財團法人中華經濟研究院
CHUNG-HUA INSTITUTION FOR ECONOMIC RESEARCH
75 Chang-Hsing St., Taipei, Taiwan, 106
Republic of China
TEL: 886-2-735-6006
FAX: 886-2-735-6035

CHUNG-HUA INSTITUTION FOR ECONOMIC RESEARCH

# AN EVALUATION OF THE EFFECT OF GOVERNMENT RESEARCH AND DEVELOPMENT PROMOTION SCHEMES IN THE ELECTRICAL COMPONENT INDUSTRY

JIANN-CHYUAN WANG & KUEN-HUNG TSAI

*DISCUSSION PAPER SERIES No.9404*
**June 1994**

Any comment or communication, please write to: Publications Department, Chung-Hua Institution for Economic Research, 75 Chang-Hsing Street, Taipei, Taiwan 106, ROC.

財團法人中華經濟研究院

CHUNG-HUA INSTITUTION FOR ECONOMIC RESEARCH
75 Chang-Hsing St., Taipei, Taiwan, 106
Republic of China
TEL: 886-2-735-6006
FAX: 886-2-735-6035

CHUNG-HUA INSTITUTION FOR ECONOMIC RESEARCH

# AN EVALUATION OF THE EFFECT OF GOVERNMENT RESEARCH AND DEVELOPMENT PROMOTION SCHEMES IN THE ELECTRICAL COMPONENT INDUSTRY

JIANN-CHYUAN WANG & KUEN-HUNG TSAI

*DISCUSSION PAPER SERIES No.9404*
June 1994

*Discussion Paper Series No. 9404*

# An Evaluation of the Effect of Government Research and Development Promotion Schemes in the Electrical Component Industry

by
Jiann-chyuan Wang and Kuen-hung Tsai

June 1994

Chung-Hua Institution for Economic Research
75 Chang-Hsing St., Taipei, Taiwan 106
Republic of China

JIANN-CHYUAN WANG & KUEN-HUNG TSAI*

# An Evaluation of the Effect of Government Research and Development Promotion Schemes in the Electrical Component Industry

## Abstract

**Keywords: R&D, R&D promotion scheme, investment tax credit**

Generally speaking, it is difficult to evaluate the effect of research and development (R&D) promotion schemes for the following reasons: first, we do not know exactly when R&D outputs will come out, and second, it is complicated to identify the contribution of R&D promotion schemes on R&D outputs. Even if we could overcome the problems stated above, other problems may occur. For instance, we cannot observe output *ex post* derived from the individual or combinational tools included in the promotion scheme since they have never been utilized alone. Under such circumstances, it becomes extremely difficult to evaluate the effect of an individual promotion tool or combinations of tools within a promotion scheme. As such, following a quasi-experimental method, this paper aims to explore the effect of each combination of promotion tools by surveying how firms' R&D investment intentions are influenced through the different scenarios conducted by the assumed cancellation of R&D promotion tools.

Using data from surveyed firms, this research reaches the following

*The authors are Research Felllow and Assistant Resaerch Fellow, Chung-Hua Institution for Economic Research.

conclusions:

1. Concerning the magnitude of influence of three government R&D promotion tools on firms' R&D investment, the investment tax credit is the most powerful, the exemption from tariffs is next, and accelerated depreciation is last.
2. The combination of investment tax credit together with tariff exemption is more influential than any other combination of two tools on firms' R&D investment.
3. Furthermore, the larger the firm's size, the lower the likelihood of R&D reduction. In other words, larger firms' investment is less sensitive than that of smaller firms to the cancellation of government R&D promotion schemes.

# I. Introduction

In recent years, because of the sharp appreciation of the New Taiwan dollar, rising labor and land costs, together with growing labor disputes and environmental protection awareness, Taiwanese labor-intensive products are losing their competitiveness in the global market. Thus, discovering how to promote firms' research and development (R&D) expenditure to upgrade production technology and increase products' value-added to stay ahead of competition is a pressing task.

However, R&D often has an open and accessible nature. In other words, investors frequently cannot totally exclude others from free-riding on their research results, especially in pure research where applications are diffuse and appropriating rewards for innovative activity are almost ignored.

Furthermore, uncertainty associated with R&D projects discourages firms from investing in inventive and innovative activities. Due to both nonexcludability and uncertainty, firms may allocate less to R&D than they otherwise might.

In addition, the Taiwan economy is predominantly comprised of small- and medium-sized enterprises whose willingness to invest in R&D has been low due to their limited R&D capabilities. For example, the barriers of scale in high-tech industries usually deter smaller firms from engaging in R&D investment.

Due to the problems stated above, government involvement in the private sector's R&D is not without merit.[1] As such, the Taiwanese government enacted the "Statute for Industrial Upgrading and Promotion" (hereafter referred to as "SIUP") on January 1, 1991 to encourage local enterprises to engage in more R&D investment. In the tax exemption regulation of SIUP, there are several important measures such as investment tax credit and accelerated depreciation.[2] Additionally, the customs tariff exemption is also regarded as a promotion tool.[3]

Theoretically speaking, an investment tax credit allows firms to deduct part of their R&D expenses from corporate taxes, which lowers their cost of investing in R&D, and thus will promote their desire to invest in R&D. By the same token, the customs tariff exemption reduces the price of importing machinery and equipment, and certainly can induce firms to make more R&D efforts. As for accelerated depreciation, it capitalizes firms' R&D expenditure, delays their tax-paying schedule, and serves as an incentive for R&D expenditure.

The question is how to assess the effects of the promotion tools. Most previous studies evaluate the effect from an *ex post* perspective. However, in addition to R&D's time-lag problem and spillover effect, the inability to identify the effect of R&D promotion tools on R&D and its outputs makes it extremely difficult to evaluate the effect of R&D promotion tools. As such, in order to evaluate the effects of an individual promotion tool and combinations of tools, we propose an experimental method of attempting to estimate the impact on firms' R&D investment through the assumed cancellation of promotion tools.

This study is divided into five sections. After the introduction, Section II presents a brief overview of the literature on the effect of R&D promotion schemes. In Section III, we elaborate on the method of evaluation. Section IV explains the sampling design and sources of data, and analyzes the survey results on firms. Section V contains concluding

[1] For more details on government intervention in civil R&D, see Wang (1991).

[2] Regulations related to investment tax credit are described in chapter 2 (section 5 to 20) of SIUP; only 5, 6 and 8 are directly related to R&D investment.

[3] Customs Import Regulations state that to apply for an exemption of tariffs on R&D equipment requires the approval of the Ministry of Economic Affairs and the equipment must be unavailable from domestic suppliers.

remarks with some suggestions for further study.

## II. Literature Review and Discussion

Due to the characteristic openness of R&D and Taiwan's small- and medium-sized enterprises (SMEs) dominating the industrial structure, overall R&D efforts in industry are not very encouraging and have resulted in slow structural transformation. Therefore, government promotion schemes may serve as an incentive to encourage local industry to engage in more R&D investment.

In the view of Arrow (1962) and Nadri (1980), when a gap exists between private and social rates of return, government can induce firms to spend more on R&D through subsidies or tax incentives on their R&D expenditure. McFetridge & Warda (1983) employed a B-index to evaluate government R&D promotion schemes. In their paper, the B-index represents the ratio of R&D cost over the present value of R&D; other things being equal, the higher the corporate tax rate, the lower the after-tax cost of R&D and the B-index. Consequently, government tax treatment on R&D can promote firms' R&D investment willingness.

Although the above theoretical literature points out that government policy measures can bridge the gap between private and social rates of return, reduce R&D cost and thus stimulate R&D efforts, several empirical studies reveal an opposite attitude toward the effect of R&D promotion schemes. Among them, Mansfield & Switzler (1985a) surveyed two groups of Canadian firms in 1981; the first group contained 65 firms which are among the largest spenders on R&D in Canada; and the second group covers 1,305 firms which also undertake R&D. Sample size was set at 55 firms (the sample accounts for almost thirty percent of all company-financed R&D expenditure in Canada). Their conclusion points out R&D tax credits have had a modest effect on firms' R&D expenditure. Additionally, based on a survey of 110 U.S. firms and 55 Canadian firms, Mansfield & Switzler (1985b) concluded that U.S. and Canadian R&D tax credits have increased industrial R&D by only 1.2 percent and 2.0 percent, respectively.

As for domestic scholars, Lin (1988), Sun (1987), and Cheng-Chih University (1986) conducted surveys on Taiwanese firms. They mostly focused on firm response to rank promotion tool priority without paying much attention to the induced effect of R&D tax incentives. Their research results can be summarized as follows: writing-off expenditure is better than customs tax exemption, and R&D tax credits are better than accelerated depreciation.

**Literature on the Effect of Government R&D Promotion Schemes**

| Literature | Cheng-Chih University (1986) | Sun (1987) | Lin (1988) |
|---|---|---|---|
| Research method | Surveyed firms from the electrical, machinery and chemical industries | Surveyed 500 Taiwanese manufacturing firms | Surveyed Taiwanese firms which qualify to apply for investment tax credits |
| Research results | The most beneficial R&D promotion tools for firms are writing-off R&D expenditure and tariff exemption for R&D equipment | Among R&D promotion tools, writing-off R&D expenditure is the most important, tariff exemption is next, followed by R&D tax credits and accelerated depreciation | Among R&D promotion tools, the economic benefit of writing-off R&D expenditure is the greatest. Tariff exemption and investment tax credits are next. Accelerated depreciation is the smallest. |

Source: Wang (1993)

From the above findings, we know that R&D tax incentives have only a very modest effect on firms' R&D expenditure. However, the previous studies as mentioned above contain some limitations which need to be addressed:

1. Sampling may affect the conclusion: According to the survey results of Mansfield & Switzler (1985b), the tax-incentive induced effect for smaller sized firms is greater than that for larger sized firms. Consequently, for Taiwan's SME-dominated industrial structure, the tax-incentive inducement effect is expected to be larger. In addition, SMEs have very limited resources to conduct R&D investment since the minimum scale of efficiency in technology-intensive industries has increased rapidly and entry barriers exist. Therefore, compared with other developed countries, it is more urgent for the Taiwanese government to assist local SMEs to build up basic economies of scale for R&D through promotion schemes.
2. R&D has spillover effects. The current year's R&D output can serve as next year's input. In addition, other firms' R&D output can be used for input. Once the firms' technological based is set up, the development of new products and new technologies is thus facilitated.
3. R&D possesses a time-lag nature: Since R&D outputs may take two or three years to realize after R&D input has been made, it is understandable that R&D inputs may not have an immediate positive linkage with output. For this reason, the ex post evaluation of the effect of R&D promotion schemes may be underestimated.

Due to the size of survey firms and R&D's time-lag nature, the findings of previous empirical studies may not be totally appropriate for Taiwan's environment. In this paper, then, we surveyed Taiwanese firms to evaluate how they respond to government R&D promotion schemes.

In the next section, we will briefly describe the approach which evaluates the effects of R&D promotion tools.

## III. Method of Evaluation

The aim of R&D promotion schemes is to encourage firms to take action in R&D activities. Therefore, to find out the effect of the scheme, we need to measure the firms' R&D expenditure evoked from the promotion scheme.[4]

[4] The R&D expenditure refers to procurement of assets or operation costs of a project for R&D in a given year (National Scientific Organization 1993).

However, if we attempt to separate the individual effect of promotion tools included in the scheme, we'll immediately encounter a problem. That is, *ex post* data don't exist because each promotion tool in the scheme has never been executed alone.

To avoid this difficulty, we alter the method of previous evaluations adopted. We assume that the decision-making behavior on R&D expenditure is rational for all firms. The firms' R&D expenditure induced from the promotion scheme represents the effect of the scheme. Therefore, we use the degree of response relative to occurred R&D expenditure in 1991 to measure the effect of each tool included in the promotion scheme. To acheive this purpose, we take the following steps.

First, we construct seven combinations, listed in Table 1, of three promotion tools other than the current one executed from January 1, 1991. Next, we surveyed the firms, selected from a random sampling framework. They are requested to answer the span of reducing their R&D expenditure relative to the occurred R&D investment in 1991 under each type indicating one or some promotion tools to be cancelled. It is clear that we can use the data collected from the above steps to evaluate the main effect of each tool, combinations of tools and the interaction effect among tools.

In addition to government R&D promotion tools, firms' R&D expenditure is influenced by other factors. Manfield & Switzer (1985b) found that firm size has an impact on R&D expenditure decision-making. Also, profit should be considered as another important factor influencing the decision-making behavior on R&D expenditure since firms need capital to engage in R&D activities. Therefore, our discussion will involve these two factors.

Let $D^*$ denote the amount of the desire evoked from the promotion scheme, size, and profit. Let X-terms be dummy variables indicating the types of combinations of promotion tools, and SL and PT indicate the firms' scale and profit, respectively. In this article we use total assets and 3-year average rate of profit to represent the scale and profit, respectively. Furthermore, we assume that the functional relationship between $D_i^*$ and these explantatory factors is linear. Thus, we have

$$D^* = \beta_0 + \sum_{j=1}^{6} \beta_j X_j + \beta_7 SL + \beta_8 PT + \varepsilon \quad \text{.........(1)}$$

Where ß-terms are parameters reflecting the impact of explantatory factors and $\varepsilon$ is the disturbance term. In practice, $D^*$ is unobservable. What we observe is the outcome of firms' decision making on R&D expenditure. Obviously, we can't use the traditional least square method to estimate the parameters in expression (1) assuming there exists a threshold, D, which reflects the critical point of firms' decision making on R&D expenditure. Further, we let y=1 if $D^*>D$ and y=0 if $D^*<D$. This means that firms choose to reduce R&D expenditure when y=1, whereas they don't decrease R&D expenditure when y=0[5]. Hence, it is clear that $D^*$ determines whether firms choose to decrease R&D expenditure or not. We assume that the cumulative distribution of the disturbance term in (1) has a logistic distribution (Maddala 1983, pp. 22-23).[6] Then, the relationship between the possibility of y=1 and y=0 can be expressed by

$$\ln\frac{P}{1-P}=\beta_0+\sum\beta_j X_j+\beta_7 SL+\beta_8 PT\text{...........}(2)$$

where p represents the possibility that firms choose to reduce R&D expenditure by some amount. Furthermore, we assume that y is a Bernoulli process. Therefore, all random choices form a binomial distribution. As a result, the maximum likelihood function can be formulated by

$$L=\prod P_i^{y_i}(1-P_i)^{1-y_i}\text{..................}(3)$$

[5] Since $D^*$denotes the amount of the desire influenced by the cancellation of the promotion scheme, we let y=1 represent the firm choose to reduce R&D expenditure when the amount exceeds the critical point set by the firm.

[6] Also, we can assume the distribution is a normal distribution. However, the logistic distribution and cumulative normal distribution are very close to each other (Amemiya 1981). Thus, the difference arising from these two distributions is rather small.

**Table 1 Combinations of Promotion Tools**

| Type | Combination | | |
|---|---|---|---|
| 1 | X | [2] | [3] |
| 2 | [1] | X | [3] |
| 3 | [1] | [2] | X |
| 4 | X | X | [3] |
| 5 | X | [2] | X |
| 6 | [1] | X | X |
| 7 | X | X | X |

Note: [1] exemption from tariffs;
[2] accelerated depreciation;
[3] investment tax credit; X deletion of the promotion tool.

where Π represents joint product. From expressions (2) and (3), we can use the maximum likelihood method (ML) to estimate parameters. Moreover, using these estimated parameters we can obtain the estimated probabilities that firms choose to reduce R&D expenditure under different combinations of promotion tools. Connecting the estimated probabilities of each type of combination with the span that each firm considers to reduce R&D expenditure under each combination, we have

$$V_j = \frac{1}{n}\sum P_{ij}R_{ij} \quad \text{........(4)}$$

where $V_j$ represents the expected decreasing span under the jth type of combination, j=1,2,....,7. $R_{ij}$ is the percentage of R&D expenditure reduction for each type of combination and n is the sample size. For each type of combination, we can estimate the expected value, $V_j$, reflecting the decreasing span of R&D expenditure through expression (4). Consequently, combining expressions (3) and (4), we can evaluate the effect for each promotion tool and the effects of combinations of tools.

# IV. Data and Results

## 1. Data Resource

The samping population in the study is all Taiwanese firms in the electrical component industry classified by 4 digit codes 3606 and 3607. We take assets as the criterion to obtain the list of firms using the randomly stratified sampling method (Cochran 1977, p. 75). Furthermore, we adopt a randomly simple sampling method to choose the firms to be investigated.

Through this process, the distribution of sample that we expect to collect is displayed in Table 2.

**Table 2 Distribution of Firms of Sampling and Collection**

| Assets (millions) | Sampling firms (%) | Collected firms (%) |
|---|---|---|
| ~ 2 | 30 (9.5) | 3 (2.4) |
| 2 ~ 5 | 108 (33.8) | 26 (21.0) |
| 5 ~ 10 | 65 (20.4) | 23 (18.5) |
| 10 ~ 30 | 60 (18.7) | 26 (21.0) |
| 30 ~ 50 | 14 (4.3) | 9 (7.3) |
| 50 ~ 100 | 14 (4.3) | 11 (8.9) |
| 100 ~ | 29 (8.9) | 26 (21.0) |
| Total | 320 (100) | 124 (100) |

Table 2 shows that the larger the firms' size, the better the collection. This means that the results of analysis provide more information for large firms than for smaller firms.

## *2. Results*

After analyzing the survey data, the preliminary result is listed in Table 3. Note the likelihood-ratio chi-square value is 39.72.[7] This implies that there is at least one parameter quite possibly greater or smaller than 0 at the 5% significance level. Inspection of Table 3 shows that these significant parameters associate with $X_1$, $X_2$, SL and PT. These findings tell us that the impact of deleting accelerated depreciation or tariff exemption has a smaller influence on decreasing R&D expenditure than that of dropping the investment tax credit. Additionally, the larger or more profitable the firm, the lower the possibility of decreasing R&D expenditure. This finding is consistent with the previous empirical study. This seems to be reasonable since larger firms have more resources to engage in R&D activities to hold or reinforce the competitive advantages.

In addition to these findings, nonsignificant coefficients also provide some information, illustrating the impact of deleting the investment tax credit on the desire to reduce R&D expenditure is almost the same as that of cancelling all promotion tools included in the scheme. Clearly, the greatest influence on the desire to reduce R&D expenditure comes from the investment tax credit.

Furthermore, the results of combining the possibilities estimated by using logit transformation of Table 3 with the span of reduction on R&D expenditure are reported in Table 4. The table shows that the average span of reduction on R&D expenditure arising from cancelling tariffs exemption, accelerated depreciation and investment tax credit are 7.8%, 4.9% and 16.6%, respectively. Thus, we find that the greatest impact on R&D reduction comes from the cancellation of the investment tax credit. Tariffs exemption is next. The least impact arises from deleting accelerated depreciation.

Table 4 also shows the effect of cancelling two or all promotion tools. The average spans of reduction on R&D expenditure deriving from the cancellation of tariff exemption and accelerated depreciation, tariff

[7] Relative to the $X^2$ value, we have a pseudo-$R^2$ value using the general definition of $R^2$ (Nagelkerke 1991). In this article, $R^2 = 0.856$ indicates that the estimated parameters can explain most variance in the possibility of choice. In other words, the estimated model fits reasonably well.

exemption and investment tax credit, accelerated depreciation and investment tax credit are 13.4%, 24.8% and 22.6%, respectively. Again, we find the largest impact on R&D reduction comes from the cancellation of investment tax credit and exemption from tariffs.

**Table 3 Results from the Choice Model**

| Explantatory Variables | Estimated Parameters |
|---|---|
| Intercept | 0.446 (0.28) |
| $X_1$ | -0.803 (0.37)* |
| $X_2$ | -1.294 (0.37)* |
| $X_3$ | -0.123 (0.38) |
| $X_4$ | -0.418 (0.37) |
| $X_5$ | 0.006 (0.38) |
| $X_6$ | -0.001 (0.38) |
| SL | -0.0005 ($6*10^{-4}$)* |
| PT | -0.050 (0.01)* |

Note: 1. $X_8^2 = 39.72$, $p < 0.01$, significance level = 5%.
2. Intercept: the 7th combination, $X_1$ - $X_6$: the 2nd to 6th combination.
3. ( ) is the standard error.
4. * indicates the coefficient is not equal to 0 at the 5% significance level.

**Table 4 Effects on R&D Reduction from Cancelling One or Some Promotion Tools**

| Types of combinations<br>Possibility & span | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Possibility of reduction | 0.412 | 0.300 | 0.639 | 0.507 | 0.630 | 0.605 | 0.610 |
| Expectespanofreduction (%) | 7.8 | 4.9 | 16.6 | 13.4 | 24.8 | 22.6 | 30.5 |

Note: Types of combinations from 1 to 7 are the same as in Table 1.

At the same time, we find the crossed impact (interaction).[8] The impact of interaction on dropping exemption from tariffs and accelerated depreciation averages a 0.7% R&D expenditure reduction. The interaction impacts of the deletion of exemptions from tariffs and investment tax credit, accelerated depreciation and investment tax credits on R&D expenditure reduction are 0.4% and 1.1%, respectively. Dropping all promotion tools, the average reduction span is 30.5%. The interaction reduction span is 1.2%. In summary, the promotion scheme stimulates about 30% or more R&D expenditure than without any promotion tools in the electrical component industry. However, we don't know how much R&D inducement will contribute to the national product.

From the above analysis, we find that in the promotion schemes the greatest impact on influencing firms' decision making on R&D expenditure happens with the investment tax credit. Exemption from tariffs comes next, and accelerated depreciation is last. Also, there exists an interaction effect with the cancellation of two or all promotion tools. In addition, we find the larger or more profitable the firm, the lower the possibility of reducing R&D expenditure. These findings imply that when the government wants to cancel some promotion tools from the current scheme, they should not cancel the investment tax credit. In addition, since smaller firms are more easily influenced by R&D schemes than larger firms, the government should rearrange R&D promotion schemes to make them more beneficial to smaller firms.

# V. Conclusion & Policy Suggestions

## *1. Conclusion of this study*

Instead of an ex post evaluation, this study attempts to use an experimental idea to estimate the expected reduction span on R&D expenditure when an individual promotion scheme is cancelled.

Using survey data from firms in the electrical component industry, the primary purpose of this research has been to explore the induced effects

[8] Here the crossed impact refers to the linkage effect arising from cancelling one promotion tool on another promotion tool.

of various government R&D promotion combinations of tools including investment tax credits, accelerated depreciation and tariff exemptions to promote R&D investment in industry in 1991.

The major conclusions include:

(1) Concerning the magnitude of influence of the three government promotion tools, the R&D tax credit is the most powerful, followed by tariff exemptions for importing R&D equipment and instruments, and by the accelerated depreciation for R&D equipment.

(2) The combination of investment tax credits with tariff exemptions is more influential than any other two-tool combination on firms' R&D investment.

(3) The larger the firm size, the larger the possibility as expected, to make R&D investment.

In summary, the R&D inducement effect of any two-tool combination is larger than that of any individual promotion tool, and a combination of all three promotion tools is certainly larger than any two-tool combination in terms of inducement effect. However, we cannot rule out firms' selfish attitude which considers that the more promotion tools government provide, the more benefit firms obtain.

## *2. Limitations of the study*

The above conclusions are influenced by some limitations, which include the scope of the study, sampling, the measurement methods and analysis techniques.

Owing to the limitations of time, cost, and precision, in the study we choose the electrical component industry as the object of study. Therefore, the result of the study may not be applicable to other manufacturing industries without reservation. Moreover, investment on R&D equipment or technology in 1991 is a function of the three promotion tools; hence there is no way to evaluate exactly how much a firm would invest when one particular promotion tactic is cancelled. This study has employed an experimental idea to attempt to estimate the expected reduction span on R&D expenditure when an individual promotion is cancelled. Furthermore, because of the deficiency of information, we cannot evaluate the promotion scheme with cost-benefit analysis, so precise suggestions for policy adjustment cannot be offered.

In the sample, most of the retrieved samples are from larger enterprises, and the conclusion may not be applied without reservation to smaller firms (assets below US$ 2 million) in the electrical component industry.

In designing the survey and measuring methods, because a high degree of measurement was desired (interval and ratio scales), some firms felt upset, and therefore refused to answer. In addition, some firms may have considered the questions too sensitive to answer, hence they refused to offer information, which may lead to measurement error in the analysis.

As to the analysis techniques, due to the deficiency of information, some relatively more precise statistical techniques cannot be used. For example, the data for R&D performance cannot be processed by a heterogeneous multivariate multiple regression model, so only a choice model is employed. The results may thus become less precise.

# References

Amemiya, T. (1981). "Qualitative Response Model: A Survey," *Journal of Economic Literature*, Vol. 19: 1483-1536.

Arrow, K. (1962). Economic Welfare and the Allocation of Resources for Inventions, in R. R. Nelson (ed.), *The Rate and Direction of Inventive Activity*, Princeton, N.J.: Princeton University Press.

Cochran, W. G. (1977). *Sampling Techniques*, 3rd ed. New York: John Wiely & Sons.

Graduate School of Business Administration (1986). *A study of the Influence of Taiwan's Current R&D System on Firms' R&D Activities*, Cheng-Chih University.

Lin, Jong-Yuang (1988). "A Study of Taiwan's R&D Promotion Schemes," *Finance Study*, Vol. 30, No. 5: 48-56 (in Chinese).

Maddala, G. S. (1983). *Limited-Dependent and Qualitative Variables in Econometrics*. New York: Cambridge Univ. Press.

Mansfield, E. and L. Switzer (1985a). "How Effective are Canada's Direct Tax Incentives for R&D?" *Canadian Public Policy*, Vol. 11: 241-246.

__________(1985b). "The Effect of R&D Tax Credits and Allowance in Canada," *Research Policy*, Vol. 14 : 97-107.

McFetridge, D. and J. Warda (1983). *Canadian R&D Incentives: Their Adequacy and Impact*, Tornoto: Canadian Tax Foundation.

Nagelkerke, N. J. D. (1991)."A Note on a General Definition of the Coefficient of Determination," *Biometrika*, Vol. 78, No. 3 : 691-692.

Nadir, M. (1980). "Contributions and Determinants of Research and Development Expenditures in the U.S. Manufacturing Industries." In George M. Von Furstenberg, ed., *Capital, Efficiency and Growth*, Ch. 5 Cambridge, Massachusetts: Ballinger.

National Scientific Organization (1993). *Indicators of Science and Technology*. Administration Yuan: ISSN 1019-3006.

Sun, Keh-Nan (1989). *Evaluation and Improvement Recommendations of R&D Promoting Schemes*. Chung-Hua Institution for Economic Research, Taipei. (in Chinese)

Wang, Jiann-Chyuan (1993). *A Study of Government R&D Promoting Schemes and Firms' Response*, Monograph, Chung-Hua Institution for Economic Research, Taipei. (in Chinese)

___________ (1991). "Should Government Intervene in Civil Research and Development ? - The Case of Taiwan," *Occasional Paper* No.9111, Chung-Hua Institution for Economic Research, Taipei.

Wang Lien, Chang-Fu, et al. (1986). A Study of R&D and the Change in Industrial Structure, Dept. of Economics, National Chung-Hsin University. (in Chinese)

# Discussion Paper Series

1. Kang Chao and Ellen S. S. Chien. "The Relative Real GDP and Price Structure of Mainland China," 1981. ***(No.8101)***
2. Kang Chao. "Economic Readjustment in Mainland China," 1981. ***(No.8102)***
3. Mingshu Hua. "The Inflationary Effect on the Structure of Trade," 1981. ***(No.8103)***
4. Kang Chao and P. C. Chang. "A Study of Regional Factor Productivities in Chinese Agriculture," 1982. ***(No.8201)***
5. Chun-yuan Wang. "The Spillover Monetary Effect of Devaluation: A Disequilibrium Interpretation of the Cooper Paradox and the 'Reversed'," 1982. ***(No.8202)***
6. Chihwa Kao. "Second-Order Efficiency in the Estimation of Heteroscedastic Regression Models," 1984. ***(No.8401)***
7. Chihwa Kao. "An Em Algorithm for the Heteroscedastic Regression Models with Censored Data," 1984. ***(No.8402)***
8. Hak Choi. "Methods of Generating Demand Functions - A Tabular Review," 1984. ***(No.8403)***
9. Chihwa Kao. "Robust Regression with Censored Data," 1984. ***(No.8404)***
10. Chihwa Kao. "The Bootstrap and the Censored Regression," 1984. ***(No.8405)***
11. San, Gee. "The Early Labor Force Experience of College Students and Their Post-College Success," 1984. ***(No.8406)***
12. Chihwa Kao. "Small Sample Studies of Estimating, the Regression Models with Multiplicative Heteroscedasticity: The Results of Some Monte Carlo Experiments," 1984. ***(No.8407)***
13. San, Gee. "Student Financial Aid, In-School Employment, and Educational and Labor Market Outcomes," 1984. ***(No.8408)***
14. An-loh Lin and Scott A. Monroe. "The Structure of Gasoline Demand Across the United States," 1985. ***(No.8501)***
15. Hak Choi. "Why the EEC-ROC Trade Remains Unimportant," 1985. ***(No.8502)***
16. Hak Choi, J. Chou and D. E. Nyhus. "A Disaggregated Exports Forecasting Model for Taiwan," 1985. ***(No.8503)***

17. Diagee Shaw. ''On-site Samples' Regression: Problems of Nonnegative Integers, Truncation, and Endogenous Stratification,'' 1987. ***(No.8701)***

18. Li-min Hsueh and Su-wan Wang. ''The Implicit Value of Life in the Labor Market in Taiwan,'' 1988. ***(No.8801)***

19. Chien-hsun Chen. ''Modernization in Mainland China: Self-Reliance and Dependence,'' December, 1990. ***(No.9001)***

20. Tain-jy Chen & Wen-thuen Wang. ''The Effects of Production Quotas on Economic Efficiency: The Case of Taiwan's Canned Food Industry,'' December 1990. ***(No.9002)***

21. Ya-hwei Yang. ''The Influence of Preferential Policies on Strategic Industries: An Empirical Study of Taiwan,'' December 1990. ***(No.9003)***

22. Solomon W. Polachek & Charng Kao. ''Lifetime Work Expectations and Estimates of Sex Discrimination,'' January 1991. ***(No.9101)***

23. Ke-jeng Lan. ''Inflation Effects on the Labor Market: A Transition Rate Model,'' April, 1991. ***(No.9102)***

24. Hui-lin Wu, Quen-leng Miao, and Ke-jeng Lan. ''Wage Differentials: Among College-and-Above Graduates in Taiwan,'' April 1991. ***(No.9103)***

25. George J. Y. Hsu and Tser-yieth Chen. ''Uncertainty and Asymmetric Information in the Modelling of Electric-Utility Tariff Regulation,'' May 1991. ***(No.9104)***

26. Ya-hwei Yang. ''An Analysis on the Structure of Interest Rate in the Banking Sector, the Money Market and the Curb Market,'' June 1991. ***(No.9105)***

27. Jiann-chyuan Wang. ''Quota Restriction Policies and Their Impact on Firms' Quantity Setting Decision Under 'Learning-By-Doing',''  June 1991. ***(No.9106)***

28. Jiann-chyuan Wang. ''Cooperative Research in Taiwanese Manufacturing,'' October 1991. ***(No.9107)***

29. Mo-huan Hsing. ''The Empirical Relevance of the Orthodox Demand Theory,'' October 1991. ***(No.9108)***

30. Hui-lin Wu and Ke-jeng Lan. ''Labor Shortage and Foreign Workers in Taiwan,'' October 1991. ***(No.9109)***

31. Ji Chou and De-min Wu. ''The Cost of Capital and the Effective Tax Rate in Taiwan: 1961 - 1985,'' October 1991. ***(No.9110)***

32. George J. Y. Hsu, Pao-long Chang, and Tser-Yieth Chen. ''Industrial Outage Costs in Taiwan: Estimation from a Proposed Curtailable Rate Program in Taiwan,'' January 1992. ***(No.9201)***

33. Charng Kao, Solomon W. Polachek, and Phanindra V. Wunnava. ''Male-

Female Wage Differentials in Taiwan: A Human Capital Approach,'' Feb. 1992. ***(No.9202)***

34. Lee-in Chen Chiu. ''The Economic Reunion of Taiwan and the Mainland China: The Impact on Industrial Development,'' May 1992. ***(No.9203)***
35. Yi Chou, Pao-long and Chyan Tuan. ''TQC Chinese Style and Its Management Implication -- Taiwan V.S. Mainland China,'' June 1992. ***(No.9204)***
36. Chung-hua Shen and Lee-rong Wang. ''Testing Efficiency of the Coffee Futures Market -- A Markov Switching Model,'' June 1992. ***(No.9205)***
37. Tain-jy Chen and Hsien-yang Su. ''On-the-Job Training as a Cause of Brain Drain'' July 1992. ***(No.9206)***
38. George J. Y. Hsu, Pao-long Chang and Tser-yieth Chen. ''A Priority Service Program and Power Outage Costs: The Case of Taiwan's Cement Industry,'' October 1992. ***(No.9207)***
39. George J. Y. Hsu and Ai-chi Hsu. ''Energy Intensity in Taiwan's Industrial Sectors: Divisia Index vs. Laspeyres Index,'' October 1992. ***(No.9208)***
40. Lee-in Chen Chiu. ''Regional Differential of Enterprise Efficiency and Labor Productivity in Coastal China,'' December 1992. ***(No.9209)***
41. Chi-ming Hou & Chien-nan Wang. ''Globalization and Regionalization -- Taiwan's Perspective,'' March 1993. ***(No.9301)***
42. Yi Chou. ''The Practice Beyond Property Right Boundaries -- Quality Management in Chinese State-owned Enterprises and Rural Enterprises,'' March 1993. ***(No.9302)***
43. Tzong-shian Yu. ''Economic Development in Transition -- The Case of Taiwan,'' June 1993. ***(No.9303)***
44. Tzong-shian Yu. ''An Analysis of the Effects of Economic Policies on Taiwan's Economic Growth and Stability,'' June 1993. ***(No.9304)***
45. Ke-jeng Lan. ''An Evaluation of the Effectiveness of Government Automation Promotion Schemes in the Electrical Component Industry,'' June 1993. ***(No.9305)***
46. Yi Chou. ''Measurement of Technical Efficiency and Its Management Implications -- The Example of Taiwan Sugar Corporation,'' June 1993. ***(No.9306)***
47. Chien-nan Wang. ''On the Choice of Exchange Rate Regimes,'' June 1993. ***(No.9307)***
48. Yi Chou & Chyau Tuan. ''Quality Management of Chinese Township Enterprises in Inland and in Coastal Areas,'' November 1993. ***(No.9308)***
49. Lee-in Chen, Chiu and Jr-tsung Huang. ''Improvement of Capital Productivity

and Technical Efficiency via DFI: Evidence from the Industrial Interaction between Taiwan and Mainland China,'' December 1993. ***(No.9309)***

50. An-loh Lin. ''Trade Effects of Direct Foreign Investment: The Bilateral Case,'' February 1994. ***(No.9401)***
51. Jiann-chyuan Wang and Homin Chen. ''The Impact of North American Economic Integration on Taiwan,'' March 1994. ***(No.9402)***
52. Joseph S. Lee. ''Is There a Bona Fide Labor Movement in Taiwan?'' April 1994. ***(No.9403)***
53. Jiann-chyuan Wang & Kuen-hung Tsai. ''An Evaluation of the Effect of Government Research and Development Promotion Schemes in the Electrical Component Industry.'' June 1994. ***(No.9404)***