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# Demand for industrial management manpower in Taiwan

## Viewpoints of quantity and skill

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**Introduction**

Analysis of manpower demand is an important area of human resource planning which has made significant contributions to human resource management. Planning to meet future needs for skills is the most frequently cited reason given by employers for engaging in human resource planning (Greer and Armstrong, 1980). In a survey of top management involvement in human resource planning, Kahalas *et al.* (1980) find that the need for higher quality human resources is the main motivating factor in that involvement. A variety of demand forecasting techniques have been used. Some involve subjective estimation, others make use of objective data. The best-known subjective method is the Delphi method which solicits forecasts from a group of experts in a systematic manner (Milkovich *et al.* 1972). Among the objective methods, regression analysis is probably the most widely adopted forecasting technique (Bright, 1976; Drui, 1963; Kao and Lee, 1996; Meehan and Ahmed, 1990; Rudelius, 1976; Schaeffer, 1974). A similar technique is time series analysis (Bartholomew *et al.*, 1991), which forecasts future demands by projecting from past demands. There are also other objective methods like stochastic model (Kwak *et al.* 1977), simulation (Greer and Armstrong, 1980), ratio analysis (Dyer, 1982), and others (Charnes *et al.*, 1978).

One trend in the industrialized societies of the world is the continuous increase of labor costs. Another trend is the shifting of the work force by manufacturing industries toward the service sector. To compensate the increase in salaries and shortage in workforce in manufacturing industries, the productivity must be improved. Many studies (Burnham, 1982; Chirillo, 1989; El Mhamedi and Binder, 1992) indicate that technology and management are the two broad categories of factors which have major influence on productivity. From an empirical study of the machinery firms in Taiwan, Kao *et al.* (1996) conclude that management has a

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stronger effect than technology does on productivity. Kao *et al.* (1997a) investigate the career development in industrial management (IM), and Kao *et al.* (1997b) explore the external suppy of IM. This paper, on the other hand, studies the demand of manufacturing firms for IM manpower in Taiwan.

Much of the literature on demand analysis is devoted to manpower forecasting at the corporate level. As a matter of fact, manpower demand at the industry level is of no less importance. The forecasted quantity serves as a basis for decision making on establishing new university departments or increasing the enrollment of the related departments. This is very important to the economic development of a country. Insufficient supply of manpower hinders the development of the related industry, whereas over-supply results in unemployment and is a waste of public resources. Although the manpower demand of the whole industry is essentially the sum of the manpower demands of individual firms, it is hardly possible to investigate the whole industry due to the large population size. Sampling is one possibility; however, more than half of the firms (55 per cent in the US and 62 per cent in Taiwan) close out within five years of their operations, indicating that the data collected will be unreliable for analysis. To solve this problem, an integration model which utilizes the reliable data of large firms to draw inferences to other firms is built in this paper. As an illustration, the IM manpower demands for three education levels, namely, junior college, university, and graduate school, for manufacturing industries in Taiwan, Republic of China, are forecasted.

In addition to quantity, another aspect of concern to many firms in demand analysis is the skills of the employees required for performing their tasks. In this paper, the skills required by the IM employees are also investigated. The differences among education levels and among industries are analyzed. This result serves as a guideline for universities in designing their curricula.

In the following sections, first, the data collected for this study are described. Then, how to forecast the quantity of IM manpower demanded at the firm level as well as the industry level is discussed. Finally, the skills required by the IM employees as perceived by the manufacturing industries are analyzed.

## Sample profile

The data collected for this study are solicited from the manufacturing firms in the Republic of China on Taiwan. Taiwan is an island of approximately 36,000 square kilometers with 21 million habitants; together with South Korea, Hong Kong, and Singapore, being considered as four dragons in Asia. Its foreign trade in terms of total amount of imports and exports ranks fourteenth in the world. Recently, the international reserves of Taiwan have reached 100 billion US dollars, second only to Japan. This economic accomplishment is mainly due to the excellent performance of the manufacturing firms, especially those of light industries. Since management plays a more important role than technology on productivity improvement (Kao *et al.* 1996), it seems worthwhile to study the IM manpower demand of the manufacturing firms in Taiwan from the viewpoints of both quantity and skill.

In Taiwan, there are approximately 122,500 registered manufacturing firms, among which around 121,000 firms are of small business. Small business of manufacturing industries as defined by the Ministry of Economic Affairs of the Republic of China is the company with capital investment of no more than 60 million New Taiwan dollars (NT$30≅US$1). In a sample survey of 4,000 small companies in Taiwan concerning the demand for general management manpower, Kao (1986) finds that none of the companies expresses the desire of hiring university graduates with a major in general management. This indicates that the manpower demand of small companies for a particular profession is almost negligible, any extraordinary case which appeared in sampling would result in a conclusion which is misleading. As a comparison, in the same survey of all of the 500 largest companies and 1,500 companies of the remaining large companies in Taiwan, the average number of general management employees demanded by each company is 2.467 persons and 0.039 persons, respectively (Kao, 1986). The manpower demand apparently concentrates on large companies. Therefore, it seems more appropriate to study large companies to acquire reliable data and make suitable extrapolations to small companies.

Among the 122,500 manufacturing firms in Taiwan, only approximately 1,500 firms are of large business (Commonwealth, 1994). For the top 1,000 firms, four have more than 10,000 employees and 78 have less than 100 employees. The range of the number of employees is rather wide. Since most of the firms ranked from 1,001 to 1,500 have less than 100 employees and their demands for IM manpower are considerably fewer, the investigation of this paper is confined to the top 1,000 firms.

To ensure that the data collected for this study are correct, an on-site visit of the firms is planned. However, as time and expenses are concerned, a sample of 100 firms instead of the complete 1,000 firms are investigated. Table I is a profile of the sampled firms, in that 18 firms are of the top 200 firms; and 20, 25, 21, and 16 firms are in the subsequent rank-classes of 200 firms. Visually, these 100 sampled firms are somewhat even-distributed over the five rank-classes. If we classify the manufacturing industries into five categories: electrical, chemical, mechanical, textile, and food, then there are 25, 19, 22, 18, and 16 sampled firms in each category. Each investigated firm is requested to provide the number of IM employees hired in 1994 and 1995 with different education levels. The average demands of the firms in different rank-classes are also recorded in Table I. As expected, higher ranked firms have higher manpower demand. In the following, the IM manpower demand in terms of quantity and skill requirements are discussed in sequence.

## Quantity demand

One major problem in forecasting the manpower demand for a profession is the erratic behaviour of a few small firms. To overcome this problem, this paper adopts the integration model proposed by Kao and Lee (1996) to concentrate the effort on large firms and to infer the effect on small firms. Referring to Figure 1, by assuming that smaller firms need fewer employees, a regression line of negative slope which shows the average manpower demand for companies of

| | Rank-class 1-200 | 201-400 | 401-600 | 601-800 | 801-1,000 | Total (Ave.) |
|---|---|---|---|---|---|---|
| Number of sampled firms | 18 | 20 | 25 | 21 | 16 | 100 |
| Electrical industry | 5 | 3 | 9 | 3 | 5 | 25 |
| Chemical industry | 3 | 5 | 5 | 3 | 3 | 19 |
| Mechanical industry | 3 | 4 | 6 | 6 | 3 | 22 |
| Textile industry | 4 | 5 | 2 | 4 | 3 | 18 |
| Food industry | 3 | 3 | 3 | 5 | 2 | 16 |
| Average demand of 1994 | 12.39 | 2.85 | 1.88 | 1.09 | 0.56 | 3.59 |
| Junior college | 5.89 | 1.55 | 0.92 | 0.57 | 0.19 | 1.75 |
| University | 5.22 | 0.90 | 0.72 | 0.33 | 0.38 | 1.43 |
| Graduate school | 1.28 | 0.40 | 0.24 | 0.19 | 0 | 0.41 |
| Average demand of 1995 | 12.72 | 3.15 | 1.96 | 1.05 | 0.69 | 3.74 |
| Junior college | 6.00 | 1.60 | 1.12 | 0.43 | 0.19 | 1.80 |
| University | 5.33 | 1.05 | 0.52 | 0.48 | 0.50 | 1.48 |
| Graduate school | 1.39 | 0.50 | 0.32 | 0.14 | 0 | 0.46 |

**Table I.** Data of the investigated firms

different ranks, in terms of the number of employees, can be fitted from the data of some large companies. The point where the regression line intersects the x-axis indicates that the demands of the companies with ranks higher than this point are negligible. The area of the triangle under the regression line serves as an estimate of the total manpower demand of the whole industry. A confidence interval for the total demand can also be constructed.

To estimate the total manpower demand for 1994, several regression models have been attempted for different education levels by using rank as the independent variable and the number of employees hired as the dependent variable. Since the demands from larger firms have larger variance, a weighted least-squares approach has been applied. The one which best fits the data is the double-log model:

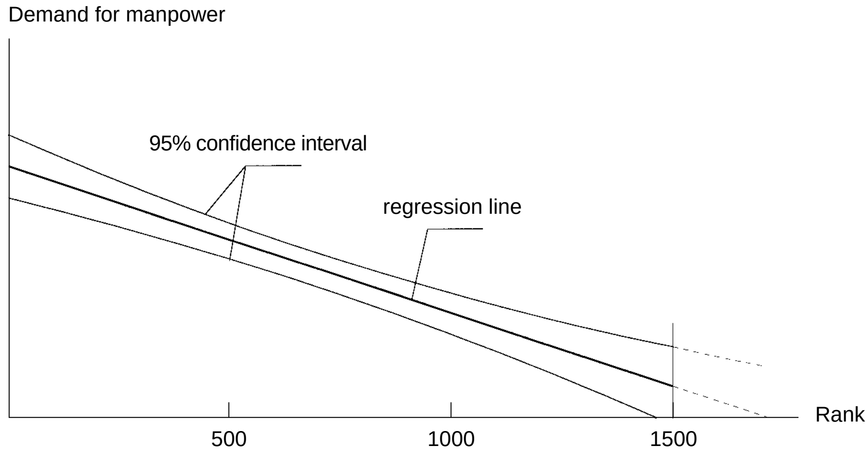


**Figure 1.** A regression line and its 95 per cent confidence limits

*Junior college*

$$\ln(\mathrm{DEMAND}_{94}+1)=5.1256-0.7625*\ln(\mathrm{RANK}) \quad (1a)$$
$$(33.61)\ (-30.14)$$

F-statistic=908.71, p-value<0.0001, MSE=0.01138, $R^2$=0.9027

*University*

$$\ln(\mathrm{DEMAND}_{94}+1)=4.1872-0.5404*\ln(\mathrm{RANK}) \quad (1b)$$
$$(23.25)\ (-18.53)$$

F-statistic=343.19, p-value<0.0001, MSE=0.01649, $R^2$=0.7779

*Graduate school*

$$\ln(\mathrm{DEMAND}_{94}+1)=2.7817-0.3553*\ln(\mathrm{RANK}) \quad (1c)$$
$$(21.33)\ (-13.77)$$

F-statistic=189.60, p-value<0.0001, MSE=0.01871, $R^2$=0.6592

where the numbers in parentheses are t-statistics. As a matter of fact, “Zipf's law” (Simon, 1955; Wyllys, 1981) also states that frequency and rank have the following relationship: ln(frequency)=$c - b\ln(\text{rank})$, where $b$ and $c$ are constants. This law is another justification for using the double-log model.

All three models have 98 degrees of freedom. The reason for using DEMAND+1 instead of DEMAND as the dependent variable is because some sampled demands are zero, which causes the logarithm operations to be undefined. As revealed by the p-values, all three models are significant in a statistical sense. As the rank increases, the demand decreases. Using junior college as an example, the demand drops to zero when the rank reaches 1193.55. Therefore, the expected total demand for IM manpower with education level of junior college is:

$$\int_0^{1193.55}\{\exp[5.1256-0.7625*\ln(x)]-1\}dx=1942.29 \quad (2)$$

Similarly, the total demands for education levels of university and graduate school can be estimated from (1b) and (1c) as 1416.13 and 302.06 persons, respectively. The sum of these three education levels is 3660.48 persons.

In forecasting, one mechanical extrapolation procedure which is widely used for short-term predictions is the naive model, in that the predicted value for the next period is the same as the value in the present period (Seo and Winger, 1979). This method is especially useful when the amount of data for analysis is insufficient. Based on this no-change model, the demand in 1995 can be predicted by the demand of 1994. To verify how reliable this prediction is, the 1995 data gathered from the investigation are fitted with three regression lines as we did for the 1994 data:

*Junior college*

$$\ln(\mathrm{DEMAND}_{95}+1)=5.0440-0.7199*\ln(\mathrm{RANK}) \quad (3a)$$
$$(25.14)\ (-21.24)$$

F-statistic=451.28, p-value<0.0001, MSE=0.01535, $R^2$=0.8216

*University*

$$\ln(DEMAND_{95}+1)=4.0743-0.5156*\ln(RANK) \quad (3b)$$
(20.73) (–16.41)

F-statistic=29.38, p-value<0.0001, MSE=0.01741, $R^2$=0.7332

*Graduate school*

$$\ln(DEMAND_{95}+1)=2.8099-0.3629*\ln(RANK) \quad (3c)$$
(19.20) (–12.92)

F-statistic=166.83, p-value<0.0001, MSE=0.02087, $R^2$=0.6300

From these regression lines, the total demands for junior college, university, and graduate school are estimated as 1978.18, 1473.07, and 340.59 persons, respectively. These values are respectively 1.8, 4.0 and 12.8 per cent higher than those predicted from the data of 1994. The sum of these three education levels is 3791.84 persons. When the three education levels are considered as a whole, the increment is 3.6 per cent. Except for graduate school, the differences in these percentages are not much. Fortunately, the 12.8 per cent increment in graduate school is not a large amount in terms of persons. Therefore, the naive model seems suitable for making predictions in this study.

By the same token, the demand of 1996 can be predicted from the demand of 1995. To wit, the demand for junior college, university, and graduate school are respectively 1978.18, 1473.07, and 340.59. By plugging the rank of a company into the regression lines, one derives the manpower demands for different education levels for this company.

As errors are always involved in sampling, the above estimations may not be exact. Therefore, a confidence interval will be informative. Referring to Figure 1, a pair of confidence limits for a regression line can be constructed by connecting the confidence intervals of the estimated demand of each rank. The bounds for the estimated total demand are the areas under the confidence limits. Taking junior college as an example, the regression line of 1995 intersects the x-axis at 1320.15. Consequently, the upper bound U and the lower bound L of the confidence interval are constructed as:

$$U=\int_0^{1320.15}\left\{\exp\left[\begin{matrix}5.0440-0.7199*\ln(x)+\\ t_{(1-\alpha/2,n-2)}\sqrt{MSE\left(\frac{1}{n}+\frac{(x-\bar{x})^2}{\sum_i(x_i-\bar{x})^2}\right)}\end{matrix}\right]-1\right\}dx$$

$$L=\int_0^{1320.15}\left\{\exp\left[\begin{matrix}5.0440-0.7199*\ln(x)-\\ t_{(1-\alpha/2,n-2)}\sqrt{MSE\left(\frac{1}{n}+\frac{(x-\bar{x})^2}{\sum_i(x_i-\bar{x})^2}\right)}\end{matrix}\right]-1\right\}dx \quad (4)$$

According to the above formula, a 95 per cent confidence interval for the estimated total demand for junior college is calculated as [1854.02, 2109.71].

Similarly, the confidence intervals for education levels of university and graduate school are [1357.06, 1597.71] and [298.76, 386.18], respectively.

Since we now have estimations of two consecutive years, namely, 1994 ($y_{94}$) and 1995 ($y_{95}$), the proportional-change model for predicting the demand of 1996 ($\hat{y}_{96}$) can be applied (Seo and Winger, 1979):

$$\hat{y}_{96}=y_{95}+k(y_{95}-y_{94}) \quad (5)$$

where k is a prespecified parameter in that smaller values imply conservative predictions while larger values imply risky predictions. When there is no adequate data for a better choice of k, an equal-change model which sets k to 1 is usually used. Under the equal-change model, the demands in 1996 for junior college, university, and graduate school are predicted as 2014.07, 1530.01, and 379.12, respectively. Notably, all these values fall into their respective confidence intervals constructed in the preceding paragraph. In the future, as data of more years are accumulated, a time series analysis can be conducted to derive more accurate predictions.

## Skill requirements

One basic function of human resource management is to match the organization's work requirements to people who are able and willing to meet those requirements. In the preceding section, the demand for IM manpower in terms of quantity is discussed. In this section, the emphasis is placed on skill requirements. Particularly, what educational disciplines in a broad sense are required in fulfilling their tasks.

In order to grasp some idea of the training expected by the manufacturing industries for the IM employees, the disciplines are broadly classified into seven categories: basic knowledge, language abilities, production, marketing, finance, human resource, and information. Among which production, marketing, finance, and human resource are the four major managerial functions; and information is considered by many scholars as the new emerging function. Basic knowledge, e.g. mathematics, chemistry, physics, etc. is the basis of certain industries and also serves as a training for logical thinking. Language abilities, mainly in English and Japanese, are becoming more and more important in this new era of globalization. Each investigated firm is questioned about the relative importance of each discipline in fulfilling the task requirements in a scale of 0 to 5. Table II contains the average scores solicited from the 100 investigated firms for different educational disciplines, industries, and education levels.

To detect the differences among educational disciplines, industries, and education levels, a three-factor analysis of variance is conducted. Table III summarizes the results. The small p-values indicate that the three main effects are all significant while all of the interactions, including the two-factor interactions and the three-factor interaction, are not. Since the differences within education levels, industries, and educational disciplines, respectively, are significant, it is worthwhile to identify what causes these differences.

| Industries | Basic | Language | Production | Marketing | Finance | HR | Information |
|---|---|---|---|---|---|---|---|
| *Electrical industry* | | | | | | | |
| Junior college | 3.44 | 3.96 | 4.16 | 3.72 | 3.76 | 3.56 | 4.16 |
| University | 3.56 | 4.20 | 4.24 | 3.84 | 4.00 | 3.76 | 4.16 |
| Graduate school | 3.64 | 4.32 | 4.20 | 3.84 | 4.04 | 3.80 | 4.12 |
| *Chemical industry* | | | | | | | |
| Junior college | 3.63 | 3.68 | 3.94 | 3.47 | 3.42 | 3.42 | 4.00 |
| University | 3.84 | 4.21 | 4.11 | 3.68 | 3.94 | 3.68 | 4.16 |
| Graduate school | 3.84 | 4.26 | 3.94 | 3.74 | 4.05 | 3.73 | 4.32 |
| *Mechanical industry* | | | | | | | |
| Junior college | 3.72 | 3.82 | 4.22 | 3.50 | 3.32 | 3.50 | 4.09 |
| University | 3.82 | 4.18 | 4.36 | 3.68 | 3.77 | 3.68 | 4.27 |
| Graduate school | 3.86 | 4.36 | 4.23 | 3.82 | 3.95 | 3.68 | 4.32 |
| *Textile industry* | | | | | | | |
| Junior college | 3.72 | 3.72 | 4.39 | 4.06 | 3.89 | 3.50 | 4.17 |
| University | 3.89 | 4.28 | 4.44 | 4.28 | 4.17 | 3.67 | 4.28 |
| Graduate school | 3.78 | 4.39 | 4.5 | 4.28 | 4.22 | 3.78 | 4.39 |
| *Food industry* | | | | | | | |
| Junior college | 3.75 | 3.69 | 4.06 | 3.69 | 3.81 | 3.69 | 4.13 |
| University | 3.81 | 4.06 | 3.94 | 4.00 | 4.06 | 3.69 | 4.19 |
| Graduate school | 3.88 | 4.25 | 3.88 | 4.13 | 4.13 | 3.75 | 4.25 |

**Table II.** Importance scores of different disciplines solicited from the investigated firms

Table IV lists the number of observations, means, standard deviations, ranks, etc. for each factor. The first part is education level. The mean values indicate that persons with higher education level are expected to be more knowledgeable in each discipline. However, a Tukey's multiple comparison test shows no significant difference between university and graduate school. Therefore, two classes are distinguished: university and graduate school in the first class and junior college in the second, as indicated in the last column of Table IV. The middle part of Table IV concerns industry, where the textile industry has the highest mean score, followed by the food, electrical, mechanical, and chemical industries. The Tukey's multiple comparison procedure categorizes the five

| Source of variation | DF | SS | MS | F-value | p-value |
|---|---|---|---|---|---|
| Model | 104 | 157.83 | 1.5176 | 3.24 | <0.0001 |
| Education | 2 | 26.44 | 13.2205 | 28.19 | <0.0001 |
| Industry | 4 | 10.91 | 2.7274 | 5.81 | <0.0001 |
| Discipline | 6 | 83.12 | 13.8538 | 29.54 | <0.0001 |
| Education*industry | 8 | 1.29 | 0.1618 | 0.34 | 0.9484 |
| Education*discipline | 12 | 9.99 | 0.8321 | 1.77 | 0.1071 |
| Industry*discipline | 24 | 22.45 | 0.9356 | 1.99 | 0.0829 |
| Education*industry*discipline | 48 | 3.62 | 0.0755 | 0.16 | 1.0000 |
| Error | 1995 | 935.73 | 0.4690 | | |
| Total | 2099 | 1093.56 | | | |

**Table III.** ANOVA table for the three-factor analysis

**Table IV.** Tukey's multiple comparison tests

| Factor | N | Mean | SD | Rank | Class |
|---|---|---|---|---|---|
| *Education* | | | | | |
| Graduate school | 700 | 4.0429 | 0.7419 | 1 | 1 |
| University | 700 | 3.9943 | 0.6595 | 2 | 1 |
| Junior college | 700 | 3.7843 | 0.7358 | 3 | 2 |
| *Industry* | | | | | |
| Textile | 378 | 4.0847 | 0.7011 | 1 | 1 |
| Food | 336 | 3.9435 | 0.6370 | 2 | 2 |
| Electrical | 525 | 3.9181 | 0.7784 | 3 | 2 |
| Mechanical | 462 | 3.9134 | 0.7163 | 4 | 2 |
| Chemical | 399 | 3.8622 | 0.7219 | 5 | 2 |
| *Discipline* | | | | | |
| Production | 300 | 4.1833 | 0.6865 | 1 | 1 |
| Information | 300 | 4.1800 | 0.6018 | 2 | 1 |
| Language | 300 | 4.1000 | 0.6568 | 3 | 1 |
| Finance | 300 | 3.8933 | 0.7374 | 4 | 2 |
| Marketing | 300 | 3.8333 | 0.7122 | 5 | 2 |
| Basic | 300 | 3.7333 | 0.7051 | 6 | 2,3 |
| Human resource | 300 | 3.6600 | 0.7525 | 7 | 3 |

industries into two classes: textile in one class and the remaining four industries in the other. Textile industry has long been the most successful industry in Taiwan (it is now being replaced by the computer industry). The higher discipline requirements seem to be an explanation for this phenomenon.

With regard to disciplines, the one receiving the most attention is production. This is reasonable because the industries investigated in this study are manufacturing industries where production is the major managerial function. The second important discipline is information. In this era of information, this result is not surprising. It is worthwhile to note that language abilities are considered as the third important discipline. To cope with the active foreign trade activities, demand for foreign language abilities is understandable. The importance of these three disciplines are statistically insignificant. Basic knowledge and human resource are the two least important disciplines. This also conforms to one's intuition. Basic knowledge is a basis for studying other advanced courses, and is not directly applicable to industries. Human resource management in Taiwan is still stagnating at the stage of executing the existed rules, rather than planning and developing new systems. Therefore, these two disciplines are the least important ones as conceived by the industries. The importance of the remaining two disciplines, namely, marketing and finance, are in between. Note that basic knowledge can be categorized as either in the second or the third class.

## Conclusion

Human resource is the most precious resource of an organization. This paper studies the manpower demand from the viewpoints of both quantity and skill.

To forecast the demand in terms of quantity, regression models are built by using the rank of the firm as the independent variable and the number of employees needed as the dependent variable. By plugging the rank into the regression model, the expected number of employees demanded by the associated firm is calculated. The total demand of the whole industry is derived by integrating the regression line from zero to the point where the regression line intersects the x-axis. Demands of individual firms and the whole industry are estimated from one model. The empirical study of the manufacturing industries in Taiwan forecasts that 3,792 IM employees are needed in 1996. As far as the education levels are concerned, the largest demand occurs at junior college (1,978 persons or 52.2 per cent), followed by university (1,473 persons or 38.8 per cent) and graduate school (341 persons or 9.0 per cent).

In the discussion of skill requirements, the disciplines required for performing the tasks are analyzed. Based on a three-factor analysis of variance, the manufacturing firms in Taiwan expect an IM employee to have good training in production management, information management, and foreign language abilities. This analysis provides a guideline for the related university departments to revise their curricula.

Although the illustrative study of this paper is the IM manpower demand of the manufacturing firms in Taiwan, the methodology is generic enough to be applicable to other professions in other countries.

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