KE, KD)) = F(C, L, M, KE, KD)$,

where C denotes capital, L labour, M materials, and where F is specified as the AIM. Developing F using a Müntz–Szatz series expansion of order 1 yields:

$$\begin{aligned}(5)\quad Q_{it} = {} & \beta_1.C_{it} + \beta_2.L_{it} + \beta_3.M_{it} + \beta_4.KE_{it} + \beta_5.KD_{it} \\ & + \beta_6.(CL)_{it}^{1/2} + \beta_7.(CM)_{it}^{1/2} + \beta_8.(C.KE)_{it}^{1/2} + \beta_9.(C.KD)^{1/2}{}_{it} \\ & + \beta_{10}.(LM)_{it}^{1/2} + \beta_{11}.(L.KE)_{it}^{1/2} + \beta_{12}.(L.KD)_{it}^{1/2} \\ & + \beta_{13}.(M.KE)_{it}^{1/2} + \beta_{14}.(M.KD)_{it}^{1/2} + \beta_{15}.(KE \times KD)_{it}^{1/2}\end{aligned}$$

We derive the expression of labour productivity from Equation (5), which, after rearranging some of the terms, can be expressed as:

$$(6)\qquad \frac{Q_{it}}{L_{it}} = \beta_2 + \beta_1 \cdot \frac{C_{it}}{L_{it}} + \beta_3 \cdot \frac{M_{it}}{L_{it}} + \beta_{.6} \cdot \left(\frac{C}{L}\right)_{it}^{1/2} + \beta_{.10} \cdot \left(\frac{M}{L}\right)_{it}^{1/2} + \beta_7 \cdot \left(\frac{C}{L}\right)_{it}^{1/2} \left(\frac{M}{L}\right)_{it}^{1/2}$$
$$+\beta_8 \cdot \left(\frac{C}{L}\right)_{it}^{1/2} \left(\frac{KE}{L}\right)_{it}^{1/2} + \beta_9 \cdot \left(\frac{C}{L}\right)_{it}^{1/2} \left(\frac{KD}{L}\right)_{it}^{1/2} + \beta_{13} \cdot \left(\frac{M}{L}\right)_{it}^{1/2} \left(\frac{KE}{L}\right)_{it}^{1/2} + \beta_{14} \cdot \left(\frac{M}{L}\right)_{it}^{1/2} \left(\frac{KD}{L}\right)_{it}^{1/2}$$
$$+\beta_4 \frac{KE_{it}}{L_{it}} + \beta_5 \frac{KD_{it}}{L_{it}} + \beta_{11} \cdot \left(\frac{KE}{L}\right)_{it}^{1/2} + \beta_{12} \cdot \left(\frac{KD}{L}\right)_{it}^{1/2} + \beta_{15} \left(\frac{KE}{L}\right)_{it}^{1/2} \left(\frac{KD}{L}\right)_{it}^{1/2}$$

For any variable *X*, let *x* denote *X*/*L*; we can rewrite:

$$(7)\qquad q_{it} = \beta_2 + \beta_1.c_{it} + \beta_3.m_{\mathrm{it}} + \beta_6.(c_{\mathrm{it}})^{½} + \beta_{10}.(m_{it})^{½} + \beta_7.(cm_{\mathrm{it}})^{½}$$
$$+ \beta_8.(cke_{\mathrm{it}})^{½} + \beta_9.(ckd_{\mathrm{it}})^{½} + \beta_{13}.(mke_{\mathrm{it}})^{½} + \beta_{14}.(mkd_{\mathrm{it}})^{½}$$
$$+ \beta_4.ke_{it} + \beta_5.kd_{it} + \beta_{11}.(ke_{it})^{½} + \beta_{12}.(kd_{it})^{½} + \beta_{15}.(kekd_{it})^{½}$$

Adding a random error term $\varepsilon_{it} = u_i + \lambda_t + \omega_{it}$ (where u_i is an individual-specific effect, λ_t a time-specific effect depicted by a set of year dummy variables, and ω_{it} a transitory error term) turns Equation (7) into our econometric model:

$$(8)\qquad q_{it} = \beta_2 + \beta_1.c_{it} + \beta_3.m_{\mathrm{it}} + \beta_6.(c_{\mathrm{it}})^{½} + \beta_{10}.(m_{it})^{½} + \beta_7.(cm_{\mathrm{it}})^{½}$$
$$+ \beta_8.(cke_{\mathrm{it}})^{½} + \beta_9.(ckd_{\mathrm{it}})^{½} + \beta_{13}.(mke_{\mathrm{it}})^{½} + \beta_{14}.(mkd_{\mathrm{it}})^{½}$$
$$+ \beta_4.ke_{it} + \beta_5.kd_{it} + \beta_{11}.(ke_{it})^{½} + \beta_{12}.(kd_{it})^{½} + \beta_{15}.(kekd_{it})^{½} + u_i + \lambda_t + \omega_{it}.$$

3.3. Estimation procedure

Equation (8) describes the econometric model to be estimated in each 2-digit industry. To estimate this equation, we used three different procedures: First, we specified u_i as a fixed effect. Second, we specified u_i as a random effect, estimated Equation (8) by GLS, and conducted a Hausman specification test for each 2-digit industry. Finally, 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. We tested two alternative specifications of the Hausman-Taylor model: in the first specification, we assume that only *ke*, *kd* and their square roots and interaction term are correlated with u_i. In the second specification, we extend that assumption to the interactions between *ke*, *kd* on the one hand and *c, m* on the other.

Finally, more control variables were added to the econometric model when using the random effect and Hausman-Taylor specifications: 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, our interpretation of results is focused on our main explanatory variables, i.e. knowledge inputs and their interactions. We first consider the results of the fixed- and random- effects estimations given in Table 3 and Table 4 respectively. Overall, we observe that our knowledge proxy variables tend to be more significant, and in a larger number of industries, if we adopt the random-effect specification. However, the Hausman tests conducted in each 2-digit industry are globally in favour of the fixed effect model; in what follows, we will therefore focus on the results of this specification[5].

TABLE 3 ABOUT HERE

TABLE 4 ABOUT HERE

With the fixed-effect specification, our proxies for embodied / disembodied knowledge (ke, kd, $ke^{½}$, $kd^{½}$, and $(ke \times kd)^{½}$) are significant in eleven industries out of twenty. On the basis of these results, two groups of industries can be distinguished: traditional or older industries on the one hand, and high-tech or more recent industries on the other. The effect of our knowledge proxy variables is rather straightforward in the former group, whereas it tends to be more complex in the latter. Let us now consider each of these groups in details.

First, in industries (11) 'Food', (22+23) 'Chemical, Petroleum and Oil Products', and (28) 'Fabricated Metal', labour productivity increases with embodied knowledge (measured either by ke or $ke^{½}$). In industry (25) 'Plastics', labour productivity increases with embodied knowledge up to a certain level, after which it decreases (ke has a significantly negative effect, whereas the effect of $ke^{½}$ is

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[5] In industries (15), (21), (22+23), (26), (32) and (39), the Hausman test statistic is negative, which does not allow us to choose between the random- and fixed- effects specifications. However, since the fixed-effect model is preferred in all other industries, we base our comments and interpretations on the results of this model.

significantly positive). In industry (17) ‘Furniture and Fixtures’, labour productivity increases with both embodied ($ke^{½}$) and disembodied (kd) knowledge. Finally, we find some evidence of complementarity between embodied and disembodied knowledge (i.e., a significantly positive effect of $ke^{½}\times kd^{½}$) in industries (16) ‘Wood and Bamboo’, (22+23) ‘Chemical, Petroleum and Oil Products’, and (27) ‘Basic Metal’. Overall, in those “traditional” industries, we find that labour productivity is mostly driven by embodied knowledge (i.e., R&D capital), which is consistent with the trend depicted in Figure 1, Section 1.

Now, for the second group: In industry (31) ‘Electronics’, labour productivity significantly *decreases* with embodied knowledge, but increases with disembodied knowledge. In industry (32) ‘Transportation Equipment’, labour productivity decreases (at a decreasing rate) with respect to embodied knowledge (both ke and $ke^{½}$ have a significantly negative effect). It increases with disembodied knowledge up to a certain level, after which it decreases (the effect of kd is negative, but the effect of $kd^{½}$ is positive). Finally, in industry (33) ‘Precision Instruments’, we observe an inverted-U shaped relationship between labour productivity and embodied knowledge (the effect of ke is negative, and the effect of $ke^{½}$ is positive), and a U shaped relationship between labour productivity and disembodied knowledge (the effect of kd is positive, but the effect of $kd^{½}$ is negative). In a nutshell, we observe that labour productivity gains in these “high-tech” industries depend much more on disembodied knowledge than they do in more traditional industries. This may have been caused by the I.U.S. policies mentioned in Section 1: Indeed, the I.U.S. encouraged knowledge transfers (esp. disembodied knowledge transfers) in targeted “strategic” industries.

4.2. Hausman-Taylor models

Given that Hausman tests favoured the fixed-effect over the random-effect specification, but was rather inconclusive in a few industries (cf. footnote 5), it is interesting to examine the results of the Hausman-Taylor models. Table 5 presents the results of the first specification described in Section 3.3. (i.e., the specification in which ke, kd, $ke^{½}$, $kd^{½}$, and $(ke \times kd)^{½}$ are assumed to be correlated with u_i). Table 6 presents the results of the second specification (in which $(c \times ke)^{½}$, $(c \times kd)^{½}$ $(m \times ke)^{½}$, and $(m \times kd)^{½}$ are *also* assumed to be correlated with u_i).

TABLE 5 ABOUT HERE

TABLE 6 ABOUT HERE

Overall, these two specifications give very similar results, and these results are quite consistent with those of the fixed-effect model (which suggests that our assumption of a correlation between our knowledge proxies and unobserved firm characteristics makes some sense). The most noticeable departure from the results of the fixed-effect models is that, with the Hausman-Taylor specifications, we observe a significant effect of our knowledge proxies on labour productivity in a larger number of industries. Those industries, such as (14) ‘Wearing and Apparel’, (19) ‘Printing’ and (24) ‘Rubber Products’, all fall in the “traditional” or “older” category. By contrast, the results in the “high-tech” group of industries (‘Electronics’, ‘Transportation’, and ‘Precision Instruments’) are left virtually unchanged. Another noticeable difference is that, with the Hausman-Taylor models, the effect of embodied knowledge on labour productivity in “traditional” industries is even more significant.

5. Conclusion

The objective of this research was to evaluate the impact of embodied/disembodied knowledge on labour productivity using the Asymptotically Ideal Model (AIM). The empirical analysis was conducted on a panel of 27,754 Taiwanese manufacturing firms, distributed across twenty 2-digit industries, and observed from 1992 to 1995. Our proxy variables for embodied and disembodied knowledge were non-wage R&D expenditures and disembodied technology imports respectively. The AIM was estimated in each 2-digit industry using fixed-effect, GLS random-effect, and Hausman-Taylor estimations. The fixed-effect and Hausman-Taylor models appeared as the most reliable specifications.

Our findings show a significant effect of knowledge on labour productivity in about half of the twenty 2-digit industries. In most of those industries, which are either “traditional” or “older” industries, labour productivity is primarily driven by embodied knowledge, i.e. R&D capital. This is consistent with the trend observed over the period in Taiwan’s manufacturing industry. However, in the smaller group of “high-tech” industries, labour productivity is affected by both embodied and disembodied knowledge. The latter is a source of labour productivity gains, whereas the former may cause labour productivity to decrease. This may be a consequence of the Industrial Upgrading Statute (IUS), a bundle of policies implemented in 1991 in “strategic” industries, and giving firms in those industries incentives to invest in disembodied knowledge.

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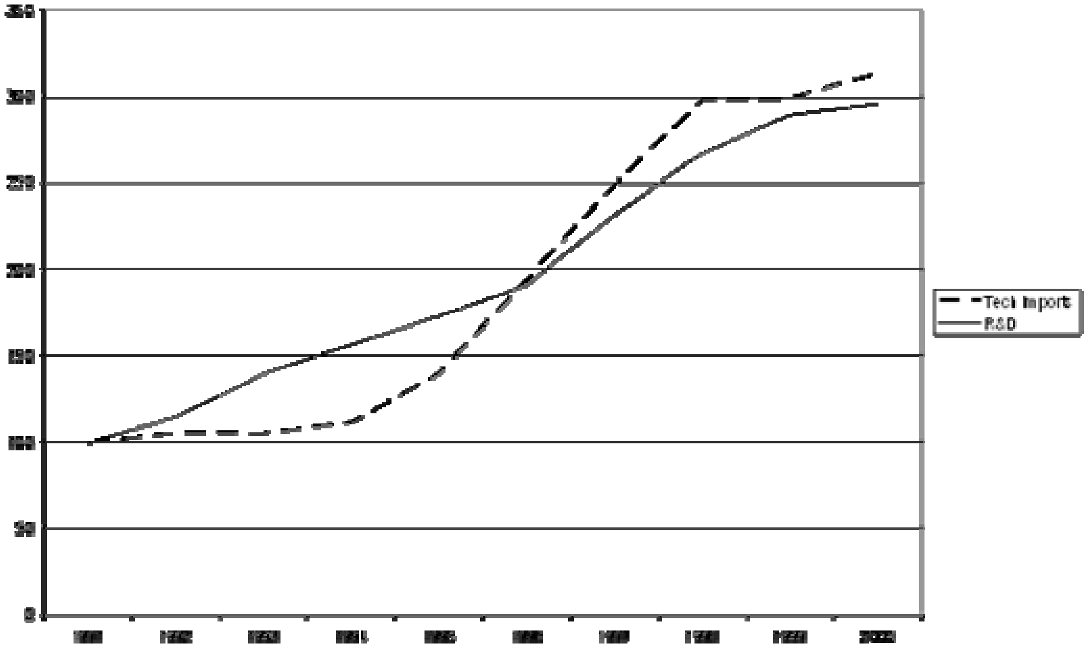
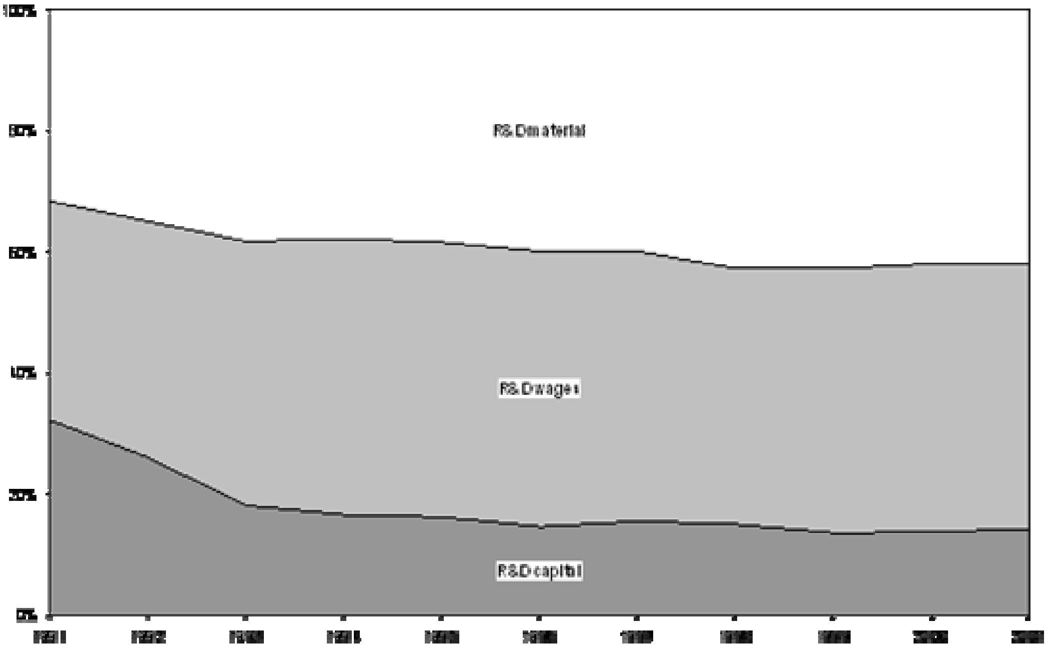
Figure 1: R&D expenditures and technology imports in Taiwan's manufacturing industry, 1991-2000 (1991 = 100)



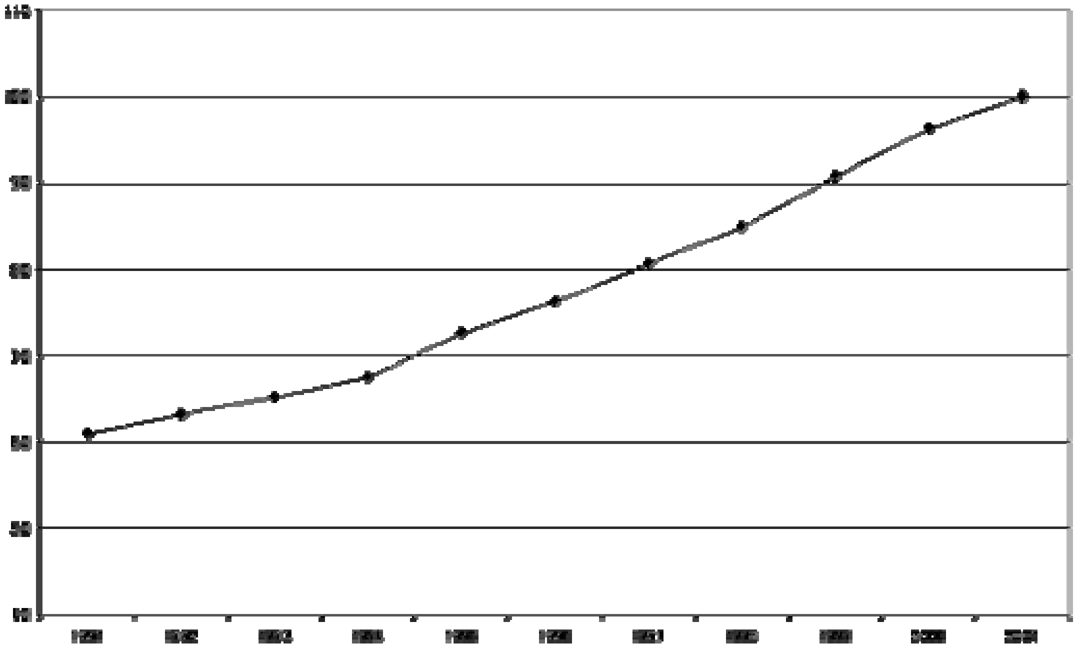
<u>Source:</u> Ministry of Economic Affairs (1997, 2001), *Industrial Statistical Survey Report*, Taiwan (based on our own calculations).

Figure 2: Composition of R&D expenditures in Taiwan, 1991-2001 (in %)



<u>Source:</u> National Science Council (1997, 2003) *Indicators of Science and Technology R.O.C.* (based on our own calculations).

Figure 3: Labour productivity in Taiwan's manufacturing industry, 1991-2001 (2001 = 100)



Source: authors' own calculation, data from Taiwan's Directorate General of Business Accounting and Statistics (*http://eng.dgbas.gov.tw*).

Table 1: breakdown and share of R&D wages in R&D expenditures by 2-digit industries

2-digit industry		Breakdown by industry # of firms	%	Wages in total R&D (average 1992-1995)
11	Food Manufacturing	3161	11.4	53.1 %
13	Textile Mill Products	1806	1.3	47.3 %
14	Wearing Apparel and Accessories	366	0.8	78.9 %
15	Leather and Fur Products	227	3.0	57.2 %
16	Wood and Bamboo Products	839	3.6	70.0 %
17	Furniture and Fixtures	994	2.8	48.4 %
18	Pulp, Paper and Paper Products	789	2.8	57.4 %
19	Printing Processing	782	2.2	84.0 %
21	Basic Chemical Matter Manufacturing	616	4.2	53.9 %
22	Chemical Products	1172	0.1	55.5 %
23	Petroleum and Coal Products	13	1.2	
24	Rubber Products Manufacturing	335	8.5	51.2 %
25	Plastic Products Manufacturing	2347	5.7	52.0 %
26	Non-Metallic Mineral Products	1592	5.4	48.3 %
27	Basic Metal Industries	1493	11.9	57.0 %
28	Fabricated Metal Products	3313	8.4	53.0 %
29	Machinery and Equipment	2329	6.8	43.9 %
31	Electrical and Electronic Machinery	1890	6.8	41.4 %
32	Transportation Equipment	1893	2.1	49.8 %
33	Precision Instruments	588	4.4	51.1 %
39	Miscellaneous Industrial Products	1209	1.3	52.0 %
	Manufacturing industry	*27754*	*100.0*	*45.3 %*

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 : AIM, fixed-effect estimates

	(11)	**(13)**	**(14)**	**(15)**	**(16)**	**(17)**	**(18)**	**(19)**	**(21)**	**(22+23)**	**(24)**	**(25)**	**(26)**	**(27)**	**(28)**	**(29)**	**(31)**	**(32)**	**(33)**	**(39)**
c	-0.02	0.01	-0.15	-0.14	-0.03	-0.04	0.89	-0.04	0.40	-0.08	0.10	-0.07	0.30	-0.01	-0.11	0.15	-0.09	0.17	-0.09	-0.06
	(0.00)**	(0.02)	(0.05)	(0.08)	(0.01)*	(0.02)	(0.08)**	(0.02)	(0.04)**	(0.03)**	(0.05)*	(0.01)**	(0.03)**	(0.03)	(0.02)**	(0.02)**	(0.02)**	(0.02)**	(0.04)*	(0.01)**
m	0.81	1.41	1.28	1.13	0.84	0.85	1.51	1.07	0.81	0.36	0.23	0.75	1.15	0.68	0.87	1.23	1.52	0.71	1.29	0.69
	(0.03)**	(0.03)**	(0.07)	(0.09)**	(0.04)**	(0.05)**	(0.15)**	(0.07)**	(0.06)**	(0.06)**	(0.08)**	(0.04)**	(0.05)**	(0.04)**	(0.03)**	(0.02)**	(0.03)**	(0.02)**	(0.09)**	(0.04)**
$c^{1/2}$	23.0	12.8	8.8	48.2	20.5	10.8	-49.1	9.7	-3.0	20.3	-6.6	25.8	-8.7	38.8	20.5	-1.9	24.7	-12.0	21.9	9.0
	(2.1)**	(2.3)**	(4.4)	(11.7)**	(3.2)**	(2.4)**	(11.2)**	(2.4)**	(8.2)	(4.0)**	(5.3)	(1.7)**	(4.4)*	(5.8)**	(1.9)**	(2.1)	(2.7)**	(2.4)**	(4.2)**	(1.9)**
$m^{1/2}$	-8.8	-52.2	-38.9	-35.4	-17.8	-13.4	-25.8	-19.6	-14.3	17.3	-2.0	-3.7	-35.3	-21.7	-24.0	-30.9	-68.1	-30.8	-12.0	-14.4
	(4.2)*	(2.9)**	(5.1)	(8.4)**	(4.7)**	(3.2)**	(10.7)*	(3.8)**	(8.1)	(4.9)**	(5.3)	(2.7)	(5.5)**	(6.0)**	(2.6)**	(2.5)**	(3.0)**	(2.3)**	(5.9)*	(3.0)**
$cm^{1/2}$	0.01	0.11	0.52	-0.33	0.04	0.26	-1.13	0.31	-0.27	0.10	0.86	0.00	-0.19	0.02	0.43	0.28	0.15	0.49	-0.22	0.47
	(0.04)	(0.03)**	(0.10)	(0.16)*	(0.06)	(0.05)**	(0.15)**	(0.05)**	(0.07)**	(0.07)	(0.09)**	(0.04)	(0.06)**	(0.06)	(0.04)**	(0.05)**	(0.04)**	(0.05)**	(0.12)*	(0.04)**
$(c \times ke)^{1/2}$	0.003	-0.06	4.39	-0.26	7.37	0.58	-1.85	-0.46	-0.92	0.06	0.31	0.17	-0.55	0.38	-0.65	1.15	0.47	1.88	0.06	-0.25
	(0.36)	(0.23)	(0.63)	(1.32)	(4.17)	(0.19)**	(1.55)	(0.55)	(0.43)*	(0.20)	(0.62)	(0.21)	(0.47)	(0.64)	(0.23)**	(0.20)**	(0.10)**	(0.15)**	(0.41)	(0.25)
$(c \times kd)^{1/2}$	-0.17	-1.22	-0.10	0.28	13.53	-1.18	-2.27	0.06	-0.18	1.14	-1.21	-0.47	1.39	0.93	0.38	-0.57	-0.09	0.98	1.49	2.91
	(0.90)	(0.72)	(2.26)	(2.22)	(4.22)**	(0.30)**	(2.02)	(0.30)	(0.76)	(0.41)**	(0.52)*	(0.40)	(1.62)	(1.75)	(0.73)	(0.26)*	(0.22)	(0.25)**	(1.10)	(2.34)
$(m \times ke)^{1/2}$	-1.63	-1.03	2.93	0.28	-2.99	-0.84	-2.28	-1.83	-0.53	-0.73	-2.32	-0.84	0.08	0.03	0.00	-0.89	0.77	1.20	-1.08	-0.93
	(0.41)**	(0.23)**	(0.41)	(0.77)	(4.21)	(0.29)**	(1.50)	(0.55)**	(0.31)	(0.22)**	(0.29)**	(0.26)**	(0.45)	(0.51)	(0.17)	(0.17)**	(0.09)**	(0.10)**	(0.31)**	(0.21)**
$(m \times kd)^{1/2}$	0.85	-1.26	-1.24	0.72	-12.28	0.43	-1.25	-0.02	-0.40	-1.13	1.85	-0.96	-0.76	-1.33	-1.51	-0.81	-2.18	-1.18	-2.07	-1.28
	(0.73)	(0.73)	(4.92)	(1.59)	(4.88)*	(0.65)	(1.98)	(0.60)	(0.35)	(0.24)**	(0.60)**	(0.35)**	(1.11)	(0.80)	(0.46)**	(0.33)*	(0.15)**	(0.15)**	(0.97)*	(0.67)*
ke	1.07	0.70	-1.60	-1.77	-3.60	-0.01	7.46	0.79	1.18	0.21	0.48	-3.14	0.05	-0.78	0.63	0.11	-0.71	-0.86	-0.71	-0.15
	(1.54)	(0.80)	(0.26)	(2.58)	(7.22)	(0.70)	(7.82)	(1.84)	(1.01)	(0.43)	(1.76)	(0.62)**	(1.05)	(0.77)	(0.30)*	(0.12)	(0.15)**	(0.14)**	(0.22)**	(0.50)
kd	1.88	-0.08	-5.33	1.45	-16.87	1.19	-1.25	-0.20	0.04	0.16	0.24	1.26	1.34	3.40	0.43	1.30	-0.28	-3.19	10.68	-7.22
	(3.10)	(1.31)	(4.71)	(3.90)	(7.57)	(0.62)*	(15.82)	(0.28)	(1.19)	(0.66)	(1.66)	(1.40)	(5.16)	(7.42)	(0.86)	(1.10)	(0.38)	(0.66)**	(4.67)*	(4.92)
$ke^{1/2}$	106	21	-100	132	-175	64	51	60	62	43	81	166	68	76	30	-23	-2.3	-62	54	66
	(53)*	(25)	(29)	(112)	(281)	(28)*	(158)	(36)	(57)	(17)*	(39)	(27)**	(48)	(72)	(17)	(15)	(13)	(12)**	(22)*	(16)**
$kd^{1/2}$	18	82	392	-128	-244	-41	114	13	59	-62	-39	-11	-124	-264	-2.8	40	74	61	-299	29
	(109)	(66)	(370)	(126)	(267)	(29)	(399)	(22)	(68)	(41)	(66)	(30)	(157)	(195)	(52)	(41)	(25)**	(21)**	(106)**	(84)
$(ke \times kd)^{1/2}$	-1.56	-1.22	-84.60	0.50	34.74	-0.79	-0.83	1.16	2.46	5.76	-0.15	1.04	-5.37	15.41	-0.27	-0.55	0.50	1.38	16.15	2.88
	(4.82)	(3.08)	(72.72)	(4.99)	(9.14)**	(1.05)	(24.67)	(1.91)	(4.88)	(1.05)**	(3.63)	(1.21)	(9.47)	(7.36)*	(0.95)	(1.23)	(0.33)	(0.60)**	(4.23)**	(3.29)
Constant	562	1361	793	948	734	591	2426	465	2156	309	728	307	1608	1701	678	1032	1558	1483	382	648
	(127)**	(81)**	(100)	(349)**	(134)**	(66)**	(338)**	(73)**	(382)**	(128)*	(132)**	(58)**	(151)**	(249)**	(61)**	(71)**	(98)**	(66)**	(119)**	(59)**
R^2	0.61	0.56	0.57	0.59	0.53	0.43	0.48	0.51	0.58	0.39	0.53	0.43	0.46	0.52	0.44	0.56	0.71	0.75	0.45	0.42

Significance: ** 1% level ; * 5% level. The null hypothesis H_0: "$\beta = 0$" was rejected in every industry at the 1% level of significance (F-test). Fixed-effect u_i is significantly different from 0 in all industries at 1% level of significance. The null hypothesis H_0: "$\beta_{11} = \beta_{13} = \ldots = \beta_{33} = \beta_{39}$" was rejected at the 1% level of significant (Chow-like test).

All models include year dummy variables.

Table 4: AIM, random-effect estimates

	(11)	**(13)**	**(14)**	**(15)**	**(16)**	**(17)**	**(18)**	**(19)**	**(21)**	**(22+23)**	**(24)**	**(25)**	**(26)**	**(27)**	**(28)**	**(29)**	**(31)**	**(32)**	**(33)**	**(39)**
c	-0.03	-0.04	-0.13	-0.18	-0.03	0.00	1.02	-0.06	0.41	-0.08	0.07	-0.08	0.29	-0.09	-0.08	0.09	-0.11	0.24	-0.09	-0.04
	(0.00)**	(0.01)**	(0.05)**	(0.09)*	(0.01)*	(0.02)	(0.03)**	(0.02)**	(0.04)**	(0.03)*	(0.05)	(0.01)**	(0.03)**	(0.03)**	(0.01)**	(0.01)**	(0.01)**	(0.02)**	(0.03)**	(0.01)**
m	1.32	1.45	1.26	1.23	1.00	1.16	1.73	1.33	1.24	0.74	0.27	1.02	1.94	0.96	1.06	1.25	1.57	0.98	1.46	1.14
	(0.02)**	(0.03)**	(0.07)**	(0.09)**	(0.04)**	(0.05)**	(0.11)**	(0.06)**	(0.07)**	(0.07)**	(0.08)**	(0.04)**	(0.05)**	(0.04)**	(0.03)**	(0.02)**	(0.03)**	(0.03)**	(0.08)**	(0.04)**
$c^{1/2}$	22.5	19.1	5.21	48.2	22.7	9.25	-46.3	11.6	3.67	22.5	-2.66	27.0	4.07	57.9	19.37	2.84	28.3	-15.7	23.4	8.26
	(1.66)**	(1.73)**	(3.78)	(10.9)**	(2.90)**	(2.09)**	(5.99)**	(2.01)**	(6.91)	(3.73)**	(4.61)	(1.41)**	(3.18)	(5.16)**	(1.59)**	(1.64)	(2.07)**	(2.30)**	(3.43)**	(1.64)**
$m^{1/2}$	6.14	-11.5	-17.4	-30.5	9.85	-7.41	17.2	-12.7	33.8	23.2	14.8	9.44	-35.7	28.9	-0.34	-5.16	-28.4	-15.4	2.20	-8.84
	(3.44)	(2.63)**	(4.49)**	(8.8)**	(4.13)*	(2.97)*	(7.76)*	(3.54)**	(8.50)**	(5.10)**	(5.00)**	(2.46)**	(5.21)**	(5.76)**	(2.33)	(2.13)	(2.52)**	(2.34)**	(5.04)	(2.90)**
$cm^{1/2}$	-0.02	-0.03	0.55	0.06	-0.16	0.07	-1.39	0.21	-0.57	0.10	0.79	-0.15	-0.62	-0.03	0.25	0.11	0.06	0.33	-0.35	0.20
	(0.03)	(0.03)	(0.10)**	(0.17)	(0.06)**	(0.05)	(0.11)**	(0.05)**	(0.08)**	(0.07)	(0.09)**	(0.03)**	(0.06)**	(0.06)	(0.04)**	(0.05)*	(0.04)	(0.05)**	(0.10)**	(0.04)**
$(c\times ke)^{1/2}$	1.02	0.03	3.65	0.38	9.18	0.80	-1.61	0.04	-0.20	0.75	0.62	0.41	-0.72	0.81	0.51	0.91	0.44	1.67	-0.03	-0.24
	(0.29)**	(0.18)	(0.58)**	(1.29)	(3.48)**	(0.19)**	(0.94)	(0.40)	(0.33)	(0.17)**	(0.51)	(0.16)*	(0.36)*	(0.55)	(0.17)**	(0.15)**	(0.08)**	(0.14)**	(0.31)	(0.22)
$(c\times kd)^{1/2}$	0.87	0.61	-0.93	-1.51	9.10	-1.09	-2.86	-0.03	-0.50	1.10	-1.44	0.54	2.03	0.62	0.97	-0.50	-0.12	0.80	-0.50	1.78
	(0.66)	(0.41)	(2.17)	(2.33)	(3.65)*	(0.30)**	(1.67)	(0.27)	(0.58)	(0.37)**	(0.47)**	(0.35)	(0.88)*	(1.10)	(0.60)	(0.22)*	(0.19)	(0.21)**	(0.90)	(1.40)
$(m\times ke)^{1/2}$	-0.55	-1.33	2.72	-0.36	-8.14	-0.74	-2.66	-1.97	-0.79	-0.56	-1.90	-0.79	-0.39	0.43	-0.20	-0.89	0.10	0.68	-1.18	-0.56
	(0.38)	(0.24)**	(0.40)**	(0.91)	(3.56)*	(0.29)*	(1.30)*	(0.52)**	(0.36)*	(0.24)*	(0.28)**	(0.24)**	(0.45)	(0.53)	(0.16)	(0.16)**	(0.09)	(0.11)**	(0.28)**	(0.21)**
$(m\times kd)^{1/2}$	0.03	-0.58	2.78	1.50	-3.18	-0.13	0.17	0.07	-0.44	-0.63	1.67	-1.34	-0.64	-1.87	-1.40	-0.78	-1.59	-1.42	-1.73	-3.31
	(0.68)	(0.66)	(2.45)	(1.82)	(3.45)	(0.65)	(1.52)	(0.50)	(0.43)	(0.27)*	(0.59)**	(0.34)**	(1.14)	(0.86)*	(0.46)	(0.31)*	(0.14)**	(0.17)**	(0.78)*	(0.58)**
ke	-3.11	-0.52	-1.56	-0.01	-4.42	-1.10	1.23	-2.34	-1.56	-1.32	5.18	-2.06	-0.09	0.35	0.14	-0.28	-0.31	-0.71	-0.62	-0.87
	(0.86)**	(0.44)	(0.22)**	(1.83)	(5.28)	(0.44)*	(3.52)	(1.33)	(0.73)*	(0.32)**	(0.81)**	(0.39)**	(0.64)	(0.61)	(0.20)	(0.08)**	(0.09)**	(0.13)**	(0.16)**	(0.36)*
kd	-2.96	-0.40	-0.73	4.35	-5.47	0.07	-9.43	-0.09	-0.60	-0.11	-1.76	-0.29	-2.12	1.44	-1.09	-2.03	-0.30	-1.77	4.62	10.9
	(2.05)	(0.64)	(2.45)	(3.97)	(6.32)	(0.60)	(6.51)	(0.21)	(0.88)	(0.59)	(1.13)	(0.75)	(2.60)	(3.15)	(0.58)	(0.60)**	(0.18)	(0.39)**	(3.47)	(3.39)**
$ke^{1/2}$	89.0	65.3	-64.2	29.3	-46.5	31.2	164.4	107.9	148.3	40.0	-26.2	78.3	51.0	-53.2	1.19	17.8	13.5	-29.7	45.2	58.3
	(23.9)**	(13.2)**	(15.0)**	(61.1)	(140.8)	(11.4)**	(71.6)*	(24.3)**	(31.7)**	(9.4)**	(18.3)	(12.6)**	(22.7)*	(38.7)	(7.81)	(7.7)*	(5.5)*	(5.8)**	(11.6)**	(8.6)**
$kd^{1/2}$	34.8	19.2	-11.7	-20.1	-160.5	19.1	493.4	0.2	153.6	50.3	69.6	80.7	-27.4	-54.6	39.9	119.1	113.2	101.4	-105.4	28.1
	(59.2)	(39.9)	(60.9)	(107)	(174)	(22.0)	(188)**	(12.9)	(46)**	(22)*	(23)**	(23)**	(64)	(105)	(32.3)	(22)**	(12)**	(13)**	(59)	(56)**
$(ke\times kd)^{1/2}$	2.70	-2.33	-6.64	-2.89	13.4	0.33	-23.7	0.45	1.11	-0.42	-0.37	-1.43	-0.86	11.9	0.01	-0.02	-0.42	-0.22	14.3	-1.98
	(2.6)	(2.6)	(50)	(4.0)	(4.6)**	(0.8)	(9.6)*	(1.8)	(2.6)	(0.8)	(2.5)	(0.7)*	(3.3)	(4.9)*	(0.6)	(0.7)	(0.2)**	(0.4)	(2.4)**	(2.3)**
Constant	-1590	78.7	403	886	-264	322	273	200	-946	-178	246	-5.5	1321	-511	241	212	160	957	197	148
	(734)**	(86.7)	(101)**	(411)*	(172)	(69)**	(812)	(72)**	(403)*	(157)	(180)	(72)	(345)**	(420)	(71)**	(126)	(101)	(110)**	(124)*	(105)
R^2	0.63	0.63	0.68	0.62	0.60	0.51	0.54	0.53	0.66	0.50	0.69	0.49	0.55	0.58	0.48	0.61	0.77	0.80	0.48	0.53
Hausman	272.8**	235.4**	181.7**	-47.0	212.2**	1493**	76.7**	984.1**	-636.9	-49.4	138.7**	3068**	-213.4	1087**	1759**	796.4**	2586**	-3194	415.1**	-152.5

Significance: ** 1% level ; * 5% level. Null hypothesis H_0: "$\beta=0$" rejected at the 1% level in all industries; random-effect u_i significantly different from zero in all industries at the 1% level.

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

Table 5: AIM, Hausman-Taylor estimates (specification 1)

	(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																				
c	-0.02	0.00	-0.13	-0.15	-0.03	0.00	1.04	-0.03	0.41	-0.06	0.09	-0.07	0.34	-0.01	-0.08	0.14	-0.08	0.19	-0.08	-0.06
	(0.00)**	(0.01)	(0.05)**	(0.08)	(0.01)	(0.02)	(0.05)**	(0.02)	(0.04)**	(0.03)	(0.05)*	(0.01)**	(0.03)**	(0.03)	(0.02)**	(0.02)**	(0.02)**	(0.02)**	(0.03)*	(0.01)**
m	1.02	1.43	1.28	1.15	0.85	1.02	1.81	1.14	0.87	0.40	0.25	0.86	1.31	0.73	0.92	1.24	1.53	0.76	1.39	0.82
	(0.02)**	(0.03)**	(0.07)**	(0.08)**	(0.04)**	(0.05)**	(0.14)**	(0.07)**	(0.06)**	(0.07)**	(0.07)**	(0.04)**	(0.05)**	(0.04)**	(0.03)**	(0.02)**	(0.03)**	(0.02)**	(0.08)**	(0.04)**
$c^{\frac{1}{2}}$	21.10	11.45	5.71	49.31	20.65	7.97	-68.63	7.40	-11.53	16.66	-5.17	23.94	-17.57	36.92	16.71	-2.48	21.58	-15.65	21.79	8.52
	(1.94)**	(2.13)**	(4.07)	(10.63)**	(2.89)**	(2.26)**	(8.26)**	(2.34)**	(7.85)	(4.17)**	(4.57)	(1.65)**	(4.51)**	(5.63)**	(1.87)**	(2.00)	(2.67)**	(2.36)**	(3.75)**	(1.69)**
$m^{\frac{1}{2}}$	-10.15	-42.92	-30.30	-33.09	-15.74	-9.69	-19.04	-15.17	-7.38	15.87	-0.32	-2.65	-35.52	-15.90	-19.05	-22.80	-63.87	-28.82	-8.75	-12.35
	(3.83)**	(2.80)**	(4.85)**	(7.93)**	(4.17)**	(3.05)**	(10.16)	(3.85)**	(7.94)	(5.20)**	(4.65)	(2.75)	(5.85)**	(5.77)**	(2.52)**	(2.43)**	(3.00)**	(2.31)**	(5.44)	(2.77)**
$cm^{\frac{1}{2}}$	0.02	0.07	0.54	-0.22	0.03	0.14	-1.43	0.25	-0.32	0.11	0.85	-0.06	-0.30	0.00	0.36	0.19	0.12	0.45	-0.30	0.39
	(0.03)	(0.03)**	(0.10)**	(0.15)	(0.06)	(0.05)**	(0.14)**	(0.06)**	(0.07)**	(0.07)	(0.08)**	(0.04)	(0.06)**	(0.06)	(0.04)**	(0.05)**	(0.04)**	(0.05)**	(0.11)**	(0.04)**
$(c\times ke)^{\frac{1}{2}}$	0.01	-0.27	4.19	-0.43	9.77	0.64	-3.16	-0.87	-0.90	0.03	0.56	0.24	-0.65	0.70	-0.48	0.95	0.51	1.99	-0.06	-0.32
	(0.34)	(0.22)	(0.62)**	(1.26)	(3.52)**	(0.19)**	(1.42)*	(0.52)	(0.41)*	(0.22)	(0.54)	(0.21)	(0.51)	(0.63)	(0.22)*	(0.19)**	(0.10)**	(0.15)**	(0.37)	(0.23)
$(c\times kd)^{\frac{1}{2}}$	0.28	-0.25	-0.67	0.07	10.85	-1.04	-1.56	-0.03	0.15	0.85	-1.47	-0.34	0.99	0.77	0.15	-0.61	-0.18	0.70	0.69	1.69
	(0.86)	(0.60)	(2.29)	(2.13)	(3.58)**	(0.31)**	(2.16)	(0.31)	(0.73)	(0.43)*	(0.45)**	(0.40)	(1.61)	(1.57)	(0.74)	(0.26)*	(0.23)	(0.24)**	(0.98)	(1.89)
$(m\times ke)^{\frac{1}{2}}$	-1.97	-1.13	2.87	0.06	-4.47	-0.87	-2.37	-1.87	-0.65	-0.76	-2.00	-0.97	0.09	0.08	-0.16	-0.83	0.70	1.07	-1.20	-0.89
	(0.39)**	(0.23)**	(0.42)**	(0.76)	(3.66)	(0.29)**	(1.59)	(0.57)**	(0.31)*	(0.24)**	(0.24)**	(0.26)**	(0.48)	(0.50)	(0.17)	(0.17)**	(0.09)**	(0.10)**	(0.29)**	(0.19)**
$(m\times kd)^{\frac{1}{2}}$	0.69	-1.21	4.70	1.00	-8.81	0.24	-0.91	0.57	-0.36	-1.12	1.92	-1.05	-0.67	-1.56	-1.43	-0.83	-2.10	-1.15	-1.60	-1.68
	(0.70)	(0.71)	(2.59)	(1.55)	(4.00)*	(0.67)	(1.92)	(0.55)	(0.35)	(0.26)**	(0.53)**	(0.36)**	(1.18)	(0.77)*	(0.46)**	(0.34)*	(0.15)**	(0.15)**	(0.89)	(0.58)**
Time-varying, correlated with u_i																				
ke	-0.50	1.29	-1.46	0.12	-3.77	0.42	10.63	0.68	0.83	0.49	4.85	-2.10	1.44	0.48	0.91	0.14	-0.45	-0.82	-0.66	-0.31
	(1.49)	(0.78)	(0.25)**	(2.20)	(5.92	(0.61)	(8.17)	(1.96)	(0.98)	(0.46)	(1.14)**	(0.60)**	(1.09)	(0.71)	(0.29)**	(0.11)	(0.14)**	(0.14)**	(0.18)**	(0.47)
kd	1.26	-1.21	-1.77	2.85	-13.21	0.68	-4.90	-0.02	-1.27	-0.63	-0.80	-0.26	3.35	5.88	-0.61	-0.21	0.06	-3.02	8.39	-3.28
	(2.94)	(1.09)	(3.03)	(3.56)	(6.55)*	(0.63)	(14.66)	(0.25)	(1.11)	(0.68)	(1.44)	(1.21)	(5.52)	(7.04)	(0.83)	(0.99)	(0.39)	(0.58)**	(4.38)	(4.45)
$ke^{\frac{1}{2}}$	133.78	12.56	-107.12	38.25	-253.72	3.53	-99.19	66.16	78.24	-4.96	-4.88	88.39	-12.98	-68.21	-5.06	-30.20	-35.02	-86.33	48.21	62.10
	(45)**	(22)	(23)**	(75)	(204)	(17)	(140)	(35)*	(51)	(16)	(28)	(19)**	(41)	(64)	(14)	(13)*	(11)**	(10)**	(16)**	(13)**
$kd^{\frac{1}{2}}$	-66	97	-66	-61	-104	4	253	-38	148	19	19	46	-172	-260	57	53	89	61	-271	132
	(93)	(66)	(77)	(107)	(201)	(25)	(346)	(18)*	(60)*	(37)	(38)	(29)	(119)	(189)	(50)	(37)	(23)**	(18)**	(99)**	(71)
$(ke\times kd)^{\frac{1}{2}}$	-1.41	-2.51	-3.39	-2.25	25.58	-0.95	9.41	0.30	1.85	6.19	-0.79	0.30	-6.37	14.69	-0.35	0.22	0.04	1.51	19.99	0.24
	(4.30)	(3.04)	(52.74)	(4.40)	(6.84)**	(1.04)	(23.38)	(2.01)	(4.77)	(1.13)**	(3.12)	(1.05)	(9.13)	(6.79)*	(0.95)	(1.26)	(0.32)	(0.55)**	(3.88)**	(3.09)
Constant term																				
	-508	661	492	1317	-151	224	2075	189	97	-559	677	-146	-154	1341	231	706	669	1215	368	335
	(1396)	(146)**	(133)**	(489)**	(531)	(98)*	(1212)	(93)*	(681)	(302)	(393)	(128)	(771)	(950)	(123)	(212)**	(218)**	(209)**	(184)*	(166)*

Significance: ** 1% level ; * 5% level. H_0: "$\beta=0$" rejected at the 1% level in all industries. Models also include: "exporting technology" dummy (time-varying, correlated w/ u_i), year dummies (time-varying, uncorrelated w/ u_i); firm age in 1992 and 4-digit industry dummies (time-invariant, uncorrelated w/ u_i); "multi-plants" dummy (time-invariant, correlated w/ u_i).

Table 6: AIM, Hausman-Taylor estimates (specification 2)

	(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																				
C	-0.02	0.00	-0.15	-0.13	-0.03	-0.01	1.03	-0.03	0.42	-0.07	0.09	-0.06	0.33	0.00	-0.09	0.15	-0.08	0.19	-0.08	-0.05
	(0.00)**	(0.01)	(0.04)**	(0.08)	(0.01)*	(0.02)	(0.05)**	(0.02	(0.04)**	(0.03)*	(0.05)*	(0.01)**	(0.03)**	(0.03)	(0.02)**	(0.02)**	(0.02)**	(0.02)**	(0.03)*	(0.01)**
M	0.97	1.43	1.28	1.14	0.84	0.95	1.76	1.11	0.86	0.40	0.25	0.82	1.30	0.72	0.91	1.24	1.53	0.74	1.37	0.78
	(0.02)**	(0.03)**	(0.06)**	(0.08)**	(0.04)**	(0.05)**	(0.14)**	(0.07)**	(0.06)**	(0.06)**	(0.07)**	(0.04)**	(0.05)**	(0.04)**	(0.03)**	(0.02)**	(0.03)**	(0.02)**	(0.08)**	(0.04)**
$c^{1/2}$	20.15	10.77	8.48	46.55	20.54	8.50	-68.10	7.51	-14.21	17.71	-5.42	23.87	-16.82	36.20	17.37	-3.33	21.08	-15.27	21.17	7.91
	(1.96)**	(2.17)**	(3.88)*	(10.87)**	(2.93)**	(2.23)**	(8.47)**	(2.31)**	(8.21)	(4.03)**	(4.61)	(1.64)**	(4.59)**	(5.55)**	(1.85)**	(2.01)	(2.65)**	(2.35)**	(3.76)**	(1.75)**
$m^{1/2}$	-12.53	-45.01	-37.82	-35.09	-17.06	-12.40	-19.90	-16.83	-10.30	15.69	0.44	-3.76	-35.87	-18.09	-20.54	-26.18	-65.94	-28.70	-9.99	-13.57
	(3.89)**	(2.84)**	(4.54)**	(7.81)**	(4.23)**	(3.00)**	(10.08)*	(3.74)**	(8.24)	(5.01)**	(4.71)	(2.71)	(5.93)**	(5.68)**	(2.47)**	(2.39)**	(2.96)**	(2.30)**	(5.40)	(2.83)**
$cm^{1/2}$	0.02	0.08	0.52	-0.29	0.03	0.19	-1.37	0.27	-0.30	0.09	0.84	-0.04	-0.29	0.00	0.38	0.21	0.13	0.44	-0.29	0.41
	(0.03)	(0.03)**	(0.09)**	(0.15)*	(0.06)	(0.05)**	(0.14)**	(0.05)**	(0.07)**	(0.07)	(0.08)**	(0.04)	(0.07)**	(0.06)	(0.04)**	(0.05)**	(0.04)**	(0.05)**	(0.10)**	(0.04)**
Time-varying, correlated with u_i																				
$(c \times ke)^{1/2}$	0.13	-0.09	4.38	-0.36	7.28	0.58	-2.72	-0.68	-0.86	0.05	0.70	0.18	-0.79	0.56	-0.65	1.10	0.48	1.87	0.07	-0.30
	(0.35)	(0.23)	(0.56)**	(1.26)	(3.82)*	(0.19)**	(1.59)	(0.56)	(0.45)	(0.21)	(0.56)	(0.22)	(0.52)	(0.62)	(0.22)**	(0.20)**	(0.10)**	(0.15)**	(0.39)	(0.24)
$(c \times kd)^{1/2}$	-0.34	-1.58	0.01	0.35	13.64	-1.18	-1.66	0.02	-0.63	1.17	-1.59	-0.55	3.34	0.39	0.42	-0.57	-0.10	0.92	1.45	1.46
	(0.86)	(0.72)*	(2.04)	(2.10)	(3.86)**	(0.29)**	(2.09)	(0.31)	(0.78)	(0.42)**	(0.46)**	(0.40)	(1.80)	(1.68)	(0.72)	(0.26)*	(0.22)	(0.25)**	(1.03)	(2.25)
$(m \times ke)^{1/2}$	-1.96	-1.16	2.91	0.20	-2.92	-0.89	-2.29	-1.76	-0.58	-0.75	-1.96	-0.90	0.20	0.05	-0.02	-0.92	0.76	1.19	-1.17	-0.95
	(0.39)**	(0.23)**	(0.37)**	(0.73)	(3.85)	(0.28)**	(1.56)	(0.56)**	(0.32)	(0.23)**	(0.25)**	(0.26)**	(0.50)	(0.49)	(0.17)	(0.17)**	(0.09)**	(0.10)**	(0.29)**	(0.20)**
$(m \times kd)^{1/2}$	0.67	-1.35	-2.49	0.89	-12.55	0.44	-1.14	0.25	-0.45	-1.15	2.04	-1.01	-1.50	-1.38	-1.56**	-0.82	-2.18	-1.19	-2.10	-1.45
	(0.70)	(0.74)	(4.33)	(1.50)	(4.47)**	(0.64)	(2.05)	(0.61)	(0.36)	(0.25)**	(0.54)**	(0.36)**	(1.24)	(0.77)	(0.45)	(0.33)*	(0.15)**	(0.15)**	(0.91)*	(0.64)*
Ke	-0.53	0.82	-1.60	-1.14	-3.46	-0.52	10.34	0.53	0.94	0.28	5.60	-2.72	0.84	-0.39	0.59	0.05	-0.69	-0.86	-0.82	-0.65
	(1.47)	(0.80)	(0.24)**	(2.41)	(6.61)	(0.67)	(8.09)	(1.88)	(1.03)	(0.44)	(1.28)**	(0.63)**	(1.17)	(0.74)	(0.30)*	(0.12)	(0.15)**	(0.14)**	(0.21)**	(0.48)
Kd	0.79	0.66	-6.37	1.74	-17.04	1.16	3.68	-0.13	0.37	0.06	-1.27	2.21	-0.32	4.63	0.35	0.83	-0.22	-3.77	10.56	-3.87
	(2.99)	(1.31)	(4.17)	(3.67)	(6.92)*	(0.61)*	(16.34)	(0.28)	(1.24)	(0.68)	(1.48)	(1.43)	(5.74)	(7.17)	(0.85)	(1.10)	(0.38)	(0.60)**	(4.36)*	(4.73)
$ke^{1/2}$	202	33	-98	109	-178	90	-31	84	83	33	-15	152	33	33	33	-15	-0.52	-60	66	94
	(50)**	(25)	(26)**	(104)	(257)	(26)**	(163)	(36)*	(57)	(18)	(30)	(28)**	(53)	(69)	(16)*	(16)	(13)	(12)**	(20)**	(16)**
$kd^{1/2}$	90	70	500	-111	-251	-48	-39	-9	39	-59	-4	8	-530	-313	-4	59	79	62	-295	114
	(105)	(66)	(323)	(118)	(244)	(28)	(411)	(23)	(71)	(42)	(57)	(31)	(173)**	(188)	(51)	(41)	(26)**	(21)**	(99)**	(81)
$(ke \times kd)^{1/2}$	-0.09	-1.97	-98.39	-0.43	35.49	-0.68	1.04	0.63	5.38	6.00	0.17	-0.04	-3.90	17.89	-0.09	-0.64	0.39	2.00	17.02	0.89
	(4.64)	(3.09)	(64.55)	(4.67)	(8.38)**	(1.03)	(25.52)	(1.95)	(5.06)	(1.08)**	(3.27)	(1.24)	(10.52)	(7.08)*	(0.93)	(1.23)	(0.33)	(0.56)**	(3.95)**	(3.16)
Constant term																				
	-426	668	545	1283	-626	178	1402	183	-197	-896	563	-296	-324	1254	185	684	600	1188	358	353
	(1641)	(157)**	(288)*	(695)	(807)	(129)	(1372)	(104)	(742)	(379)*	(376)	(160)	(806)	(1102)	(137)	(257)**	(253)*	(230)**	(206)	(201)

Significance: ** 1% level ; * 5% level. H_0: "$\beta=0$" rejected at the 1% level in all industries. Models also include: "exporting technology" dummy (time-varying, correlated w/ u_i), year dummies (time-varying, uncorrelated w/ u_i); firm age in 1992 and 4-digit industry dummies (time-invariant, uncorrelated w/ u_i); "multi-plants" dummy (time-invariant, correlated w/ u_i).

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