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# Determinants of Highly-Skilled Migration – Taiwan's Experiences

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# Determinants of Highly-Skilled Migration – Taiwan's Experiences

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Over the past four decades, a large number of technical emigrants and students have flowed from Taiwan to the United States, providing a pool of talented technical expertise and entrepreneurship. This has, however, aroused concerns about a brain drain in the home economies. Many of these highly-skilled scientists and professionals from Taiwan have joined high-tech firms in the United States after completion of their education in U.S. universities, and some have even started up their own businesses, notably in Silicon Valley. Meanwhile, others have brought back their experience as well as relationships built up in the valley to establish their own companies in Taiwan, particularly in the Hsinchu Science-based Industrial Park. According to HSIP statistics, returnees established 118 of the 378 companies, which are still active in the park, accounting for 31.2 percent. And 18 of these companies introduced foreign capital into the HSIP, accounting for 36 percent of foreign invested companies in the HSIP. Their contribution has clearly been one of the keys to the formation of industrial cluster and the successful development of information industries in Taiwan's Hsinchu Science-based Industrial Park.

Another contribution of the returnees to their countries has been the spillover effect of knowledge and technologies learned abroad. In his recent study, Tsay (2002) observed an increasing proportion of returnees working for industries employed in the HSIP (from 4.5% in 1983 to 37.9% in 1995). However the proportion of foreign-educated employees to domestic-educated employees remains stable over the past decade (see table 1). This shows that the increase in the number of returnees does not cause the reduction to the domestic-educated workers. Instead, there might exist a specific combination of employees of both backgrounds, so that the spillover effect can be best used.

[1] The authors would like to thank the National Science Council for making possible their research on the migration of the highly-skilled labor. They wish to offer their heartfelt gratitude to the valuable comments of Dr. Ping-Lung Hsin in the previous draft. His suggestions have been incorporated in this revision. Correspondence: leein@mail.cier.edu.tw

**Table 1 Foreign Educated Employees in the HSIP**

Unit: persons, years

| Year | Domestic-educated | | Foreign-educated | | Total | |
|---|---|---|---|---|---|---|
| | Number | Year | Number | Year | Number | Year |
| 1985-1990 | 82,353 (97.0) | 13.5 | 2,539 (3.0) | 18.9 | 84,892 (100) | 13.7 |
| 1991-1995 | 145,140 (95.0) | 13.8 | 7,604 (5.0) | 17.9 | 152,744 (100) | 14.0 |
| 1996-2000 | 334,750 (91.3) | 14.2 | 31,735 (8.7) | 16.2 | 366,485 (100) | 14.4 |
| 2001 | 87,651 (94.5) | 14.5 | 5,082 (5.5) | 16.9 | 92,733 (100) | 14.6 |
| 2002 | 89,507 (94.7) | 14.5 | 4,996 (5.3) | 17.0 | 94,503 (100) | 14.7 |

Notes:
1. Numbers for year groups are aggregated.
2. Year stands for average education years.
3. Numbers in parentheses are percentage of different education categories.
Source: Hsinchu Science-based Industrial Park.

These successful experiences of these entrepreneurs at the Hsinchu science park have been frequently reported on by various media, and the relationship between returning highly-skilled expatriates and development of high-tech industries has also been widely discussed in academic journals. Few of these, however, have quantitatively analyzed determinants affecting mobility of highly-skilled workers due to serious data constraints. This paper attempts to contribute in this respect using microdatasets provided by the National Youth Commission.[2]

This paper explores data provided by the National Youth Commission in order to examine determinants of migration of highly-skilled workers, kinds of overseas students or professionals most likely to return to their home countries and economic condition or place attributes most likely to attract highly-skilled migrants.

## 1. Literature Review

Determinants motivating individual migration decisions have been well examined by researchers, such as Sjaastad (1962), Greenwood (1969, 1975, 1976), Harris and Todaro (1970), Schwartz (1973), Mueller (1978, 1982), Mincer (1978), Nakosteen and Zimmer (1980), Herzog et al. (1986) and Davis et al. (2001).

[2] To provide the information of Taiwanese oversea experts for the recruitment needs of governmental, academic, and private institutions, NYC started to build a oversee talent database since 1979, and keeps on updating it till 2001. This database is the main source of our analysis. After 1996 NYC further build up a virtual job market to substitute the preceding database. We use the information collected by this new database for the year after 1996.

Sjaastad (1962) viewed migration behavior as a kind of investment, arguing that migrants would add up returns and costs of decisions before choosing to migrate. His view was shared by Harris and Todaro (1970), who further pointed out that migration would continue as long as expected earning differentials are above zero, even when unemployment rates in receiving areas are higher than those of sending areas. Mueller (1982) and a number of other researchers also followed the above concept to build the microfoundation of their theoretical frameworks. Given the lack of microdata, however, Sjaastad's suggestion cannot immediately be realized by empirical work.

As a direct result of this data constraint, Greenwood (1969, 1975, 1976) built many simultaneous equation models in his early works, and applied logarithmic least regression or two-stage least-square methods to analyze a set of explanatory aggregate data. He found that factors, such as distance, average income, average education, unemployment rate, state of urbanization, climate and migrant stock, were all significant to migrant numbers. Of all these factors, migrant stock, distance, average education and state of urbanization are notably explanatory. He argued that the distance factor is the proxy for psychological costs for migrants; the further the distance, the greater the impediments to migration. As for education and state of urbanization, these are proxy for economic prosperity in receiving and sending economies. Moreover, he argued that migrant stock helps trace unobserved factors, and improves explanatory powers of the model. His works provided an example of macroanalysis of migration stock, and demonstrated importance of place attributes. Schwartz (1973) also highlighted the negative effect of the distance factor while estimating impact of age and education factors on distance elasticity, finding that educational level of migrants reverses negative effect of distance. One could also interpret that the education factor has a positive effect on migration.

Although the studies of Greenwood and Schwartz were based on aggregate data, results were also evidenced by the work of Mueller (1978, 1982), which utilized microdatasets. Thanks to availability of these microdatasets, Mueller was able not only to develop a model of microfoundation migration theory with rational-expectation consideration, but was also able to perform an empirical study. He divided determinants into two groups, namely personal and place attributes. By utilizing longitudinal employee-employer data, he tested the theory empirically with a multinominal-logit model, and found that place attributes are highly significant to individual migration decisions, an observation that echoes the studies of Greenwood and Schwartz. Mueller's work provided a theoretical and empirical framework for microanalysis, and a standard classification of different determinants. He, however, produced few findings on influence of personal attributes, again because of data constraints.

Mincer (1978) discussed effects of family ties on migration decisions, arguing that determinants of migration would be more complicated than a personal decision, since marital status, number of children and family-income structure also influence individual decisions. He concluded that a single person is more likely to migrate than a married one.

Nakosteen and Zimmer (1980) pointed out that incidental-truncation error might occur in migration data since those migrating are those who would receive net benefits of moving following the suggestion of Sjaastad (1962). They also studied effect of place attributes on migration, and found that growth of state per-capita income had significant positive effect.

Herzog et al. (1986) were the first to study migration behavior of all workers, finding factors, such as age, education, children of school age, prior geographic mobility, educational quality, accessibility to recreation and per-capita income, were all highly significant to migration decisions. They further specified behavior of highly-skilled migrants and found that age, education, children of school age, transportation and city-scale determinants were crucial to migration decisions. Their study verified the assumption of Mincer, providing insight into decision-making of highly-skilled migrants, which provided a useful example for this study.

Davis et al. (2001) employed a conditional-logit approach to estimate impact of population, unemployment rate, per-capita income and distance determinants on individual migration decisions, and found all these determinants to be significant. Their work provided a theoretical framework for further empirical studies.

Besides the above studies, Rosenthal and Strange (2001) examined the impact of labor market pooling effect and knowledge spillover effect on the formation of industry clusters. They found that labor market pooling have the most robust effect. Their study hints that the existence of a specified industrial clusters might be importance factor to the migration of the talents needed by that industry.

To summarize, personal attributes, such as age, education, marital status, number of children and tenure, are significant in the decision to migrate, as are place attributes, such as unemployment rate, distance and state of urbanization (economic growth).

## 2. Model Specification

### a. Empirical model

Considering the above review of the theoretical framework and characteristics of the microdataset from the National Youth Commission, variables listed in Table 1 were selected, followed by establishment of a logit model in order to study determinants of migration.

**Table 1 Variable Descriptions**

| Attributes | Variable Name | Description |
|---|---|---|
| Dependent Variable | Back | Status of return: 0 for those staying abroad, 1 for returnees. |
| Personal Attributes | Sex | Gender: 0 for men, 1 for women. |
| | Age | Age in years. |
| | Degree | Highest degree received: 1 for doctorate, 2 for Masters, 3 for Bachelor and 4 for medicine. |
| | Special | Specialized areas: 1 for humanities, 2 for sciences, 3 for law, 4 for economics and business administration, 5 for engineering, 6 for agriculture, 7 for medicine and 8 for education. |
| | Tenure | Years worked. |
| Place Attributes | EXGDPPC | Expected Ratio of per capita GDP for Taiwan to that of the US. |
| | INFTUS | Ratio of the price standard in Taiwan to that of the US. |

Source: Dataset from National Youth Commission.

Since the goal of this study is to examine determinants affecting decision to return, status of return is chosen as the dependent variable. Because the dependent variable is qualitative and has only two possible outcomes: returned vs. not returned, we can construct a binomial-logit model[3] to test relationship between dependent variable and personal attributes, such as tenure, age, sex, specialized area dummies s1 to s7, degree dummies d1 to d3, and place attributes such as income and living cost proxies, expected GDP per capita ratio[4] and inflation rate ratio. We follow the suggestion of Harris and Todaro (1970), and construct the income-difference proxy, expected GDP per-capita ratio as follows:

$$Exgdppc_t \equiv \mathrm{Ex}[Gdppc_{t,tw}] \,/\, \mathrm{Ex}[Gdppc_{t,US}]$$
$$= [\ Gdppc_{t,tw} * (1 - Unemp_{t,tw})\ ] \,/\, [\ Gdppc_{t,US} * (1 - Unemp_{t,US})\ ]$$

where $Gdppc_t$ and $Unemp_t$ are deflated GDP per capita at 1996 price and unemployment rate at year t, and tw and US stands for Taiwan and the United States respectively.[5]

The empirical model applied to estimate probability $p = Pr\ (back=1 \mid tenure, age, sex, s1 \ldots s7, d1 \ldots d3, exgdppc, inftus)$ is:

(1) $$Logit\ (p) \equiv \log\ (\ p\ /\ (1-p)\ ) = a0 + a1Tenure + a2Age + a3Sex + a4S1 + a5S2 + a6S3 + a7S4 + a8S5 + a9S6 + a10S7 + a11D1 + a12D2 + a13D3 + a14Exgdppc + a15Inftus + \varepsilon$$

[3] Another possible approach to examine determinants of migration is to substitute status of return with years in the United States as a dependent variable to construct a survival model. However the National Youth Commission database could not provide this information. Under this constraint, using the logit model is the only feasible approach to study determinants of migration.

[4] Because of asymmetries of unemployment rate and labor income statistics, we use overall unemployment rate and GDP per capita as proxies for the unemployment rate and income of the highly skilled.

[5] We were thus able to integrate effect of unemployment rate into the model.

In order to test for structural change, we also add two time dummies into the model. T1 is equal to zero for the years before 1980, and equal to one after 1981. That is the time point of the establishment of HSIP. T2 is zero for the years before 1988, and equal to one after 1989. That is the time point after the lifting of martial law in Taiwan. The model then becomes:

(2) $Logit\ (p) \equiv \log\ (\ p\ /\ (1\text{-}p)\ ) = a0 + a1Tenure + a2Age + a3Sex + a4S1 + a5S2 + a6S3 + a7S4 + a8S5 + a9S6 + a10S7 + a11D1 + a12D2 + a13D3 + a14\ Exgdppc + a15Inftus + a16T1 + \varepsilon$

(3) (3) $Logit\ (p) \equiv \log\ (\ p\ /\ (1\text{-}p)\ ) = a0 + a1Tenure + a2Age + a3Sex + a4S1 + a5S2 + a6S3 + a7S4 + a8S5 + a9S6 + a10S7 + a11D1 + a12D2 + a13D3 + a14\ Exgdppc + a15Inftus + a16T2 + \varepsilon$

## b. Data description

The datasets from the National Youth Commission consist of a dataset of overseas experts and a dataset of returnees. The datasets contain personal information on overseas experts and returnees, such as sex, birthday, country where the person studied or stayed, return status, degree received, school, major, specialized area and work experience. From the columns on work experience description and school names, information was extracted on total working years and tenure was then calculated. This was followed by further integrating place attributes into the dataset. Place attributes chosen were expected per-capita GDP ratio and inflation-rate ratio, which act as proxies for differences in income and living costs between Taiwan and the United States.

Other variables used in this study are back, sex, age, highest degree received, specialized area, tenure, expected GDP per-capita ratio, inflation-rate ratio and time dummies. Of these, sex, degree and specialized area, all of which are qualitative data, are treated with control dummies.

Descriptive-statistic properties of all variables are listed in tables 2 and 3. Table 2 shows frequency and means of different variables, while Table 3 provides distribution of overseas and returning experts and students by personal traits. It is observed that under the category of gender, male experts and students made up the majority of both overseas and returning experts and students. That said, a larger proportion of male experts and students stayed in the United States and did not return to Taiwan. In contrast, most female experts and students returned to Taiwan after completing their studies.

**Table 2 Frequency and Means of Independent Variables**

| Attributes | Variable Name | | Valid Samples | Sample Means | Standard Deviation |
|---|---|---|---|---|---|
| | Variable | Value | | | |
| Personal Attributes | Sex | 1 | 30,483 | 0.342 | 0.47 |
| | | 2 | 15,864 | | |
| | Degr_id1 | 1 | 10,054 | 1.65 | 0.54 |
| | | 2 | 15,949 | | |
| | | 3 | 485 | | |
| | | 4 | 98 | | |
| | Special | 1 | 2,696 | 4.14 | 1.79 |
| | | 2 | 3,827 | | |
| | | 3 | 881 | | |
| | | 4 | 6,528 | | |
| | | 5 | 10,054 | | |
| | | 6 | 294 | | |
| | | 7 | 1,130 | | |
| | | 8 | 1,570 | | |
| | Age | | 36,741 | 35.49 | 11.4 |
| | Tenure | | 37,507 | 7.41 | 8.99 |
| Place Attributes | EXGDPPC | | 45,777 | 0.44 | 0.064 |
| | INFTUS | | 45,777 | 0.99 | 0.013 |

Note: A total of 46,717 observations were made.

In addition, age is proved by chi-square test to be relevant with status of return. The under-30 age group makes up the majority of returnees, while the majority of those staying abroad are mostly distributed in the age groups from 35 to 55. This finding reflects effect of marital factor according to Mincer (1978). Those, whose ages are between 35 and 55, generally have children of school age and switching jobs and residences causes inconvenience to both themselves and their families.

**Table 3 Distribution of Personal Traits to ReturnStatus**

| Personal Traits | | Status of Return | | Valid Samples |
|---|---|---|---|---|
| | | Overseas | Returnee | |
| Sex | Male | 16,909<br>(36.48) | 13,574<br>(29.29) | 30,483<br>(65.77) |
| | Female | 3,498<br>(7.55) | 12,366<br>(26.68) | 15,864<br>(34.23) |
| Age | Under 30 | 378<br>(1.03) | 17068<br>(46.45) | 17446<br>(47.48) |
| | 31-35 | 971<br>(2.64) | 5970<br>(16.25) | 6941<br>(18.89) |
| | 35-40 | 1505<br>(4.10) | 1750<br>(4.76) | 3255<br>(8.86) |
| | 41-45 | 1952<br>(5.31) | 607<br>(1.65) | 2559<br>(6.96) |
| | 46-50 | 1915<br>(5.21) | 225<br>(0.61) | 2140<br>(5.82) |
| | 51-55 | 1428<br>(3.89) | 57<br>(0.16) | 1485<br>(4.05) |
| | 56-60 | 1128<br>(3.07) | 39<br>(0.11) | 1167<br>(3.18) |

| | | | | |
|---|---|---|---|---|
| | Above 60 | 1715<br>(4.67) | 25<br>(0.07) | 1740<br>(4.74) |
| Area of Specialization | Humanities | 637<br>(2.36) | 2,059<br>(7.63) | 2,696<br>(9.99) |
| | Sciences | 2,909<br>(10.78) | 918<br>(3.40) | 3,827<br>(14.18) |
| | Law | 320<br>(1.19) | 561<br>(2.08) | 881<br>(3.27) |
| | Economics and Business Administration | 1,471<br>(5.45) | 5057<br>(18.74) | 6,528<br>(24.20) |
| | Engineering | 7,365<br>(27.30) | 2,689<br>(9.97) | 10,054<br>(37.26) |
| | Agriculture | 210<br>(0.78) | 84<br>(0.31) | 294<br>(1.09) |
| | Medicine | 799<br>(2.96) | 331<br>(1.23) | 1,130<br>(4.19) |
| | Education | 219<br>(0.81) | 1,351<br>(5.01) | 1,570<br>(5.82) |
| Highest Degree | Doctor | 7,797<br>(29.33) | 2,257<br>(8.49) | 10,054<br>(37.82) |
| | Master | 5,021<br>(18.89) | 10,928<br>(41.10) | 15,949<br>(59.99) |
| | Bachelor | 481<br>(1.81) | 4<br>(0.02) | 485<br>(1.82) |
| | Medicine | 96<br>(0.36) | 2<br>(0.01) | 98<br>(0.37) |

Notes:
1. A total of 46,717 observations were made.
2. Chi-square values for sex, age, specialized area and degree received were 4,728.95, 3,798.50, 7,039.22, and 5,798.51 respectively. All the results are statistically significant.

It is also found that experts and students who studied sciences and engineering tended to stay abroad. These two categories accounted for 73 percent of nonreturning experts and students. In contrast, those who studied economics and business administration tended to return home. This category accounted for 38.75 percent of returnees, followed by those who studied engineering at 20.61 percent.

Another characteristic worthy of mention is the distribution of different degreeholders between returnees and overseas groups. Doctorate holders dominate overseas groups, while Masters degreeholders dominate the returnee group. After closer study of area of specialization for 9,259 doctorate holders, it was found that 2,440 of these specialized in sciences (26.35 percent), and 4,181 in engineering (45.16 percent). Both categories combined account for 71.5 per cent of doctorate holders. These statistics provide further information on characteristics of overseas experts in the United States.

Chi-square tests were also performed on return status and sex, age, specialized area and highest degree received. The results were all statistically significant. This relationship may also be found in the results of logit estimates.

## 3. Empirical Evidence

Estimation results are presented in Table 4. First, effects of specialized-area dummies for humanities, sciences, engineering and medicine are significant at the 1 percent level. Parameter values of control dummies for sciences, engineering and medicine, however, are negative, while parameter value of the control dummy for humanities is positive. This hints that experts specializing in humanities tend to return, while those specializing in sciences, engineering and medicine tend to stay abroad. This finding supports concerns over loss of science and technology human resources.

Second, the degree dummy for doctorate holders has a greater negative parameter coefficient value than the degree dummy for Masters degreeholders. This finding suggests that propensity to return based on degree received is negative; The higher the degree received by overseas experts or students, the greater the possibility that they will find suitable positions abroad, and therefore, stay overseas longer. Furthermore, according to the Glaser (1978) study, the longer they stay abroad, the fewer their connections with their home economy, and therefore, the lower the probability of a return.

Third, the findings suggest that parameter value of tenure is negative; i.e., the longer overseas experts and students work abroad, the lower the probability that they will return. It is quite reasonable for them to stay overseas because otherwise they would need to give up position, tenure and pension rights in present companies. Enormous incentives would have to be provided to compensate for such losses.

Fourth, empirical estimation of the logit model suggests that difference in income level, with GDP per capita as a proxy in this model, has a significant positive effect on decision to return. That is to say, overseas experts and students return to contribute knowledge and technology to economic development of home economies. In contrast, if economic situation in home economies were to remain unchanged or become even worse, overseas experts and students tend to stay abroad due to income disparity or lack of opportunities to contribute talent in home economies.

Fifth, time parameter estimated for time dummy T1 is positive, and the probability difference between T1 = 1 and 0 is (0.7632 – 0.5086) = 0.2546. This result demonstrates that the return rate has a significant change after 1981, when the HSIP has established. It thus implies the positive effect of the establishment of HSIP on recruiting oversea experts and students. HSIP provides a working environment compatible to that of developed countries, and therefore increases incentive to return of oversea experts and students.

## Table 4 Impact of Personal and Place Attributes on Likelihood of Migration (Logit Estimates)

| Variables | Parameter Coefficient | | | | |
|---|---|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** | **Model 4** | **Model 5** |
| Constant | 6.562*** (0.262) | 34.790*** (1.777) | 52.391*** (2.098) | 50.346*** (2.193) | 46.674*** (2.207) |
| **Personal Attributes** | | | | | |
| Tenure | -0.013** (0.005) | -0.004 (0.005) | -0.022*** (0.005) | -0.022*** (0.005) | -0.022*** (0.006) |
| Age | -0.259*** (0.005) | -0.246*** (0.005) | -0.253*** (0.005) | -0.253*** (0.005) | -0.251*** (0.005) |
| Sex | 0.058 (0.055) | 0.122** (0.053) | 0.056 (0.057) | 0.055 (0.057) | 0.037 (0.058) |
| Specialized Area Dummy: Humanities | 0.646*** (0.122) | 0.285** (0.117) | 0.569*** (0.126) | 0.573*** (0.126) | 0.529*** (0.129) |
| Specialized Area Dummy: Sciences | -1.025*** (0.098) | -1.383*** (0.096) | -1.046*** (0.101) | -1.045*** (0.101) | -1.084*** (0.103) |
| Specialized Area Dummy: Law | 0.298* (0.164) | 0.033 (0.157) | 0.185 (0.169) | 0.182 (0.169) | 0.164 (0.173) |
| Specialized Area Dummy: Economics and Business Administration | 0.036 (0.095) | -0.170* (0.093) | -0.013 (0.097) | -0.010 (0.098) | -0.064 (0.100) |
| Specialized Area Dummy: Engineering | -1.505*** (0.085) | -1.737*** (0.084) | -1.520*** (0.087) | -1.520*** (0.087) | -1.548*** (0.089) |
| Specialized Area Dummy: Agriculture | 0.06 (0.253) | -0.576** (0.235) | 0.102 (0.259) | 0.130 (0.261) | 0.136 (0.269) |
| Specialized Area Dummy: Medicine | -0.928*** (0.141) | -1.476*** (0.134) | -1.014*** (0.146) | -1.017*** (0.147) | -1.055*** (0.150) |
| Degree Dummy for Doctor | -1.442*** (0.11) | -2.287*** (0.105) | -1.760*** (0.111) | -1.777*** (0.111) | -2.039*** (0.113) |
| Degree Dummy for Master | -0.985*** (0.112) | -1.847*** (0.106) | -1.267*** (0.113) | -1.291*** (0.113) | -1.575*** (0.115) |
| Degree Dummy for Bachelor | -8.013*** (0.986) | -8.190*** (0.954) | -7.782*** (0.972) | -7.799*** (0.971) | -7.951*** (0.959) |
| **Place Attributes** | | | | | |
| GDP Per-capita Ratio | 13.051*** (0.427) | | 16.772*** (0.514) | 16.013*** (0.563) | 7.547*** (0.760) |
| Inflation-Rate Ratio | | -22.755*** (1.764) | -47.718*** (2.166) | -46.46*** (2.204) | -41.854*** (2.279) |
| **Time Dummy** | | | | | |
| T1 | | | | 1.136*** (0.383) | |
| T2 | | | | | 4.079***\ (0.286) |

Notes:
1. Total 46,716 observations, of which 16,604 observations contain missing values; therefore, 30,959 observations are used in the computation.
2. *** = statistically significant at 1 percent level, and ** at 5 percent level. Standard errors are in parentheses.

Moreover, we further calculated the probability difference between T2 =1 and 0, and found that it is (0.7815 – 0.0571) = 0.7244. This finding supports the study of Rosenthal and Strange (2001), in which they found labor market pooling to be the most robust influence on agglomeration. A great advantage of industry cluster is that cost of staff recruitment would be significant reduced by gathering together. Eight years after the establishment of HSIP, the cluster of high-tech industries has been well shaped, and obtained greater power to attract the most skilled labors, both domestically and internationally.

Finally, living-cost proxy in this model, i.e., inflation-rate ratio, has a significant negative parameter value, which means that a relatively higher living cost may discourage potential returnees. Maintaining a rather stable price standard helps reduce cost of settlement for returnees, while providing a stable economic environment. These last three findings echo the theory of Sjaastad (1962) exactly.

In addition to the above test, the same regression model was also exercised with annual data to observe annual change within the dataset. Results are presented in Table 5. Due to number of valid returned samples distributed mainly after the 1990s, logit estimates for the above model are often insignificant before 1990. By comparing parameter sign of variables, it is found that sign for tenure and specialized-area dummies for sciences and engineering remain negative, while that for degree dummies changes from time to time.

## 4. Conclusion

With the NYC dataset, this paper finds that specialized areas, degree received, sex, age (which could be viewed as a proxy for marital status and children of school age), tenure, the existence of proper job opportunity (e.g. high-tech industrial clusters), differences in expected income levels and living costs between sending economy and receiving economy are all significant determinants of the return of oversea experts. It is found that those with higher degrees and those specializing in high-demand areas of the labor market of receiving economies tend to stay abroad after completing education. The longer they stay abroad, the lower the probability of return. Empirical evidence also shows that the narrower the income gap and lower the living costs, the higher the return rate of experts and students.

Based on results obtained by this study, and difficulties encountered during the research process, our suggestions are twofold. First, a database of science and technology human resources must be established so that the government can help industries find research and professional staff for both innovation and production. This database should collect data on both domestic and foreign experts, namely overseas experts, students and even experts of other nationalities. The Taiwan government could start to build this database by merging data collected by the National Youth Commission, Ministry of Education and National Science Council.

Second, the government should continue its efforts to attract expatriates back. As suggested in this study, assisting returning experts and families adjust to a new life is a good ways to bring them back. In light of the example of HSIP, the said assistance could be realized by the establishment of high-tech industrial parks, which provide both a suitable work opportunities as well as living place. However, the government can also provide further assistance for returning experts so that they can contribute all that they have learned abroad to development of high-tech industries in home economies.

## Table 5 Estimated Coefficients for Personal Traits Variables, 1979-2000

| Variables | 1979 | 1982 | 1983 | 1984 | 1985 | 1986 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tenure | -0.1920** | -0.8427 | 0.1395 | 1.8081 | 0.6231 | 0.0211 | -0.0814 | -0.0542 | -030383 | 0.00185 | 0.0272 | 0.0572 | -0.0371*** | -0.1462*** | -0.2093*** | -030327** | -0.0401** | -0.0002 |
| | (0.0881) | (0.6220) | (7.3251) | (9.4233) | (5.0606) | (0.0610) | (0.1003) | (0.1018) | (0.0541) | (0.0531) | (0.0483) | (0.1119) | (0.0141) | (0.0456) | (0.0341) | (0.0130) | (0.0162) | (0.0179) |
| Age | 0.0467 | -0.3169 | -0.1677 | -2.1704 | -0.1748 | -0.0329 | -0.0520 | -0.0362 | -0.0301 | -0.0266 | 0.0071 | -0.1409 | --0.3224*** | -0.2445*** | -0.1884*** | -0.2049*** | -0.3067*** | -0.2952*** |
| | (0.0617) | (0.2623) | (8.1310) | (4.8875) | (6.3045) | (0.0609) | (0.0714) | (0.0843) | (0.0484) | (0.0540) | (0.0449) | (0.1110) | (0.0147) | (0.0269) | (0.0193) | (0.0118) | (0.0157) | (0.0183) |
| Sex | -1.5360 | -3.9527 | 5.0299 | -7.4503 | 3.0413 | 0.0682 | -8.6764 | -0.8926 | -0.7488 | -10.8588 | -0.7603 | -8.6329 | 0.1701 | -0.0460 | 0.1507 | -0.2499 | 0.0441 | 0.0107 |
| | (1.2567) | (52.6046) | (221.5) | (120.2) | (125.4) | (1.2104) | (50.3530) | (1.2195) | (1.1660) | (83.1132) | (1.2048) | (55.9361) | (0.1608) | (0.3615) | (0.3071) | (0.1722) | (0.1794) | (0.2) |
| S1 | -0.4747 | 6.6199 | 3.2057 | -3.9206 | 4.6415 | -9.8525 | -10.8075 | -0.6188 | -11.0168 | -12.9223 | -0.6738 | -2.0723 | 1.1944*** | 0.4813 | -0.8683 | 0.9545*** | 1.0162*** | 1.2561*** |
| | (1.4117) | (225.7) | (178.5) | (295.3) | (405.9) | (88.2904) | (186.4) | (1.2954) | (640.8) | (274.8) | (1.3065) | (212.1) | (0.3571) | (1.0190) | (0.7345) | (0.3527) | (0.3346) | (0.4161) |
| S2 | -0.9290 | 2.3576 | -0.5392 | -14.8206 | -10.8570 | -2.4295* | -11.4078 | -2.7774** | -0.0360 | -3.4685*** | -11.1452 | -1.0174 | -0.5193* | -1.9923*** | -1.8289*** | 0.0060 | 0.1303 | -0.1299 |
| | (1.2853) | (162.6) | (143.8) | (84.2463) | (298.6) | (1.2984) | (65.2245) | (1.2313) | (1.3784) | (1.1634) | (117.1) | (1.5599) | (0.2877) | (0.6925) | (0.5487) | (0.2796) | (0.2876) | (0.3213) |
| S3 | -11.2555 | 6.4698 | 18.7928 | -4.7716 | -10.7687 | -9.8348 | -0.0963 | -11.2543 | 1.6809 | -1.6587 | -11.5672 | -10.0786 | 1.1152** | -0.1897 | -1.8492** | 0.9024* | 1.5001*** | 0.5387 |
| | (111.6) | (242.1) | (101.0) | (413.9) | (300.2) | (124.4) | (1.1633) | (212.8) | (1.6785) | (1.2221) | (473.9) | (173.3) | (0.4677) | (1.0964) | (0.8904) | (0.4833) | (0.5217) | (0.4895) |
| S4 | -2.2043 | 4.8468 | 8.8820 | -12.5251 | 4.3472 | -10.0053 | -11.0983 | -11.6305 | -11.7695 | -13.5970 | -10.8741 | -9.3654 | 0.2471 | -1.8001*** | -1.3590*** | 0.7559*** | 1.1527*** | 0.5465* |
| | (1.6106) | (174.4) | (304.9) | (568.9) | (282.0) | (80.9208) | (115.8) | (108.4) | (336.5) | (155.9) | (169.6) | (102.6) | (0.2787) | (0.6066) | (0.4655) | (0.2774) | (0.2839) | (0.3163) |
| S5 | -11.2400 | 9.7274 | 1.3584 | -18.2988 | -11.1518 | -2.2666** | -11.7374 | -11.8516 | -033971 | -3.9436*** | -2.1056** | -1.7467 | -0.9663*** | -3.7647*** | -2.0859*** | -0.6924*** | -0.4748* | -0.4421 |
| | (37.0209) | (152.4) | (95.7680) | (105.5) | (283.4) | (1.0614) | (46.6907) | (50.7810) | (1.2804) | (1.0709) | (0.9164) | (1.3459) | (0.2482) | (0.4951) | (0.4090) | (0.2413) | (0.2551) | (0.2776) |
| S6 | -9.8479 | 5.0877 | 6.9900 | 18.2249 | - | -10.2480 | -11.7622 | -11.6962 | -11.4338 | -0.0711 | -11.3245 | -9.9851 | 0.0372 | 1.0280 | 1.5854 | 1.2521** | 2.0761** | 0.3576 |
| | (118.3) | (215.3) | (461.5) | (227.8) | | (152.9) | (334.8) | (278.3) | (1103.1) | (1.4044) | (394.9) | (427.6) | (0.8036) | (1.4807) | (1.3435) | (0.5931) | (0.8780) | (0.9397) |
| S7 | -10.0596 | -1.1026 | -0.8169 | -13.3147 | -4.1451 | -9.6592 | -10.7089 | -11.2050 | 2.3961 | -1.8879 | -10.9158 | -8.9738 | -0.4160 | -2.8920** | -2.4298*** | 0.4849 | -0.3887 | -0.2256 |
| | (110.9) | (533.1) | (242.8) | (110.2) | (310.8) | (65.7103) | (141.2) | (159.1) | (1.4829) | (1.4162) | (187.8) | (137.6) | (0.4423) | (1.3564) | (0.9182) | (0.4156) | (0.4601) | (0.4824) |
| D1 | 0.1703 | -3.8897 | -0.5984 | 7.4873 | -0.0298 | 6.1515 | 9.2861 | 8.1299 | -1.5648 | 11.7074 | 8.8591 | 8.9431 | 0.3747 | -4.1535*** | -3.5297*** | 1.3561*** | 14.9102 | 3.4251*** |
| | (221.2) | (524.2) | (275.3) | (1298.8) | (368.1) | (159.5) | (149.8) | (163.8) | (1.3474) | (232.6) | (174.7) | (161.0) | (0.4120) | (0.5498) | (0.4753) | (0.4194) | (198.6) | (0.7162) |
| D2 | 1.3807 | -5.6389 | -14.3016 | -5.7084 | -2.8325 | 5.8441 | 7.8168 | 8.0004 | -1.9070 | 9.7817 | 9.1261 | -0.2528 | 0.7805* | -3.4450*** | -2.5321*** | 1.9342*** | 15.8333 | 3.9668*** |
| | (221.2) | (524.2) | (280.9) | (1303.6) | (365.5) | (159.5) | (149.8) | (163.8) | (1.4202) | (232.6) | (174.7) | (169.8) | (0.4105) | (0.5563) | (0.4666) | (0.4223) | (198.6) | (0.7132) |
| D3 | -4.7635 | -3.1973 | -16.3381 | 1.1045 | - | -1.4793 | 4.8575 | -0.4831 | -12.1755 | 0.1294 | -0.5318 | 0.2892 | -16.8579 | -21.5068 | -19.5300 | -1.3450 | 0.5534 | -11.8802 |
| | (251.2) | (530.5) | (354.6) | (1397.0) | | (175.3) | (200.2) | (203.9) | (553.5) | (298.2) | (307.5) | (199.5) | (546.1) | (971.0) | (931.6) | (1.2861) | (462.3) | (507.3) |

*Notes:*

1. ** stands for statistical significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level. Standard errors are in parentheses.*
2. *Due to insufficient sample size, Chi-square value of likelihood ratio for the years 1982-86, 1990, 1992-93 is not statistically significant at the 10 percent level.*

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