

## High Tech Indicators: Who's Gaining?

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### Introduction

Worldwide attention to technological innovativeness and competitiveness indicators has increased dramatically. This is especially prevalent in Europe, with the development of the Innovation Scoreboard, the Entrepreneurship Scoreboard, and so forth [<http://www.cordis.lu/innovation-smes/scoreboard/home.html>]. However, the prominent European and OECD indicators do not cover the industrializing countries. Sources that do cover industrializing nations include:

- The World Bank's *World Development Report* [<http://econ.worldbank.org/wdr/wdr2003/>]
- The *World Competitiveness Yearbook* [<http://www01.imd.ch/wcy/>].
- The World Economic Forum's *Global Competitiveness Report* [<http://www.weforum.org/site/homepublic.nsf/Content/Global+Competitiveness+Programme>]
- The UN Commission on Science and Technology for Development (CSTD) and the UN Conference on Trade and Development (UNCTD) reach out farther in seeking to devise technological competitiveness and information & communications technology (ICT) indicators for most countries [<http://r0.unctad.org/stdev>].

This paper reports on the export competitiveness indicators developed by the Georgia Tech Technology Policy and Assessment Center (TPAC). We have been producing “High Tech Indicators” (HTI) since 1987. Beginning in 1990, and continuing in 1993, 1996, 1999, and 2003, HTI has been supported by the U.S. National Science Foundation and reported in *Science & Engineering Indicators* [[www.nsf.gov/sbe/srs/seind02](http://www.nsf.gov/sbe/srs/seind02)]. HTI is based on a model that identifies four “input” factors as anticipating future national high-tech based export capabilities, gauged by three “output” factors.<sup>2</sup> Three key advantages of HTI over other indicators are its conceptual basis, coverage of rapidly industrializing economies, and the available time series.

The HTI series is attaining sufficient maturity to enhance its value in drawing comparisons across countries, regions (e.g., Southeast Asia, Latin America, Eastern Europe), and time (e.g., sharp upsurge seen for China recently). HTI currently tracks changes in export competitiveness for 33 nations. It was developed particularly to gauge future technology-based competitiveness of the industrializing countries. Recent HTI results have been described in several publications.<sup>3 4 5</sup> Interest in the HTI indicators has

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<sup>2</sup> J. David Roessner, Alan Porter, Nils Newman, and David Cauffiel, "Anticipating the Future High-Tech Competitiveness of Nations: Indicators for Twenty-Eight Countries," *Technological Forecasting and Social Change*, **51** (1), January 1996: 133-149.

<sup>3</sup> Alan L. Porter, J. David Roessner, Xiao-Yin Jin, and Nils C. Newman, "Changes in National Technological Competitiveness: 1990-93-96-99," *Technology Analysis & Strategic Management* **13** (4), 2001: 477-496.

risen over the years, reaching into the analytical, popular, and policy communities, with significant international recognition.

These are the countries HTI tracks:

- The “Big Three” – United States, Japan, and Germany
- Western Europe (UK, France, Netherlands, Italy, Switzerland, Sweden, Spain, and Ireland)
- English Heritage Nations plus Israel (Canada, Australia, South Africa, New Zealand, and Israel)
- Eastern Europe (Russia, Poland, Hungary, and Czech Republic)
- Asian Tigers (Singapore, South Korea, and Taiwan)
- Asian “Cubs” (Malaysia, China, Thailand, Indonesia, Philippines, and India)
- Latin America (Mexico, Brazil, Argentina, and Venezuela).

Interest in many of these countries is keen because of their rapid increase in technological competitiveness.

### The HTI Model

HTI combines statistical measures, compiled from a number of sources, with expert opinion gathered from our International Indicators Panel. We combine these to compose “indicators” for the target input and output factors. The expert opinion items compensate for statistical gaps to cover essential components of the indicators. This expert opinion consists of judgments by persons knowledgeable about technology-intensive development in each country. Our 2003 HTI benefited from the responses of 371 experts. Recent HTI Summary reports, along with the survey instrument and an appendix that describes the components of our “Input” and “Output” indicators are available [<http://tpac.gatech.edu>].<sup>6</sup>

Our four input indicators consist of:

- *National Orientation (NO)* reflects “directed” action to achieve technological competitiveness.
- *Socioeconomic Infrastructure (SE)* -- institutions that support and maintain the resources essential to the functioning of a modern, technology-based economy.
- *Technological Infrastructure (TI)* -- institutions and resources that contribute to a nation's capacity to develop, produce, and market new technology.
- *Productive Capacity (PC)* -- the physical and human resources devoted to manufacturing products and the efficiency with which those resources are used

The one output indicator we emphasize here is:

- *Technological Standing (TS)* -- reflects current high technology product export performance

The referenced reports on HTI explore changes in these indicators over time. They also investigate the association of “input” factors (“drivers”) to “outputs” (technology-based products and services). Such relationships are not straightforward.<sup>7</sup> We note that our HTI model postulates that our input factors

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<sup>4</sup> J. David Roessner, Alan L. Porter, Nils C. Newman, and Xiao-Yin Jin, “A Comparison of Recent Assessments of the High-Tech Competitiveness of Nations,” *International Journal of Technology Management*, **23** (6), 2002: 536-557.

<sup>5</sup> Alan L. Porter, J. David Roessner, Xiao-Yin Jin, Nils C. Newman, “Measuring National ‘Emerging Technology’ Capabilities,” *Science and Public Policy*, Vol. **29** (3), 2002: 189-200.

<sup>6</sup> Porter, A.L., Roessner, J.D., Newman, N., Jin, X-Y, and Yglesias, E., *Indicators Of Technology-Based Competitiveness Of 33 Nations--2003 Summary Report*, Georgia Tech, Technology Policy and Assessment Center, Atlanta, GA, report to the National Science Foundation under contract #D020024, April 23, 2003.

<sup>7</sup> Roessner, J.D., Porter, A.L., Jin, X-Y., Newman, N.C., and Yglesias, E., *Indicators of Technology-based Competitiveness: Incorporating Recent Changes in the Concept, “High-technology,” and in Data Availability*,

portend changes in technology-based export competitiveness roughly 15 years later. Thus our data are just barely attaining sufficient duration to assess the HTI predictive powers. Early results suggest limited predictability, with TI and PC better predictors than NO and SE.<sup>8</sup>

The component measures that constitute each indicator are scaled from 0-100. These "S-scores" range from a minimum (zero or lowest scale value) to a relative maximum (100 = value of the highest of the 33 countries on that component). This enables reasonable combination of our expert opinion items (scaled initially from 1-5) together with our statistical measures that can differ in range by orders of magnitude. S-scores are also easily comprehended.

For certain purposes, we average the four input indicators to give a general "INPUT" indicator. That is what we report here in conjunction with our main output indicator, TS -- Technological Standing. TS tends to mute somewhat the huge differences from the largest technology-based exporters (US, Japan) to smaller economies. This reflects its incorporation of one expert opinion measure addressing current high tech production along with two statistical measures (concerning high tech exports and the value of electronics exports).

### **National High Tech Indicators Profiles**

We concentrate on one revealing depiction of HTI results here. Figure 1 shows a scattergram of all of our countries for which we have data spanning the period 1993--2003.<sup>9</sup> This plots:

- X-axis: the composite INPUT indicator values for 1993 and 2003
- Y-axis: TS -- Technological Standing for 1993 and 2003

The axes range from 0 to 100, with the middle value, 50, used to create 4 quadrants. The values are connected by an arrow running from 1993 to 2003. This shows the direction of change. For instance, consider Japan and the USA. In 1993, they were very close to each other on both INPUT and TS, with Japan slightly ahead on both. A decade later, the USA has increased on both indicators, while Japan has declined on both.

Note that these S-score-based measures are based on composite measures and they are relative. In other words, the decline in Japan's values DOES NOT mean an absolute decline in the underlying components for Japan, just a lower position relative to the leader on the measures. Japan's high tech and electronics exports actually increased over this period, but not quite proportionately to the leader. Also recognize that our indicators are based on 33 highly competitive countries, so "weak" showing is again only relative. You may also note that not all highly developed countries appear. HTI does not include every OECD country because its primary focus is on the industrializing countries. Also, not all our 33 countries appear because some were added since 1993. We don't present precise scaling in the figures to emphasize patterns and changes, not precise values. Numerical indicator values are available at <http://tpac.gatech.edu>.

With these cautions in mind, the figures provide some fascinating results. Let's first consider our country groupings:

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Atlanta: Georgia Tech School of Public Policy and Technology Policy and Assessment Center, final report to the National Science Foundation, 2001 [project #9901310].

<sup>8</sup> Porter et al., 2001, op cit.

<sup>9</sup> HTI are generated every 3 years. In 2003 we just redesignated them using the year in which they are published (2003) instead of the year in which most data are collected (2002). Also, we note that many of the statistical measures lag, so the data years used vary somewhat on individual measures, and even for particular countries on a given measure. Anyway, the span from 1993 HTI to 2003 HTI is really 9 years.

- *The “Big Three” – United States, Japan, and Germany.* When HTI began, in the late 1980's, West Germany was closer to the US and Japan, and more distant from the other countries. Since then, probably due considerably to the incorporation of East Germany, high tech export competitiveness has been more of a "Big Two." Nonetheless, for this recent decade, Germany shows progress on INPUT and a bit on TS ("Standing") as well.
- *Western Europe (UK, France, Netherlands, Italy, Switzerland, Sweden, Spain, and Ireland).* Ireland is not included, having been added since 1993. (For a small nation, Ireland shows lively competitiveness -- see //tpac.gatech.edu.) Of this group, note the nice gains by the UK and The Netherlands. Italy has increased on INPUT; we'll see if this is reflected in eventual TS gains.
- *English Heritage Nations plus Israel (Canada, Australia, South Africa, New Zealand, and Israel).* Israel, another dynamic, small economy, was added since 1993, so is not shown. Canada, Australia, and New Zealand show strong advances on both INPUT and TS. South Africa shows the worst trajectory of all the countries plotted.
- *Eastern Europe (Russia, Poland, Hungary, and Czech Republic).* Hungary and the Czech Republic don't appear as they were added after 1993. Russia and Poland show strong gains, particularly in INPUT.
- *Asian Tigers (Singapore, South Korea, and Taiwan).* The Tigers show tremendous economic strides. When HTI began, these were the "newly industrializing countries." Compare their Standing in technology-based export competitiveness to the Western European countries. If you were looking to cluster similarly performing economies, you might lump together the UK, Singapore, France, The Netherlands, Taiwan, and South Korea. This would have been hard to imagine back in 1987! Note that the similarities extend to INPUT as well as TS. We do note that TS emphasizes electronics, a particular strength of the Tigers, but nonetheless, all now recognize this shift in technology-based economic power toward Asia.
- *Asian “Cubs” (Malaysia, China, Thailand, Indonesia, Philippines, and India).* We discuss below.
- *Latin America (Mexico, Brazil, Argentina, and Venezuela).* Venezuela was added since 1993. We discuss below.

## **Asia and Latin America**

We provide two additional figures that leave out countries for clarity. Figure 2 shows our Asian countries. Country profiles are interesting.

- *Singapore:* a world high tech power. Note that HTI does not compensate for country size by using "per capita" or other normalization. The only moderating influence in our indicators is that we include a number of simply scaled (1-5) expert opinion measures. So, Singapore's ascent is simply amazing.
- *South Korea and Taiwan:* powerful technology export competitors
- *Malaysia:* the "Asian Cub" most like a Tiger since the inception of HTI; indeed Malaysia is a major high tech player (compare their Standing in Figure 1 to Italy and Canada). The decline in their INPUT score from 1993 to 2003 raises a "red flag" of warning to suggest possible review by its policy-makers. Looking at our discrete Input indicators, Malaysia has dipped modestly on NO, TI, and PC. Again, this does not necessarily indicate that problems exist, nor explain what policy

actions would bolster future high tech competitiveness, but it suggests deeper analyses might be worthwhile.

- *Thailand and Indonesia:* Both have increased their Standing since 1993, but both show large decline in INPUT. Again, technology policy makers might want to explore the situation to see if the indicators are picking up real concerns for future technological development.
- *The Philippines:* Shows good gains on both TS and INPUT.
- *India:* Shows strong advance on INPUT and moderate TS gains. This doesn't fully capture the impression that India is booming in information-oriented products and, especially, services. We suspect this is due to two factors: very recent gains that don't yet reflect strongly in these data, and the HTI emphasis on technology-intensive manufacturing. We are revising HTI to better capture information-intensive facets.
- *China:* Wow! Our INPUT-1993 did not suggest this magnitude of gain in Standing. However, the commensurate gains in INPUT-2003 imply that China is not done gaining in TS! The trajectory of Chinese increase in high tech competitiveness suggests a new "Big Three" in a decade (US, Japan, China -- consider Figure 1 again).

HTI indicators are not unduly affected by the "Asian Contagion" -- the financial difficulties of a few years ago. Indeed, in our 1999 HTI summary, we commented that this did not appear to be exerting long term depression on technology-based export competitiveness. At that time, many worried that it would do so, so we think the HTI model did well in this regard.

Figure 3 shows the "Asian Cubs" together with three Latin American countries. In the late 1980's, these were the two prominent sets of industrializing economies. Brazil's trajectory would not have been anticipated by our model. That suggests the model is probably not rich enough to "advise" policy on its own (no surprise). In Brazil's case, changes in competitive policy (ending a protectionist approach), compounded with monetary and social issues, have somehow resulted in no gain in TS (again, these are relative measures). However, the decline in Brazil's INPUT suggests that those in power might want to analyze what is happening more deeply. Likewise, Argentina's position bears examination.

In contrast, Mexico has risen from a weak TS & weak INPUT position in 1993. Gains on both are encouraging. Special ties with the USA certainly affect Mexican technology-intensive exports beyond what a general model could capture.

### **Stepping Back and Looking Ahead**

Our model would say look at INPUT-1993; the stronger it shows, the stronger TS-2003 should be. The model was devised to anticipate which industrializing nations would be most apt to become stronger export competitors. We leave this as an exercise for the interested reader. The fit is obviously not simple. We are exploring relations between the four Input indicators (NO, SE, TI, and PC) with future TS. We refer the reader to the website and selected references mentioned. However, looking ahead, we would suggest considering a country's present INPUT as a rough pointer toward future prospects. In this regard, note the countries with high INPUT-2003:

- USA -- a dominant leader in TS, and in INPUT, suggesting bright prospects
- Japan -- slipped somewhat, but still by far the second strongest on both TS and INPUT
- Extremely strong INPUT countries -- watch for continued competitive gains for Germany, UK, The Netherlands, Singapore, Taiwan, and Canada.
- Also very strong on INPUT-2003 -- France & Sweden, and (not shown) Israel & Ireland

The focus in these HTI indicators is on manufactured products for export. As the world shifts increasingly into an "Information Economy," we also want to track economies that are strong in

information-intensive activities. We are in the process of reformulating HTI to place far more weight on these factors likely to reflect in high tech services and so forth. We anticipate reporting on the 'new' HTI shortly. We have gathered a range of additional statistical measures and are presently analyzing how best to incorporate these.

What will the future bring in high tech export competition? We close with a view from our International Indicators Panel -- the experts whose opinion is incorporated into the indicators. Figure 4 shows their average ratings for each of our 33 countries on 1) present competitiveness, and 2) anticipated competitiveness in 15 years. As scaled here, values range from "10" -- essentially no capability, to "50" -- products considered technically advanced, "state of the art," in international markets. The message could not be clearer. Anticipate continued broadening of global competitiveness. Our experts anticipate all of these nations pursuing technological competitiveness, and successfully so. Particularly note the strength of expectations across the board.

Figure 1.

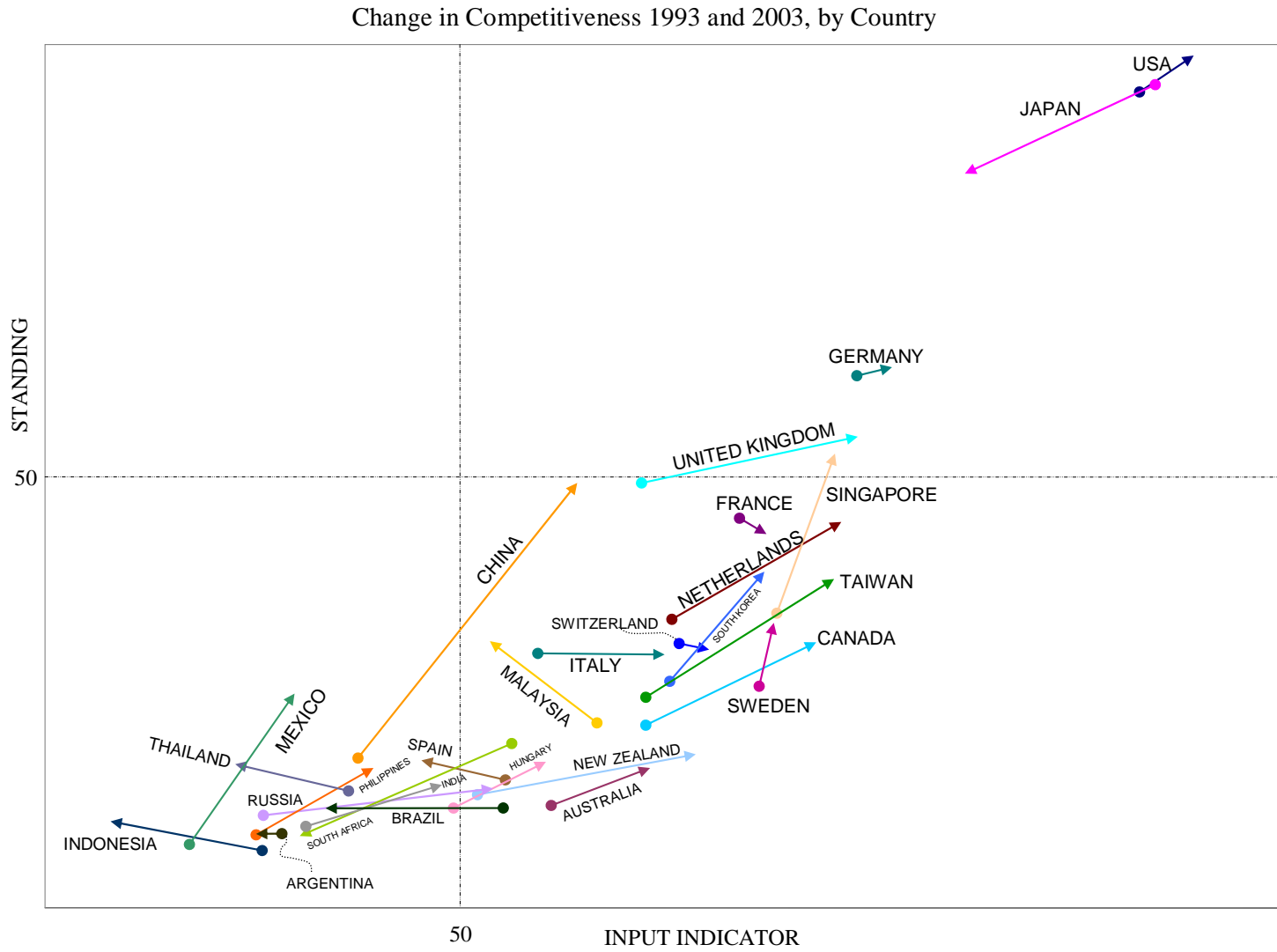


Figure 2.

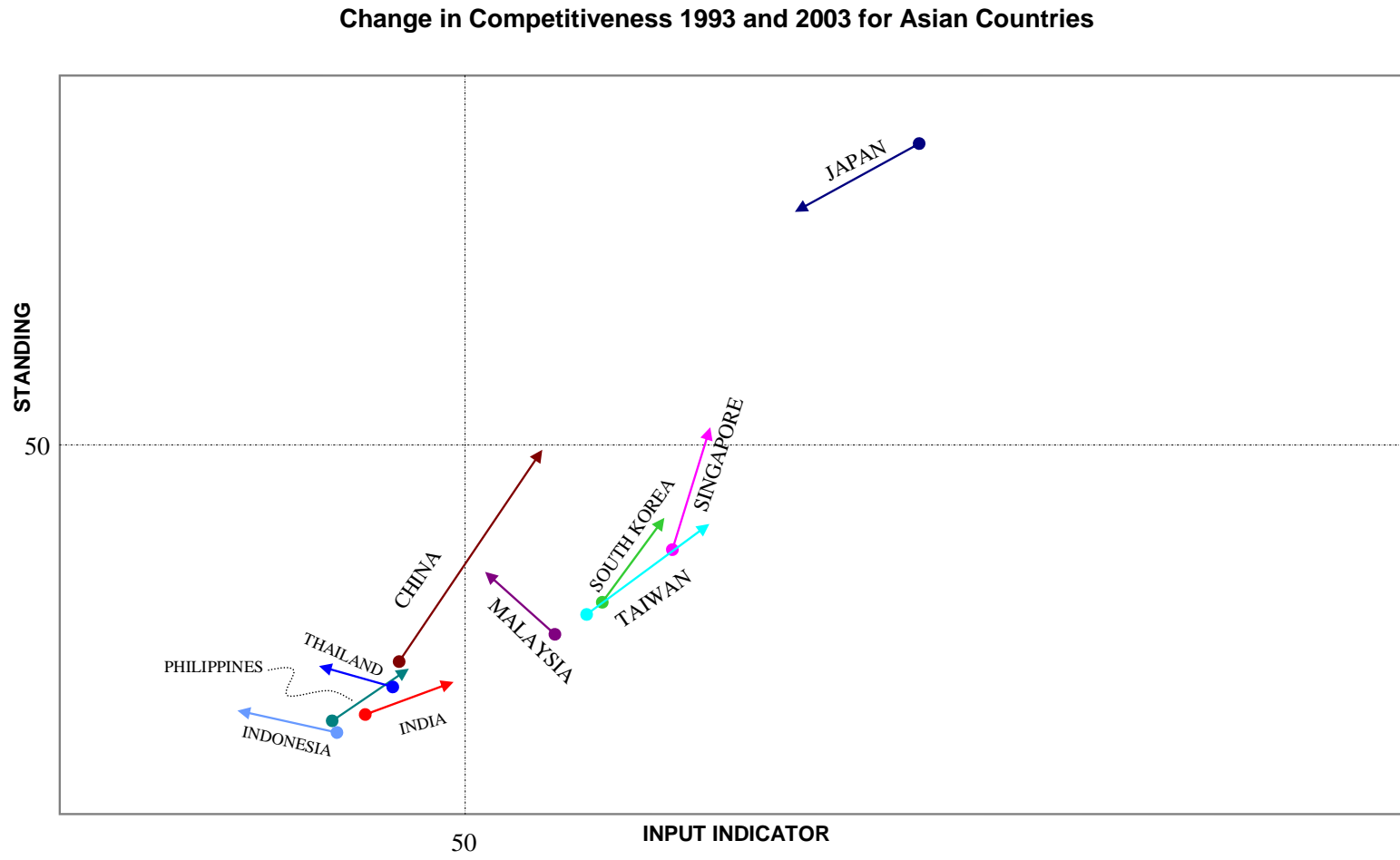


Figure 3.

Change in Competitiveness 1993 and 2003 for Asian Cubs and Latin America

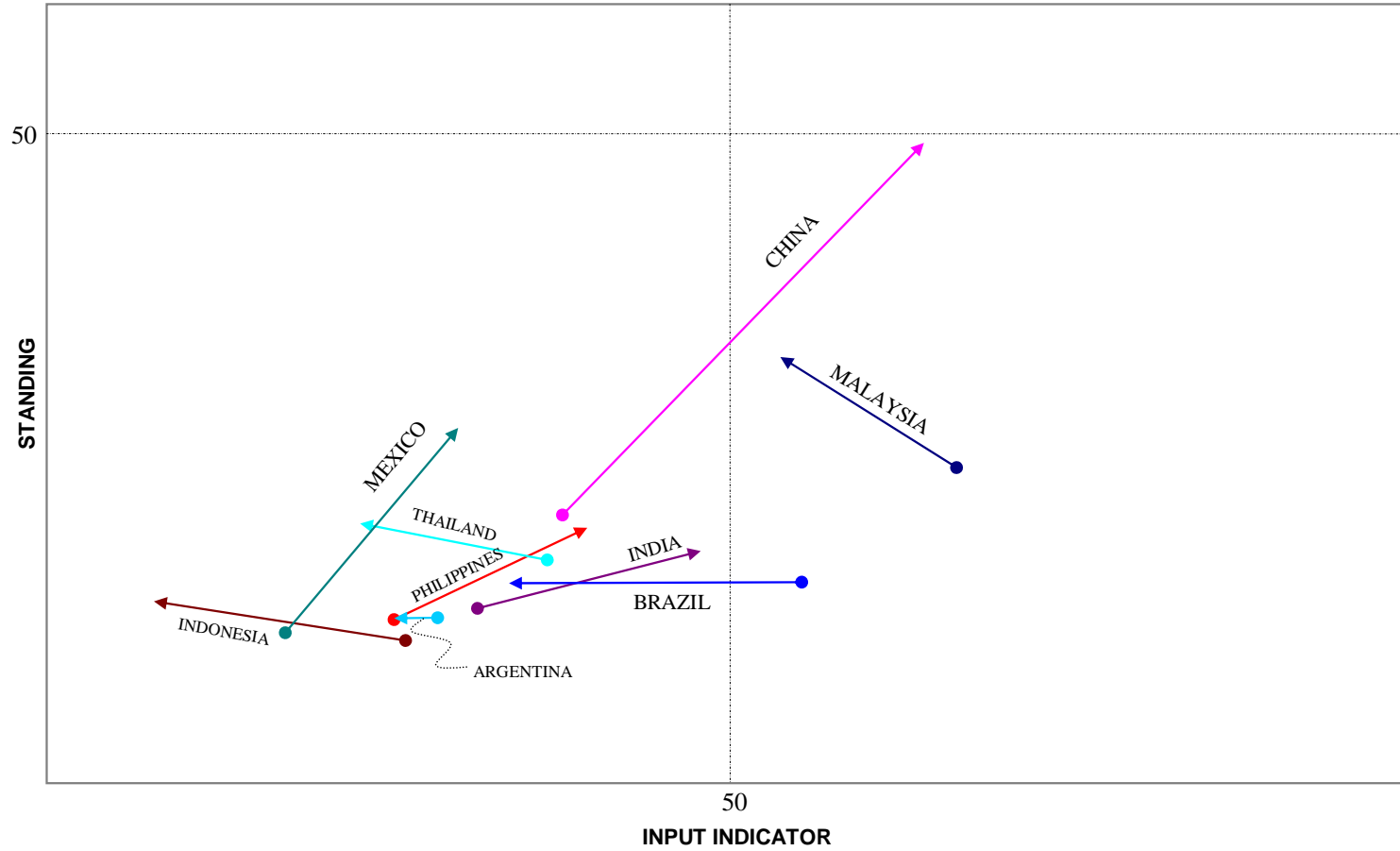


Figure 4.

**Present vs. Future (15 yrs): Overall High Tech Production Capability 2003**

