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## Japan remains fifteenth in Potential Competitiveness Ranking for 50 countries

### [ Key Points ]

- (1) We have created a potential competitiveness ranking for 50 countries. Potential competitiveness is a measure of a country's ability to increase per-capita GDP over the next ten years.
- (2) Japan ranked sixth in 1980, ninth in 1990, then dropped to fifteenth in 2000, and has remained there in the latest measurement period. Japan is strong in "science and technology", while it is weak in "government", "infrastructure" and "finance".
- (3) The latest measurement ranks Hong Kong first, Singapore second, and the United States third. Statistical revision has moved Hong Kong into first place, displacing the United States from the position it held until 2002. Fourth and subsequent high-ranking places are taken by European countries and Canada. China has edged up to 35th in the latest measurement from 37th in 2000 and 36th in 2002.

### Introduction

We have developed a ranking of potential competitiveness for 50 countries. The rankings have been created for 1980, 1990, 2000, 2002 and the most recent (latest) period. The latest-period rankings are primarily based on 2003 data, while also including 2002 data on education, science and technology, as well as 2004 statistical information technology (IT) data. In short, competitiveness has been measured on the basis of current data.

We have ranked countries by eight determinants of competitiveness: (1) internationalization, (2) enterprise, (3) education, (4) finance, (5) government, (6) science and technology, (7) infrastructure, and (8) IT, and have then generated overall potential competitiveness indices (see "Ranking Method" for the method employed) using Principal Component Analysis (see Annotation 1 "Principal Component Analysis").

### 1. Rankings results

#### In overall competitiveness, Hong Kong comes in first place

Hong Kong comes in first in the latest potential competitiveness measurement (see Fig. 1). The United States, which ranked first in 2002, has receded to third place and Singapore ranks second, as it did in 2002.

Hong Kong's improvement is largely due to positive movements in government and science and technology, by 15 and 11 places, respectively, due to revision of statistical data. In respect to government, Hong Kong has previously not made public the "ratio of customs duties to tax revenue", which indicates the degree of its openness to trade. The ratio was estimated at a percentage similar to

that of Singapore (2.6%). This time, however, Hong Kong announced that the ratio is 0.6%, which revealed a high degree of trade openness and contributed to a higher ranking. Also, in science and technology, Hong Kong has revised the “number of engineers per 10,000 R&D staff” significantly upwards from 93.5 in the 1995 compilation to 1,568 in 2002. The revised statistics have shown Hong Kong’s real capabilities and the country now ranks first for internationalization, seventh for IT, and eighth for enterprise. Yet, it is in 24th and 25th place for education and science, respectively.

The United States has fallen in terms of government, internationalization, enterprise, and education. It has receded to second place for internationalization, where it was first in 2002, because of lower growth in exports and imports than Hong Kong. By item, the United States only comes in first for science and technology and IT. The lower ranking for government is attributable to its ever-worsening fiscal deficits.

There has been no significant item-wise change for second-ranking Singapore. The simple fact is that the United States and Hong Kong have changed places.

China was in 41st place in 1990, 37th in 2000, and has now advanced to 35th place. It ranks 12th for internationalization and 28th for science and technology. It ranks 30th or lower for other items. China’s low ranking compared with its strong presence in international trade is attributable to the measurement of national economic strength, which covers not only the rapidly developing coastal regions but also the inland regions that are lagging behind in terms of economic development.

The ranking for China including Hong Kong, as computed by nominal GDP-weighted competitiveness indicators, was 36th in 1980 (40th for China alone), 34th in 1990 (41st), 33rd in 2000 (37th), and 30th (35th) for the latest measurement period.

Table 1 Rankings of the top three countries

|                      | Hong Kong  | Singapore  | United States |
|----------------------|------------|------------|---------------|
| Overall              | 1<br>(3)   | 2<br>(2)   | 3<br>(1)      |
| Internationalization | 1<br>(2)   | 3<br>(3)   | 2<br>(1)      |
| Enterprise           | 8<br>(9)   | 6<br>(7)   | 7<br>(6)      |
| Education            | 24<br>(15) | 31<br>(32) | 4<br>(3)      |
| Finance              | 1<br>(1)   | 3<br>(3)   | 10<br>(11)    |
| Government           | 14<br>(29) | 1<br>(4)   | 23<br>(17)    |
| Science              | 25<br>(36) | 21<br>(22) | 1<br>(1)      |
| Infrastructure       | 2<br>(2)   | 1<br>(1)   | 13<br>(13)    |
| IT                   | 7<br>(9)   | 12<br>(12) | 1<br>(1)      |

Note: Numbers in parentheses are 2002 rankings

### Japan remains in 15th place

Japan remains in 15th place for overall competitiveness (see Table 2). Item-wise, Japan has improved with respect to enterprise and internationalization, which are responsive to short-term economic factors, but has remained low for government and education, areas afflicted by structural problems.

Table 2 Japan's ranking

|                      | Deviation |        |        | Ranking |        |        |
|----------------------|-----------|--------|--------|---------|--------|--------|
|                      | 2002      | Latest | Change | 2002    | Latest | Change |
| Overall              | 58.0      | 57.9   | -0.1   | 15      | 15     | 0      |
| Internationalization | 49.1      | 49.9   | 0.7    | 17      | 17     | 0      |
| Enterprise           | 63.9      | 64.3   | 0.5    | 4       | 4      | 0      |
| Education            | 59.0      | 58.4   | -0.6   | 10      | 11     | -1     |
| Finance              | 48.6      | 47.4   | -1.3   | 24      | 27     | -3     |
| Government           | 52.4      | 52.5   | 0.1    | 28      | 28     | 0      |
| Science              | 68.3      | 68.2   | 0.0    | 2       | 2      | 0      |
| Infrastructure       | 49.9      | 49.5   | -0.4   | 26      | 27     | -1     |
| IT                   | 58.3      | 57.6   | -0.7   | 15      | 17     | -2     |

Japan ranks second for science and technology and fourth for enterprise. It ranks tenth or lower for other items. Particularly with respect to government, Japan has dropped in the latest measurement to a fairly low 28<sup>th</sup> place.

Relative to 2002, Japan has remained in 15th place for overall competitiveness, but has suffered changes in rankings for individual items. In terms of deviation scores, Japan has risen in internationalization and enterprise due to expansion in exports and imports as well as direct investment. However, it has fallen in finance, IT, education, and infrastructure. The lower deviation score in finance is attributable to the continuing quantitative monetary easing policy, which has been implemented amid rising stock market capitalization on the back of the market's rebound, a condition that has been keeping the Japanese financial system in an abnormal condition.

### Japan's ranking is moving up, but the country faces structural problems

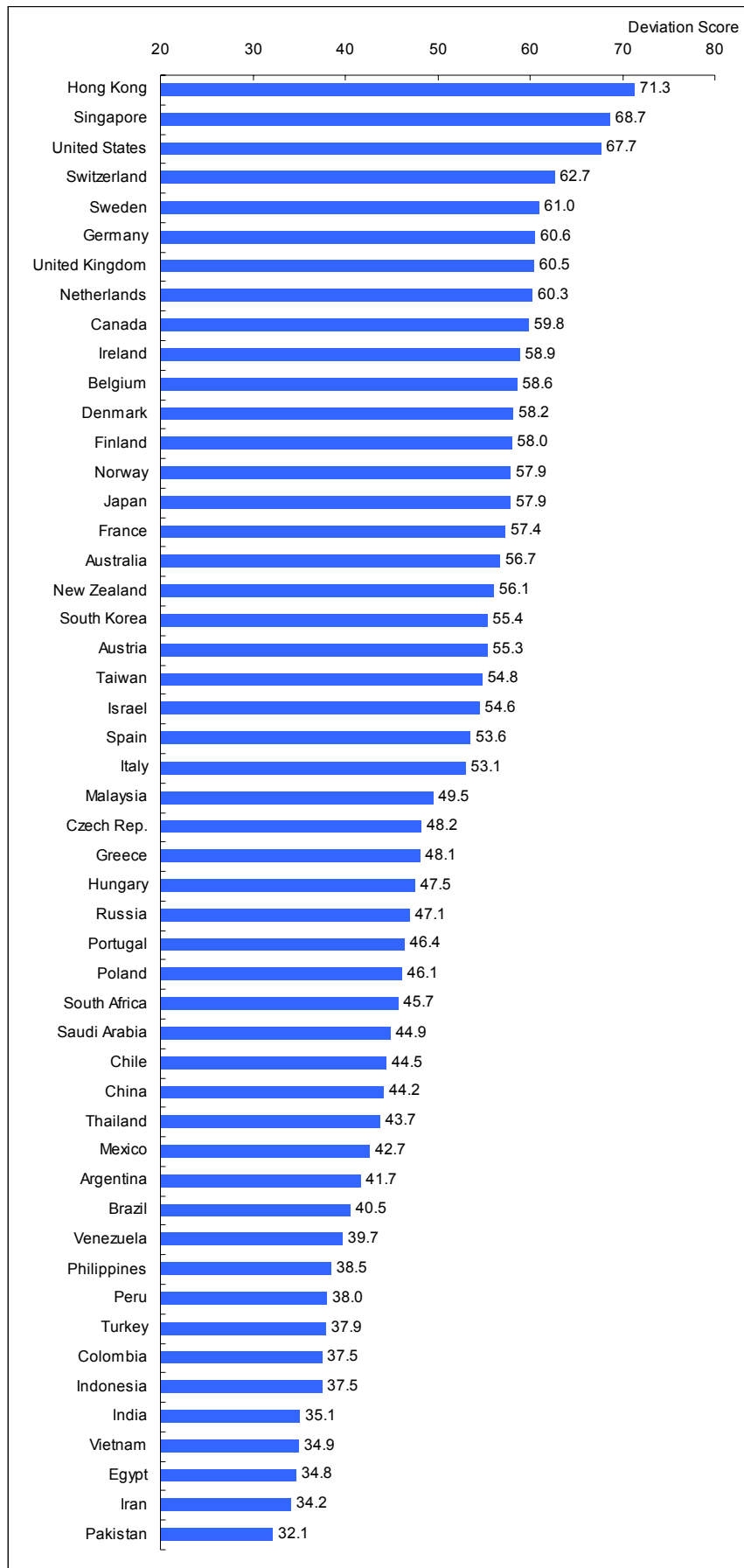
Japan's ranking will likely rise in the future, but may not be expected to advance significantly unless its structural problems are resolved.

Japan's ratio of exports or imports to GDP continues to rise and will contribute to improved competitiveness in terms of internationalization and enterprise. Increase in market capitalization spurred by recent soaring stock prices will serve to improve Japan's ranking in domestic finance; yet stock prices have risen to only about 15,000 on the Nikkei Stock Average as of December 15, 2005, short of 2000's average level of 17,000.

On the other hand, it is unlikely that there will be any improvement in indicators that reflect structural problems. The ratio of fiscal deficits to GDP, one of the indicators that comprise the government score, is improving, but the deficits remain large. No signs of improvement are seen in TOEFL scores, direct domestic investment, or IT-related indicators. There has been no improvement in competitiveness in terms of international logistics. Also, Japan's infrastructure ranking will likely remain poor.

With the bad loan problem having been more or less resolved, the financial sector now presents a brighter picture; however, the sector continues to operate under an abnormal zero interest rate policy and quantitative monetary easing. Hence, we may not expect the sector to improve in competitiveness for some time.

Figure 1 Latest rankings of Potential Competitiveness



### Singapore makes a good showing amongst Asian countries

In Asian countries or regions, Hong Kong stands highest in the latest measurement of potential competitiveness (see Fig. 2), ranking first after being third in both 1990 and 2000. Despite its low ranking in science and technology (25th) and education (24th), Hong Kong places high in other items, for instance, taking first place for internationalization and finance.

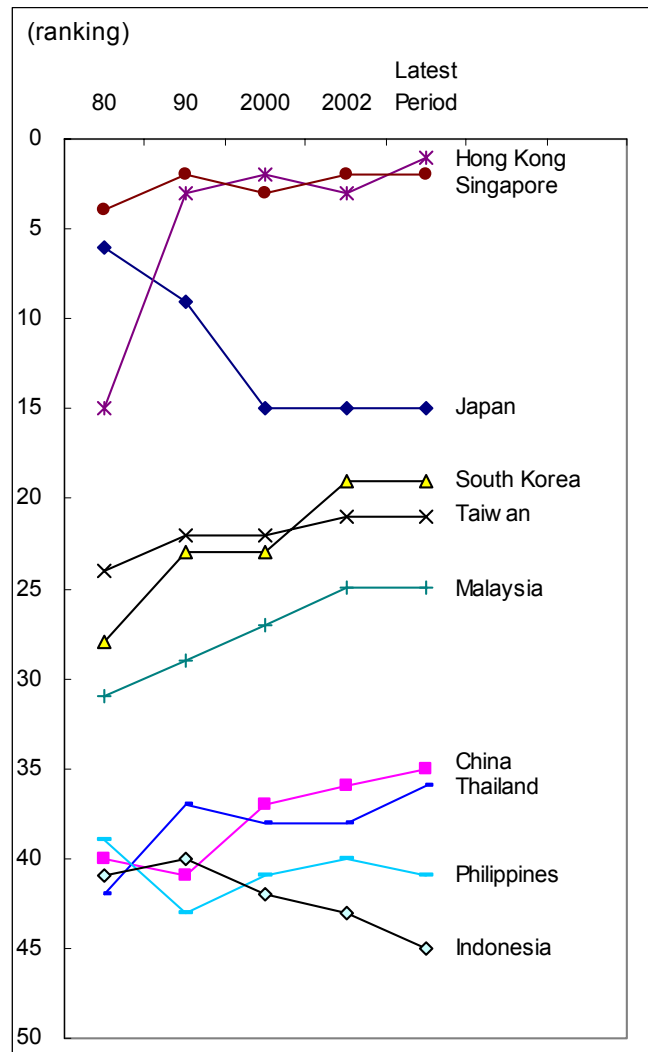
Also, Singapore fares well, ranking second in overall competitiveness. Singapore is in first place for government and infrastructure, and in third place for internationalization and finance. However, it is weak in terms of education and science and technology. Singapore is followed by Japan, South Korea and Taiwan.

South Korea takes 19th place for overall competitiveness. It places highest for IT (4th) and education (5th), while it ranks low for internationalization, enterprise, government, and infrastructure.

Taiwan's overall position is 21th. It ranks sixth for infrastructure and seventh for science and technology.

Among the ASEAN nations, the highest ranking nation is Singapore, followed by Malaysia, Thailand, the Philippines, and Indonesia.

Figure 2 Rankings of Potential Competitiveness in Asian countries or regions



## 2. Significance of Potential Competitiveness

Competitiveness is measured in different ways. This project discusses “potential competitiveness”, which is defined not as an outcome of economic growth, but as an ability to be competitive in future. The measure primarily seeks to determine if a country is equipped with the necessary groundwork for future improvement in competitiveness. High-level education and good infrastructure mean strong potential competitiveness.

One of the existing, representative competitiveness indicators is provided by The World Competitiveness Yearbook, published by the International Institute for Management Development (IMD) in Switzerland. The IMD develops rankings of competitiveness using a variety of different indicators but does not give reasons for its selection of such indicators. While the IMD uses questionnaire surveys, our present project features quantitative analyses based on available

socio-economic data.

### 3. Thoughts on competitiveness

#### Differentiation between causes and effects

Competitiveness may be defined in many ways. When an indicator is assumed to express competitiveness, it is important to determine if it represents the “cause” or the “effect” of competitiveness. For example, high-level education or labor productivity is a cause of a nation’s strong competitiveness, while an increase in income is an indicator that represents the effect of such competitiveness.

The approach taken in this analysis is to first determine the effects of competitiveness and then to select the causal indicator.

#### Examining competitiveness indicators

Indicators representative of competitiveness may be divided into causal indicators and resultant indicators as follows: (Table 3 identifies the competitiveness indicators.)

##### < Causal indicators >

##### Productivity

Higher labor productivity enables the same amount of input to produce greater output and increase income. Higher-level education and knowledge are supposed to enhance productivity. Technological advancement may lead to higher productivity of capital, which will enable the same amount of investment to produce more. In such a sense, productivity is an indicator that shows the source of competitiveness.

Productivity improvement is surely important, but it cannot be determined from productivity statistics alone without information of the level of labor or capital input, which is also important.

##### < Resultant indicators >

##### Foreign exchange rate

The foreign exchange rate is the exchange value of a currency and is assumed to represent the strength of a nation. In the current context, however, it may not simply represent national strength, given a huge stock of financial capital that facilitates large speculative movement. A foreign exchange rate may be artificially changed by coordinated intervention.

##### International competitiveness in terms of foreign trade

A developing country needs to depend upon imports for high value-added products. If its domestic industry becomes more competitive, the country may substitute domestic production for importation. Furthermore, if its products are competitive, the country may export them to overseas markets. Greater exports will increase domestic production, and therefore national income. In such a sense, the foreign trade indicator is assumed to represent competitiveness. It should be noted, however, that

Table 3 Competitiveness indicators at a glance

|                                | What is represented                   |
|--------------------------------|---------------------------------------|
| < Causal indicators >          |                                       |
| Labor productivity indicator   | Efficiency                            |
| Capital productivity ind.      | Efficiency                            |
| Total factor productivity ind. | Efficiency                            |
| < Resultant indicators >       |                                       |
| Output indicator               | Productivity                          |
| Exchange rate ind.             | Directly represents national strength |
| Ind. of export share, etc.     | Competitiveness as measured in trade  |

the indicator does not take into consideration competitiveness of non-traded items, such as services.

Indicators that represent trade competitiveness are export share, revealed comparative advantage (RCA) indices, revealed international competitiveness (RIC) indices, international competitiveness coefficients, etc. (see Annotation 2 for calculating formulas).

#### Defining per-capita GDP growth as competitiveness

In this project, we have used per-capita GDP as an overall competitiveness indicator. The greater the per-capita capital and the higher the productivity for a given period, the greater the growth of per-capita income. A competitive country is one that can provide products or services to domestic or foreign markets efficiently. An appropriate comprehensive indicator that measures such competitiveness should be based on per-capita output.

#### Nationality or boundaries

There are different ways of defining factors that contribute to a country's competitiveness. A multinational company performs many business activities outside of its home country and contributes to production and employment in the investee country. The "national" competitiveness of a country may be considered to be represented by competitiveness that also includes overseas activities performed by the country's multinational companies.

This project, however, is focused on analyzing primarily the competitiveness of different countries and regions within Asia, and we regard ease of foreign investment as influencing competitiveness. We have therefore included contributions by foreign-owned companies established locally in the calculation of competitiveness of the investee country or region.

#### Rate of change versus amount of change

The level of per-capita GDP may be regarded as an indicator of the competitiveness of a country, but what is important is the per-capita increment of GDP. For measurement of growth, the rate of change may be regarded as an indicator of competitiveness, in which case, generally, the lower the level of GDP, the higher the rate of growth. A currently highly competitive country should naturally be considered more competitive than a country without any existing competitiveness. So it is not appropriate to use the rate of change in the calculation of competitiveness. We have therefore adopted the amount of change in per-capita GDP as a competitiveness indicator that adds the level of GDP to the rate of change as follows:

Level  $\times$  rate of change = amount of change

#### Comparison on a dollar basis

"Per-capita GDP" may be real or nominal. Here, we have decided to compare results in terms of nominal GDP because it is difficult to use real values for comparison of income between countries and between regions.

International comparison requires a unified unit, which may be dollar-based or purchasing power parity (PPP)-based. In our case, we have adopted the dollar as a measure that is exchangeable via trade. A PPP-based measurement indicates the strength of a country's domestic purchasing power, but for international comparison a measurement that is based on the internationally arbitrated dollar value is more appropriate.

#### Time relationship between potential competitiveness and per-capita GDP increment

Potential competitiveness computed using various indicators shows the potential capabilities of a country at a given moment to compete over the next ten years. For instance, the potential competitiveness indicator as of 1980 indicates a country's ability to increase per-capita GDP during the 1980s (Table 4).

Table 4 Relationship between potential competitiveness and realized competitiveness

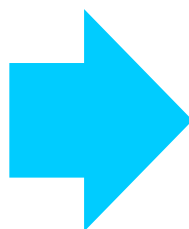
|   |
|---|
| Potential competitiveness as of '80 → influential on competitiveness in the 1980s |
| Potential competitiveness as of '90 → influential on competitiveness in the 1990s |
| Potential competitiveness as of the latest period                                 |
| → will be influential on competitiveness over the next 10 years                   |

A look at the relationship between potential competitiveness and realized competitiveness as of '80 and '90 finds a correlation coefficient of 0.77 for the 1980s and of 0.73 for the 1990s (Table 5).

Potential competitiveness and realized competitiveness do not correspond completely because potential competitiveness indicators are based on data provided at the initial point in time of the period under measurement and the possibility of unforeseen events occurring over the next ten years needs to be acknowledged. For example, Japan's potential competitiveness, which ranked ninth as of '90, resulted in realized competitiveness falling to 14th place as measured by the '90-'00 per-capita GDP because of the collapsed financial bubble and the delayed disposal of subsequent bad loans.

Table 5 Relationship between potential competitiveness and per-capita GDP increment

|                  | Potential Competitiveness Index |      | Per-capita GDP Increment     |             |      |
|------------------|---------------------------------|------|------------------------------|-------------|------|
|                  | 80                              | 90   | 1980 - 1990                  | 1990 - 2000 |      |
| 1 Ireland        | 52.8                            | 57.9 | 4190                         | 13021       |      |
| 2 United States  | 73.0                            | 70.1 | 5140                         | 5703        |      |
| 3 Argentina      | 44.4                            | 42.9 | -2009                        | 2137        |      |
| 4 United Kingdom | 60.5                            | 62.9 | 3883                         | 4165        |      |
| 5 Israel         | 50.4                            | 53.9 | 2187                         | 3288        |      |
| 6 Italy          | 55.3                            | 53.3 | 3569                         | 2708        |      |
| 7 Iran           | 37.6                            | 36.9 | -89                          | 366         |      |
| 8 India          | 36.8                            | 33.9 | 96                           | 136         |      |
| 9 Indonesia      | 39.4                            | 41.2 | 274                          | 238         |      |
| 10 Egypt         | 36.9                            | 38.2 | 239                          | 246         |      |
| 11 Australia     | 57.8                            | 57.5 | 2584                         | 4911        |      |
| 12 Austria       | 59.3                            | 55.0 | 5271                         | 5422        |      |
| 13 Netherlands   | 61.9                            | 61.6 | 3855                         | 6239        |      |
| 14 Canada        | 61.0                            | 61.0 | 2690                         | 3752        |      |
| 15 South Korea   | 47.4                            | 51.3 | 4057                         | 5231        |      |
| 16 Greece        | 49.0                            | 46.9 | 173                          | 2294        |      |
| 17 Colombia      | 35.5                            | 36.4 | 251                          | 166         |      |
| 18 Saudi Arabia  | 44.2                            | 47.6 | -4454                        | -351        |      |
| 19 Singapore     | 63.0                            | 64.8 | 6618                         | 10842       |      |
| 20 Switzerland   | 66.4                            | 62.1 | 6110                         | 825         |      |
| 21 Sweden        | 63.6                            | 61.1 | 4617                         | 4087        |      |
| 22 Spain         | 49.4                            | 51.0 | 3100                         | 3425        |      |
| 23 Thailand      | 39.2                            | 42.1 | 881                          | 827         |      |
| 24 Taiwan        | 50.2                            | 53.3 | 4811                         | 8410        |      |
| 25 Czech Rep.    | 53.7                            | 48.8 |                              | 112         |      |
| 26 China         | 39.9                            | 39.7 | 184                          | 474         |      |
| 27 Chile         | 41.8                            | 43.3 | 618                          | 2022        |      |
| 28 Denmark       | 61.4                            | 58.7 | 4499                         | 6675        |      |
| 29 Germany       | 62.6                            | 62.8 | 5226                         | 4097        |      |
| 30 Turkey        | 37.9                            | 41.5 | 620                          | 571         |      |
| 31 Japan         | 62.0                            | 61.5 | 11660                        | 4819        |      |
| 32 New Zealand   | 54.9                            | 57.2 | 1271                         | 2739        |      |
| 33 Norway        | 60.5                            | 62.5 | 5246                         | 9114        |      |
| 34 Pakistan      | 31.8                            | 31.6 | 130                          | 68          |      |
| 35 Hungary       | 47.1                            | 45.4 | 659                          | 514         |      |
| 36 Philippines   | 40.6                            | 38.8 | -82                          | 61          |      |
| 37 Finland       | 60.0                            | 57.7 | 6217                         | 5162        |      |
| 38 Brazil        | 41.7                            | 39.5 | -177                         | 547         |      |
| 39 France        | 59.9                            | 59.7 | 4548                         | 4128        |      |
| 40 Vietnam       | 36.6                            | 32.5 |                              | 158         |      |
| 41 Venezuela     | 42.4                            | 41.7 | -642                         | -49         |      |
| 42 Peru          | 37.8                            | 34.5 | -664                         | 438         |      |
| 43 Belgium       | 57.2                            | 59.4 | 4374                         | 5355        |      |
| 44 Poland        | 42.6                            | 44.6 |                              | 1074        |      |
| 45 Portugal      | 45.8                            | 45.1 | 2631                         | 2958        |      |
| 46 Hong Kong     | 59.0                            | 63.1 | 7523                         | 5877        |      |
| 47 Malaysia      | 45.6                            | 47.1 | 807                          | 1693        |      |
| 48 South Africa  | 48.1                            | 47.5 | -508                         | -92         |      |
| 49 Mexico        | 41.9                            | 43.6 | -95                          | 619         |      |
| 50 Russia        | 52.3                            | 49.5 | 505                          | -1195       |      |
|                  |                                 |      | Correlation coefficient      | 0.77        | 0.73 |
|                  |                                 |      | Rank correlation coefficient | 0.81        | 0.77 |



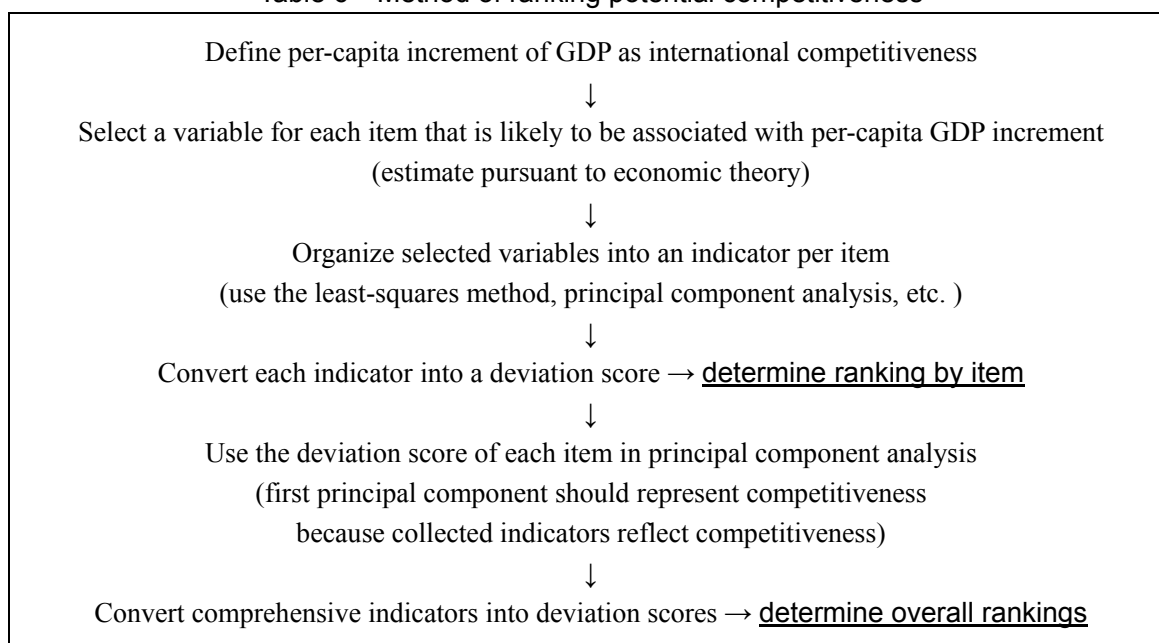
#### 4. Ranking method

##### Ranking by item

Table 5 outlines the specific ranking method used. First, create rankings for the following eight areas: (1) international trade and finance, (2) enterprise, (3) education, (4) domestic finance, (5) government, (6) science and technology, (7) infrastructure, and (8) IT.

Next, adopt the per-capita increment of GDP as a judgment criterion for international competitiveness, and then look for factors that increase this increment for each item. We have estimated and reviewed indicators that serve as a basis for rankings using a variety of different variables pursuant to economic theory, and have selected the indicators shown in Table 6.

Table 6 Method of ranking potential competitiveness



##### Method of estimating by item

Selection of indicators for an item such as education or science and technology varies depending upon the characteristics of the item, but is based upon the following formula provided by endogenous growth theory:

$$y = AK^\alpha h^\beta \quad \rightarrow \quad \dot{y}/y = \alpha \dot{k}/k + \beta \dot{h}/h + \dot{A}/A$$

$y$ : per-capita GDP                       $K$ : per-capita physical capital

$h$ : per-capita human capital         $A$ : total factor productivity

Analysis should proceed centering around moves of human capital expressed as  $h$  and the rate of technological advance expressed as  $A$ , taking into consideration government expenditure, foreign trade, finance, political stability, civil liberties, political corruption, improvement of social infrastructure, income distribution, ethnic diversity, etc.

Estimates are made using the above formulas; however, as competitiveness defined herein is GDP increment, it is not possible to concurrently estimate variables correlated to each other because of multicollinearity. The impact of  $A$  or  $h$  on competitiveness is measured by the following formula:

$$\Delta y = a + bA + cB$$

$\Delta y$ : per-capita increment of GDP       $A, B$ : indicators serving as sources of competitiveness

$a, b, c$ : parameters

Below are the resultant socio-economic indicators adopted for each item.

Table 7 Indicators adopted for each item

|                      |   |   |   |  |
|----------------------|---|---|---|--|
| Internationalization | Export of goods and services (ratio to GDP and absolute amount) | Import of goods and services (ratio to GDP and absolute amount) | Outflow of direct investment (ratio to GDP and absolute amount) | Inflow of direct investment (ratio to GDP and absolute amount) |
| Enterprise           | Ratio of fixed capital formation to GDP                         | Ratio of combined exports & imports to GDP                      | Labor productivity of manufacturing industry                    | Developing country dummy                                       |
| Education            | Rate of enrollment in higher education                          | TOEFL scores  | Average years of school attendance                              | Ratio of government education expenditure to GDP               |
| Domestic finance     | Ratio of bank liquidity reserves to its assets                  | Ratio of credit to private sector to total domestic credit      | Ratio of stock market capitalization to nominal GDP             |  |
| Government           | Ratio of customs duties to tax revenue                          | Ratio of tax revenue to GDP                                     | Ratio of budget balance to GDP                                  | Inflation  |
| Science              | Cumulative number of patents granted to U.S.                    | Number of R&D researchers per population                        |   |  |
| Infrastructure       | Aircraft departures per capita                                  | Containers handled per capita                                   | Rate of power transmission/distribution loss                    | Ratio of paved roads   |
| IT                   | Rate of fixed-line phone diffusion                              | Rate of PC diffusion  | Rate of cell phone diffusion                                    | Rate of Internet diffusion                                     |
|                      | Rate of Internet host diffusion                                 | Rate of broadband diffusion                                     |   |  |

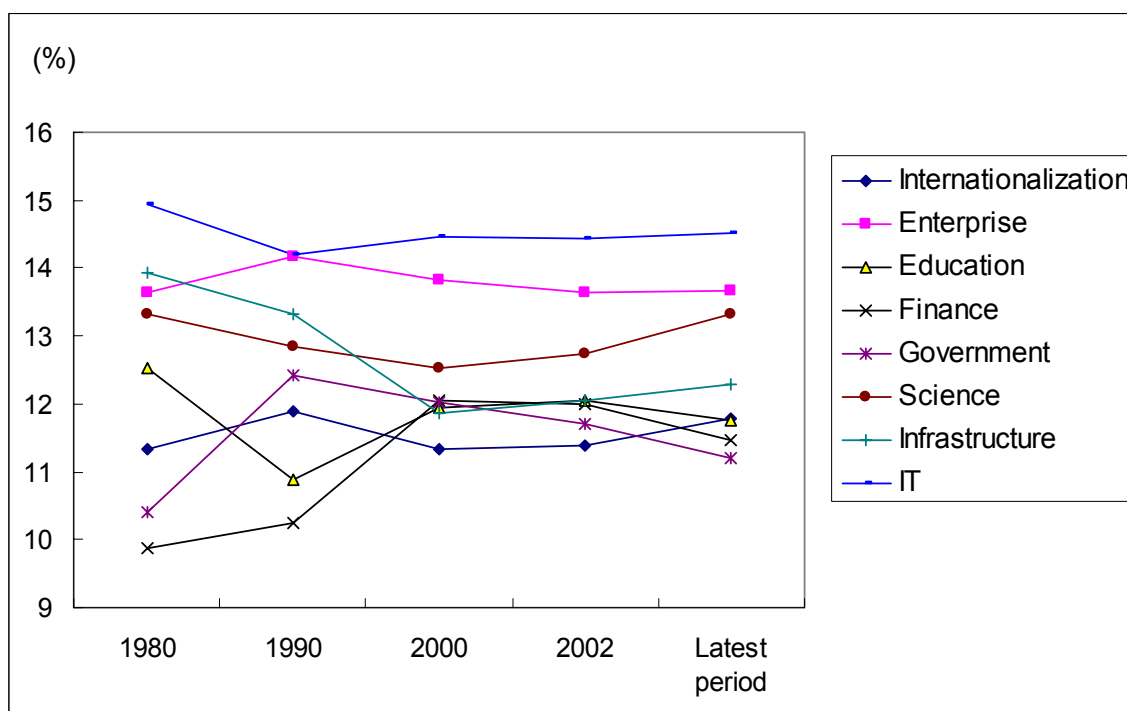
Note: The above indicators have been used to compute competitiveness for the latest period.

#### Integration of deviation score by item

Each item is converted into a deviation score and is then included in a Principal Component Analysis. As each selected item is related to competitiveness, its first principal component should be a comprehensive indicator of competitiveness. As the analysis performed gave positive coefficients (eigenvector) for all items, the comprehensive indicator is assumed to be the weighted average of all items. Weights are shown in Figure 4.

If each item has an equal weight, the weight would be 12.5% (=100÷8). Although slightly variable, the weight obtained for each item is close to the average weight. Across the periods, IT and enterprise show a heavier weight while internationalization is lower. During and after 2000, infrastructure and government have had a lower weight while finance has been rising, which may show that the focal point of competitiveness has been shifting from the government sector to the private sector, as represented by finance.

Figure 4 Weight of the Comprehensive Indicator by item



## [ References ]

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( Contact : Asian Research Department 81-3-3639-2915 )

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**Japan Center for Economic Research (JCER)**

Nikkei Kayabacho Bldg. 2-6-1 Nihombashi Kayabacho, Chuo-ku, Tokyo 103-0025, Japan  
 Phone:81-3-3639-2810 / FAX:81-3-3639-2839 / E-mail:jcernet@jcer.or.jp

## Annotation 1 Principal Component Analysis

### What is Principal Component Analysis?

Principal Component Analysis is intended to express multiple variables  $x_1, x_2, x_3, \dots$  as a comprehensive variable  $z_m$  (principal component) where the first principal component is expressed as follows:

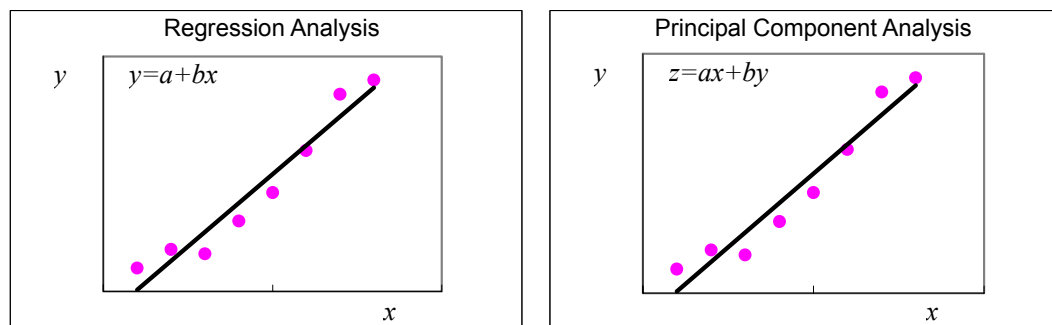
$$z_1 = a_{11}x_1 + a_{12}x_2 + \dots + a_{1p}x_p$$

Coefficients  $a_1, a_2, \dots, a_p$  of the principal component  $z_1$  should be determined so that  $z_1$  and each of variables  $x_1, x_2, x_3, \dots$  may be correlated to a maximum extent. This method will enable a series  $z_1$  to be determined that incorporates to a maximum degree the characteristics of the original variables.

### How Regression Analysis and Principal Component Analysis differ from each other

Regression Analysis estimates parameters  $a$  and  $b$ , assuming that they have a relationship with  $y$  and  $x$ , whereas Principal Component Analysis estimates parameters  $a$  and  $b$  in order to obtain the indicator  $z$ , which is the integration of  $x$  and  $y$ . When there are two variables, each of them can be obtained by drawing a straight line on the plane in a way that is suitable for each variable. Regression Analysis seeks to obtain parameters  $a$  and  $b$ , while Principal Component Analysis creates a new series  $z$  after obtaining these parameters.

### Difference between Regression Analysis and Principal Component Analysis



### Method for computing two variables

Below, a specific explanation of two variables is given. Let  $X_1$  and  $X_2$  be economic indicators, such as GDP indicators, and suppose you have  $X_1$  and  $X_2$  data pertaining to various countries. Now you intend to create the indicator  $z$ , which synthesizes the two data variables as follows:

$$Z_1 = a_1X_1 + a_2X_2$$

Ensuring  $z_1$  reflects the characteristics of each of  $X_1$  and  $X_2$  to a maximum degree is the same as maximizing the dispersion of  $Z_1$ . However, if this is the only condition, it will permit  $a_1$  and  $a_2$  to

be combined in many ways; therefore,  $a_1^2 + a_2^2 = 1$  is set as an additional condition.

The condition can be computed by finding the eigenvectors  $(a_1, a_2)'$  and the eigenvalue  $(\lambda)$  of  $A$ .

$$A \begin{pmatrix} a_1 \\ a_2 \end{pmatrix} = \begin{pmatrix} a_1 \\ a_2 \end{pmatrix} \quad \dots (1)$$

$A$  is a correlation coefficient matrix of  $X_1$  and  $X_2$ .

$$A = \begin{pmatrix} 1 & r_{12} \\ r_{21} & 1 \end{pmatrix}$$

If the correlation coefficient matrix  $A$  is found, then from the expression (1) above, the eigenvectors  $(a_1, a_2)'$  and the eigenvalues  $\lambda_1, \lambda_2 (\lambda_1 > \lambda_2)$  will be found, whereby  $\lambda_1$  will be the eigenvalue of the first principal component and  $\lambda_2$  that of the second principal component.

#### Scores of principal component

The principal components obtained above will enable the synthesized indicator of indicators  $X_1$  and  $X_2$  to be created for each country. Scores of principal components have been created for each country by normalizing the synthesized indicator.

If  $x = (X - \text{average of } X) / \text{standard deviation of } X$ ,

$$X = a_1 x_1 + a_2 x_2$$

#### Cumulative contribution rate

The rate of cumulative contribution shows the extent to which each principal component reflects the information of the original variable. If the rates of cumulative contribution of all principal components are put together, they will represent 100%.

Rate of contribution of first principal component =  
eigenvalue of first principal component / total of all eigenvalues

Rate of cumulative contribution =  
rate of contribution of first principal component +  
rate of contribution of second principal component + ...

#### Factor loading

Factor loading = correlation coefficient of  $Z$  and  $X$

Factor loading =  $\sqrt{\text{eigenvalue}} \times \text{eigenvector}$

## Annotation 2 International competitiveness indices in terms of foreign trade

### 1. Export share

$$\text{Export share} = \frac{\text{Exports of Goods } a \text{ by Country } b}{\text{World exports of Goods } a}$$

### 2. Revealed Comparative Advantage (RCA) index

$$RCA \text{ index} = \frac{(\text{Exports of Goods } a \text{ by Country } b) / (\text{Total exports of Country } b)}{(\text{World exports of Goods } a) / (\text{Total exports of the world})} \times 100$$

### 3. Revealed International Competitiveness (RIC) index

$$RIC \text{ index} = \frac{\text{Exports of Goods } a \text{ by Country } b - \text{Imports of Goods } a \text{ by Country } b}{\text{Production of Goods } a \text{ by Country } b}$$

### 4. International competitiveness index

$$\text{Index of international competitiveness} = \frac{\text{Exports of Goods } a - \text{Imports of Goods } a}{\text{Exports of Goods } a + \text{Imports of Goods } a} \times 100$$

Appendix Table 1 Overall Rankings

|    | 80             |      | 90             |      | 2000           |      | 2002           |      | Latest period  |      |
|----|----------------|------|----------------|------|----------------|------|----------------|------|----------------|------|
| 1  | United States  | 73.0 | United States  | 70.1 | United States  | 69.4 | United States  | 68.5 | Hong Kong      | 71.3 |
| 2  | Switzerland    | 66.4 | Singapore      | 64.8 | Hong Kong      | 68.6 | Singapore      | 68.3 | Singapore      | 68.7 |
| 3  | Sweden         | 63.6 | Hong Kong      | 63.1 | Singapore      | 67.5 | Hong Kong      | 68.0 | United States  | 67.7 |
| 4  | Singapore      | 63.0 | United Kingdom | 62.9 | Switzerland    | 63.5 | Switzerland    | 63.5 | Switzerland    | 62.7 |
| 5  | Germany        | 62.6 | Germany        | 62.8 | Norway         | 61.8 | Norway         | 61.5 | Sweden         | 61.0 |
| 6  | Japan          | 62.0 | Norway         | 62.5 | Sweden         | 61.4 | Netherlands    | 61.1 | Germany        | 60.6 |
| 7  | Netherlands    | 61.9 | Switzerland    | 62.1 | United Kingdom | 61.1 | Germany        | 60.5 | United Kingdom | 60.5 |
| 8  | Denmark        | 61.4 | Netherlands    | 61.6 | Netherlands    | 61.1 | United Kingdom | 60.2 | Netherlands    | 60.3 |
| 9  | Canada         | 61.0 | Japan          | 61.5 | Finland        | 60.7 | Sweden         | 59.5 | Canada         | 59.8 |
| 10 | Norway         | 60.5 | Sweden         | 61.1 | Germany        | 60.7 | Canada         | 59.4 | Ireland        | 58.9 |
| 11 | United Kingdom | 60.5 | Canada         | 61.0 | Canada         | 59.6 | Ireland        | 59.3 | Belgium        | 58.6 |
| 12 | Finland        | 60.0 | France         | 59.7 | Ireland        | 59.4 | Finland        | 59.2 | Denmark        | 58.2 |
| 13 | France         | 59.9 | Belgium        | 59.4 | Belgium        | 58.2 | Denmark        | 58.7 | Finland        | 58.0 |
| 14 | Austria        | 59.3 | Denmark        | 58.7 | Denmark        | 58.0 | Belgium        | 58.3 | Norway         | 57.9 |
| 15 | Hong Kong      | 59.0 | Ireland        | 57.9 | Japan          | 58.0 | Japan          | 58.0 | Japan          | 57.9 |
| 16 | Australia      | 57.8 | Finland        | 57.7 | France         | 57.5 | France         | 57.6 | France         | 57.4 |
| 17 | Belgium        | 57.2 | Australia      | 57.5 | Australia      | 56.1 | New Zealand    | 56.4 | Australia      | 56.7 |
| 18 | Italy          | 55.3 | New Zealand    | 57.2 | New Zealand    | 55.7 | Australia      | 56.2 | New Zealand    | 56.1 |
| 19 | New Zealand    | 54.9 | Austria        | 55.0 | Austria        | 54.2 | South Korea    | 55.5 | South Korea    | 55.4 |
| 20 | Czech Rep.     | 53.7 | Israel         | 53.9 | Israel         | 54.0 | Austria        | 55.3 | Austria        | 55.3 |
| 21 | Ireland        | 52.8 | Italy          | 53.3 | Italy          | 53.6 | Taiwan         | 54.2 | Taiwan         | 54.8 |
| 22 | Russia         | 52.3 | Taiwan         | 53.3 | Taiwan         | 53.4 | Israel         | 53.9 | Israel         | 54.6 |
| 23 | Israel         | 50.4 | South Korea    | 51.3 | South Korea    | 53.1 | Spain          | 53.6 | Spain          | 53.6 |
| 24 | Taiwan         | 50.2 | Spain          | 51.0 | Spain          | 52.6 | Italy          | 53.2 | Italy          | 53.1 |
| 25 | Spain          | 49.4 | Russia         | 49.5 | Greece         | 48.5 | Malaysia       | 49.1 | Malaysia       | 49.5 |
| 26 | Greece         | 49.0 | Czech Rep.     | 48.8 | Czech Rep.     | 48.5 | Czech Rep.     | 49.1 | Czech Rep.     | 48.2 |
| 27 | South Africa   | 48.1 | Saudi Arabia   | 47.6 | Malaysia       | 48.0 | Greece         | 47.9 | Greece         | 48.1 |
| 28 | South Korea    | 47.4 | South Africa   | 47.5 | Portugal       | 46.9 | South Africa   | 47.4 | Hungary        | 47.5 |
| 29 | Hungary        | 47.1 | Malaysia       | 47.1 | Hungary        | 46.6 | Russia         | 47.1 | Russia         | 47.1 |
| 30 | Portugal       | 45.8 | Greece         | 46.9 | Russia         | 46.5 | Hungary        | 46.9 | Portugal       | 46.4 |
| 31 | Malaysia       | 45.6 | Hungary        | 45.4 | Poland         | 46.5 | Portugal       | 46.6 | Poland         | 46.1 |
| 32 | Argentina      | 44.4 | Portugal       | 45.1 | South Africa   | 46.2 | Poland         | 46.5 | South Africa   | 45.7 |
| 33 | Saudi Arabia   | 44.2 | Poland         | 44.6 | Saudi Arabia   | 44.6 | Saudi Arabia   | 44.4 | Saudi Arabia   | 44.9 |
| 34 | Poland         | 42.6 | Mexico         | 43.6 | Argentina      | 43.5 | Chile          | 43.9 | Chile          | 44.5 |
| 35 | Venezuela      | 42.4 | Chile          | 43.3 | Chile          | 43.1 | Argentina      | 43.5 | China          | 44.2 |
| 36 | Mexico         | 41.9 | Argentina      | 42.9 | Mexico         | 43.0 | China          | 43.3 | Thailand       | 43.7 |
| 37 | Chile          | 41.8 | Thailand       | 42.1 | China          | 42.8 | Mexico         | 42.6 | Mexico         | 42.7 |
| 38 | Brazil         | 41.7 | Venezuela      | 41.7 | Thailand       | 42.4 | Thailand       | 42.6 | Argentina      | 41.7 |
| 39 | Philippines    | 40.6 | Turkey         | 41.5 | Brazil         | 40.0 | Brazil         | 39.6 | Brazil         | 40.5 |
| 40 | China          | 39.9 | Indonesia      | 41.2 | Turkey         | 39.5 | Philippines    | 38.8 | Venezuela      | 39.7 |
| 41 | Indonesia      | 39.4 | China          | 39.7 | Philippines    | 39.3 | Peru           | 38.3 | Philippines    | 38.5 |
| 42 | Thailand       | 39.2 | Brazil         | 39.5 | Indonesia      | 39.1 | Turkey         | 38.1 | Peru           | 38.0 |
| 43 | Turkey         | 37.9 | Philippines    | 38.8 | Venezuela      | 38.5 | Indonesia      | 37.7 | Turkey         | 37.9 |
| 44 | Peru           | 37.8 | Egypt          | 38.2 | Peru           | 38.3 | Venezuela      | 37.7 | Colombia       | 37.5 |
| 45 | Iran           | 37.6 | Iran           | 36.9 | Colombia       | 36.8 | Iran           | 37.0 | Indonesia      | 37.5 |
| 46 | Egypt          | 36.9 | Colombia       | 36.4 | Egypt          | 36.0 | Colombia       | 36.3 | India          | 35.1 |
| 47 | India          | 36.8 | Peru           | 34.5 | Iran           | 36.0 | Egypt          | 35.5 | Vietnam        | 34.9 |
| 48 | Vietnam        | 36.6 | India          | 33.9 | Vietnam        | 35.4 | Vietnam        | 34.4 | Egypt          | 34.8 |
| 49 | Colombia       | 35.5 | Vietnam        | 32.5 | India          | 33.2 | India          | 33.3 | Iran           | 34.2 |
| 50 | Pakistan       | 31.8 | Pakistan       | 31.6 | Pakistan       | 31.5 | Pakistan       | 32.4 | Pakistan       | 32.1 |