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Section 9

"Outlook and Challenges to Coal in Asia: 1994-2015,"

by Charles J. Johnson and Binsheng Li, presented at JAPAC International Symposium "Coal Flow '96" The Role of Coal in the 21st Century—Over the Uncertainty," held February 8-9, 1996 in Tokyo, Japan.

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OUTLOOK AND CHALLENGES TO COAL IN ASIA:1994-2015

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Presented at

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Introduction

Coal is Asia's leading primary energy source, in contrast to the dominant role held by oil in the rest of the world. As shown in Figure 1, coal accounts for 45 percent of total primary energy consumption in Asia, more than double its 21 percent share in the rest of the world.[2] A key factor in the dominance of coal in the region is China which accounts for 70 percent of Asia's total coal consumption.

In addition to coal, the other anomalous energy source is natural gas which is only one-third as important in Asia as in the rest of the world. The reasons for the low use of natural gas are (1) relatively small reserves in most Asian countries, (2) the remote location of reserves in some countries, and (3) limited pipeline infrastructure for transportation. Asia's natural gas pipeline infrastructure is still in its infancy, but is projected to grow rapidly over the next two decades. However, even under optimistic assumptions, natural gas would account for only slightly more than one-third of the energy share projected for coal in 2015.

As shown in Figure 1, the remaining energy sources -- oil, nuclear and hydropower -- account for about the same share of primary energy

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[2] In this paper, Australia is included within the Asian region because of its geographic proximity to Asia. All tons are metric tons, and lignite is not included with coal.

consumption in both Asia and the rest of the world.

The two key threats to coal's long term dominance in Asia are: (1) its uneven distribution of reserves and lack of adequate rail transportation infrastructure, and (2) growing environmental concerns about coal-related pollution. Even with increased attention to emissions control for coal, continued growth in coal consumption is expected to result in further deterioration of the environment in Asia for another one to two decades. China will remain the largest polluter in Asia, but we believe it will become Asia's largest user of emissions control technology by 2015.

We have subjectively weighed the above constraints to increased coal use in preparing the projections of the future role of coal in the Asian region. This paper shows past trends in coal production and consumption, plus projections of coal production, consumption and trade over the 1994-2015 period. The projections in this paper are useful as a general indicator of long term patterns in Asia. However, there are too many uncertainties about economic growth rates and energy and environmental policies to suggest that our projections will be accurate for every economy. This paper concludes with the preliminary results of research under way, which suggests that increasing economic wealth in China is the most important factor in solving China's coal-related pollution problems.

Asia's Growing Coal Consumption: 1980-2015

Figure 2, shows Asian coal consumption doubled from 0.9 billion tons in 1980 to 1.8 billion tons in 1994. Asian coal consumption is projected to double again to 3.6 billion tons by 2015. The annual growth rate in consumption is projected to decrease from the 4.7 percent growth rate over the 1980-1994 period, to 3.4 percent over the 1994-2015 period. China and India are projected to continue to dominate Asian coal consumption over the next two decades. Their share of total consumption will remain at 80-85 percent of Asian coal consumption over the next two decades.

Figure 3 shows that electricity generation accounted for 64 percent of

the growth in consumption over the 1980-1994 period. Electricity generation is projected to account for 65-75 percent of the growth in coal consumption over the next two decades. The steel industry's 12 percent share of the growth in consumption over the 1980-1994 period, is projected to gradually decrease over the next two decades. The most important users in the "other" category are industrial uses, and the declining household use sector.

A 1995 survey of international companies showed that the majority of companies prefer coal as the most competitive energy option (Johnson and Li, 1995b). Figure 4 shows the results of the survey with companies preferring coal in 10 of the 13 Asian economies in the survey. The survey covered less than half the active investors in Asia, therefore exact percentage estimates in Figure 4 may not be as useful as the relative ranking of coal for various economies. The results of the survey reflect the strong preference for coal-fired power plants in Asia among private investors. For three economies, China, Australia and India, more than 75 percent of the companies surveyed prefer coal for power plants. The three economies where less than 50 percent of the companies prefer coal are Hong Kong, Thailand and Malaysia.

Asia's Growing Share of World Coal Consumption

As shown in Figure 5, Asia's share of world coal consumption has grown from 28 percent in 1980 to 52 percent in 1995, and is projected to increase to about 60 percent in 2015. In terms of the growth in total tons of coal consumed, Asia is projected to account for 70-80 percent of the growth in world coal consumption over the 1995-2015 period.

With Asia continuing to dominate the growth in world coal consumption, international coal companies are increasingly turning to Asia for investment opportunities in coal mines. But the present investment pattern in Asia is highly skewed, with Australia and Indonesia receiving most of the foreign investment in new coal mine developments. China and India lag far behind in attracting private sector investment in coal mining developments due to their less attractive investment environments.

Thermal Coal's Growing Share of World Coal Trade

As shown in Figure 6, thermal coal's share of Asia's coal imports grew from 45 percent in 1990 to 56 percent today, and is projected to reach 72 percent in 2015. Although coking coal trade in Asia is not expected to grow significantly over the 1994-2015 period, growth in consumption in Asia is projected to increase by 80-105 million tons, almost entirely due to the growth of the steel industries in China and India. China will continue to meet most of its coking coal requirements from domestic supplies, while India is expected to continue to import increasing tonnages of higher quality coking coal imports.

The most important factor in increasing thermal coal demand is the high growth rate in electricity consumption in most Asian economies. Asian economies typically have electricity growth rates averaging more than 6 percent per year, more than twice the average for the rest of the world. Coal-fired power plants are the lowest cost, long term option for base-load electricity generation in the majority of Asian economies, even after the added costs of strict environmental controls on emissions from power plants.

Coal Production

Asian coal production is projected to parallel the growth in consumption over the next two decades, therefore net imports to Asia will grow slowly. Three factors will ensure that most traded coal within Asia will originate in Asia: (1) Asia's location is far from major coal suppliers in North and South America, (2) large coal reserves exist within Asia, and increasingly, (3) most Asian economies are able to attract sufficient domestic and foreign investment for timely expansions in coal production. The most competitive non-Asian source of coal is South Africa, but it is not projected to increase its share of Asian trade.

Figure 7 shows projected Asian coal production doubling over the next two decades to 3.6 billion tons in 2015. Asian coal production is dominated by four economies -- China, India, Australia and Indonesia. These four economies are projected to account for 97-98 percent of the projected growth

in Asia's coal production over the 1994-2015 period.

Exporting Economies

Figure 8, shows Australia, Indonesia and China projected to account for 97-98 percent of net coal exports in Asia in 1994 and 2015.

Australia produced 194 million tons of coal in 1994, and accounts for about 73 percent of net exports within the Asian region. Production is projected to increase to 220-240 million tons in 2000 and 320-360 million tons in 2015. Australia's share of exports could dip as low as about 70 percent in the late-1990s due to increased exports from Indonesia and China, then turn upward after 2000, reaching almost 80 percent by 2015. Australia's continued dominance in coal exports is due to: (1) the combination of large, high quality coal deposits within 300 kilometers of modern deepwater ports, and (2) its ranking as the most favorable investment climate in Asia for coal (Johnson and Li, 1995b).

Indonesia is expected to remain Asia's second largest net coal exporter over most of the 1994-2015 period. Indonesia is projected to increase its coal production from 34 million tons in 1994 to 75-80 million tons in 2000, and 115-135 million tons in 2015. Due to the lower quality of most Indonesian coal, and the projected high growth rate in coal consumption for electricity generation in Indonesia, exports are not expected to exceed 50 million tons per year during the 1995-2015 period.

China's production of 1.2 billion tons in 1994 is projected to reach 1.4-1.5 billion tons in 2000 and 2.1-2.5 billion tons in 2015. The growth in domestic demand for coal is expected to keep China's annual net coal exports within the 20-35 million tons range over the 1994-2015 period.

Although China has large reserves of coal, most foreign investors are wary of major investments in coal mines in China, and this leads to greater uncertainty about the ability of China to smoothly meet its growing domestic requirements and export goals. There is little doubt that foreign investors are interested in investing in China's large and growing coal and power sectors, providing they can obtain reasonable returns on their investments. However,

a 1995 industry survey, ranked China's investment climate for coal mines and power plants, second to last place among the thirteen economies in the survey (Johnson and Li, 1995b). The investment climate in China for foreign investors is expected to gradually improve over the next decade, but the timing of the improvements is speculative.

Importing Economies

The shares of coal imported to various Asian economies will change substantially over the next two decades as shown in Figure 9. Japan's share is projected to decrease from the present 56 percent to 36 percent in 2015. The largest gains are for the Philippines and Thailand which are projected to increase from a combined total of about 1.5 percent in 1994 to 12 percent in 2015.

Figure 10 shows annual net coal imports in 1994 and projected imports in 2015 for coal importing Asian economies. Japan is expected to easily maintain its position as Asia's largest coal importer over the 1994-2015 period. However, South Korea is projected to lead the region in the increase in imports, adding 38 million tons, followed by Japan and India, projected to increase imports by 25-30 million tons each over the next two decades.

Japan is by far the largest coal importing country in Asia, importing 111 million tons in 1994, three times as much as the second largest importer, South Korea. Japan's net coal imports are projected to peak in the 140-150 million ton per year range before 2010, then gradually decrease. Japan will remain the world's largest coal importing economy over the next two decades. Japan's domestic coal production is not economic, and the timing of closure of the remaining mines is largely dependent on efforts to minimize the disruptive impacts to miners and local communities.

South Korea is Asia's second largest net coal importer with 39 million tons imported in 1994. Coal imports are projected to increase to about 48 million tons in 2000 and 80 million tons in 2015. South Korea's domestic anthracite industry is not economic and production has declined from a peak

of 24 million tons in 1988 to 7 million tons in 1994. These long term projections do not include the impact on coal consumption that would occur through closer economic and perhaps political relations between North and South Korea.

Taiwan's imports of 27 million tons in 1994 are projected to increase to about 32 million tons in 2000 and 50 million tons in 2015. Taiwan has insignificant domestic coal reserves.

India (9 million tons) and Hong Kong (8 million tons) were the only other economies with significant coal imports in 1994. India is projected to increase imports to 35 (range 30-50) million tons by 2015, however Hong Kong is projected to increase imports by no more than 6-7 million tons over the 1994-2015 period.

Philippines, Thailand and Pakistan. The Philippines and Thailand are projected to grow from minor importers today (1-2 million tons per year) to at least 20 million tons each by 2015. Pakistan is projected to increase its imports from 2 million today to 10-20 million tons in 2015. Pakistan has large, low quality coal resources, but their remote location and difficult mining conditions make large scale development doubtful for at least a decade.

Asia's Biggest Environmental Challenge: Cleaning Up China's Polluted Air

Coal's continued growth in Asia is assured only if governments reduce the serious environmental impacts of increased coal use. Most of Asia's coal related pollution is generated in China, which accounts for more than 70 percent of Asia's SOx, more than half the region's particulates, and about half the region's NOx and CO_2 emissions. NOx and particulate emissions can be controlled at low costs with existing technologies. At present, the only commercial option for reducing CO_2 emissions from burning fossil-fuels is by increasing energy efficiency.

The most difficult regional coal-related environmental challenge facing Asia over the next two decades is the control of SOx emissions. The two proven commercial technologies for SOx control are fluidized bed combustion

(FBC) and flue gas desulfurization (FGD) that typically add 15-25 percent to the cost of generating electricity.

Chinese officials are concerned with the high costs of SOx control technologies, and power companies are unlikely to install high efficiency SOx control technologies on a wide scale over the next decade. China has installed a small number of FGD systems but Chinese officials have reservations about the high costs of these technologies. Therefore, officials are reluctant to commit to the relatively high costs of SOx control technologies even though there is increasing concern within China about the high levels of SOx pollution. Policies to control coal-related emissions have yet to be rigorously enforced in China, and it is difficult to predict when tough environmental legislation will be enforced in China.

Chinese government officials are concerned about the growing pollution problems China. Officials generally present optimistic assessments of their progress in controlling coal-related pollution, but our analysis suggests China's coal-related pollution problems are becoming more serious. We are developing a model to provide insights into the location and timing of SOx control technologies in China. The fundamental assumption of our model is that the level of pollution control will increase with rising per capita incomes. An examination of the trends in use of SOx control technologies among coal using countries of the world shows increasing use of SOx control technologies with increasing per capita incomes. There no one specific acceptable level of pollution control in all economies, but a trend toward tighter SOx emission standards at higher income levels.[3]

The per capita income of China is quite low and it will take a number of decades for average national per capita incomes to reach the level where most economies enforce strict SOx control legislation. However, the conclusions are different at the province level where some Chinese provinces are much

[3]There are a number of other factors that influence the level of acceptable pollution. Stringent environmental legislation is sometimes enacted at low income levels (such as in Indonesia) or may be less stringent than expected at high income levels.

richer than others, and likely to reach middle income levels within two decades.

We are not sure at what income and pollution levels Chinese provinces will enforce SOx control. For our preliminary analysis, we assumed that at income levels between South Korea and Taiwan, they would install SOx control technologies. South Korea (1993 GNP/capita: US$6,790) and Taiwan (1993 GNP/capita: US$10,202) both have embarked on programs to install SOx control systems on power plants. Taiwan's SOx control program is ahead of South Korea's, however South Korea will impose strict emission limits in 1999. To provide better comparability, per capita income was converted to "purchasing power parity" (PPP) for South Korea, Taiwan and Chinese provinces.[4]

In Figure 11 the vertical axis shows estimated per capita incomes in terms of PPP for 1993, and the horizontal axis shows the estimated concentration of SOx per square kilometer. South Korea and Taiwan are shown in the upper right hand corner of the figure, and Chinese provinces are scattered below and to the left of their richer neighbors. The curves through Taiwan and South Korea did not include any Chinese provinces in 1993, therefore, no Chinese province had high enough per capita incomes to enforce SOx control technologies.

At the subprovince and city level there are to a number of areas (such as the Pearl River Delta) that already have sufficiently high incomes to expect enforcement of strict SOx limits.[5]

Figure 12 shows our preliminary projections of per capita PPPs and SOx levels per square kilometer for Chinese provinces in 2015. Our projections for 2015 show that many provinces will reach the South Korea and

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[4] Purchasing power parity is a coefficient for the number of units of currency required to buy the same amount of goods and services in the domestic market. PPP provides a better measure than GNP/capita of the actual per capita purchasing power in various economies.

[5] The adoption and enforcement of national environmental legislation could accelerate the installation of SOx control technologies.

Taiwan per capita income/pollution levels (curves) by 2015, and therefore will have sufficient income levels to install SOx control technologies. High level SOx control is assumed for provinces above the Taiwan curve, medium level control is assumed for provinces between the South Korean and Taiwan curves, and low level control is assumed for provinces falling below South Korea in Figure 12. The data from Figure 12 was used to prepare the map of China in Figure 13.

By 2015 most coastal provinces are projected to become high users of SOx control technologies, as are selected inland provinces -- particularly the heavily polluted eastern half of Sichuan (see Figure 13). Western provinces are projected to be low users of SOx control technologies, with medium users mostly located in eastern, non-coastal areas. Our preliminary results indicate China will meet the wealth criteria within two decades to invest heavily in SOx control technologies.

One caveat: China's highest sulfur coal exists mostly in the south, as shown in Figure 14. It is likely that the government will enforce legislation earlier than predicted by our model, to require the use of SOx control technologies in those areas that are burning very high sulfur coal.

The preliminary results presented here show that even low per capita income Asian economies, such as China, when examined at a province level, can become rich enough within two decades to invest in SOx control technologies. The preliminary analysis presented here should be used in conjunction with other information -- particularly environmental legislation and the degree to which it is being enforced. The combination of both economic and policy considerations is likely to improve our ability to estimate when and where China and other Asian economies will invest in SOx control technologies.

Conclusions

Asia will account for about 75 percent of world growth in coal consumption over the 1994-2015 period. Trade will increase more rapidly than consumption; however, net imports to Asia from outside of Asia will

grow slowly. Thermal coal will account for most of the growth in coal consumption and trade, but substantial growth in coking coal consumption is projected for China and India.

Coal is projected to maintain about 40 percent of the energy market. Natural gas is the fuel of choice where available, and its growing share in Asia's energy mix will cut into coal's dominant position in some areas of Asia.

Asia has some of the worst coal-related pollution in the world. The size of the environmental problems is beyond the scope of foreign aid assistance from industrialized economies. Although timely foreign assistance and cooperation is an important element in reducing the growth in coal-related pollution in Asia, it is individual Asian economies that will need to carry the major share of the burden in cleaning up their environments. Asia will increasingly need to clean up its own environment through better environmental legislation and enforcement, and higher electricity tariffs that will allow investors to recover the costs of pollution control technologies.

Our preliminary analysis suggests that the worst polluted country in Asia, China, will become rich enough within two decades to afford the costs of cleaning up its own environment. China's pollution problems are so large that quick fixes to China's pollution problems are impossible, and it will take at least a decade of aggressive environmental action to halt the growth in pollution. Decreasing central government funding in China will shift more of the burden of environmental cleanup to the provinces and probably private sector investors.

In closing, coal's dominant role in Asia appears secure for the next two decades due to its continued competitive position, and the ability of an increasing share of Asia to pay for environmental control technologies.

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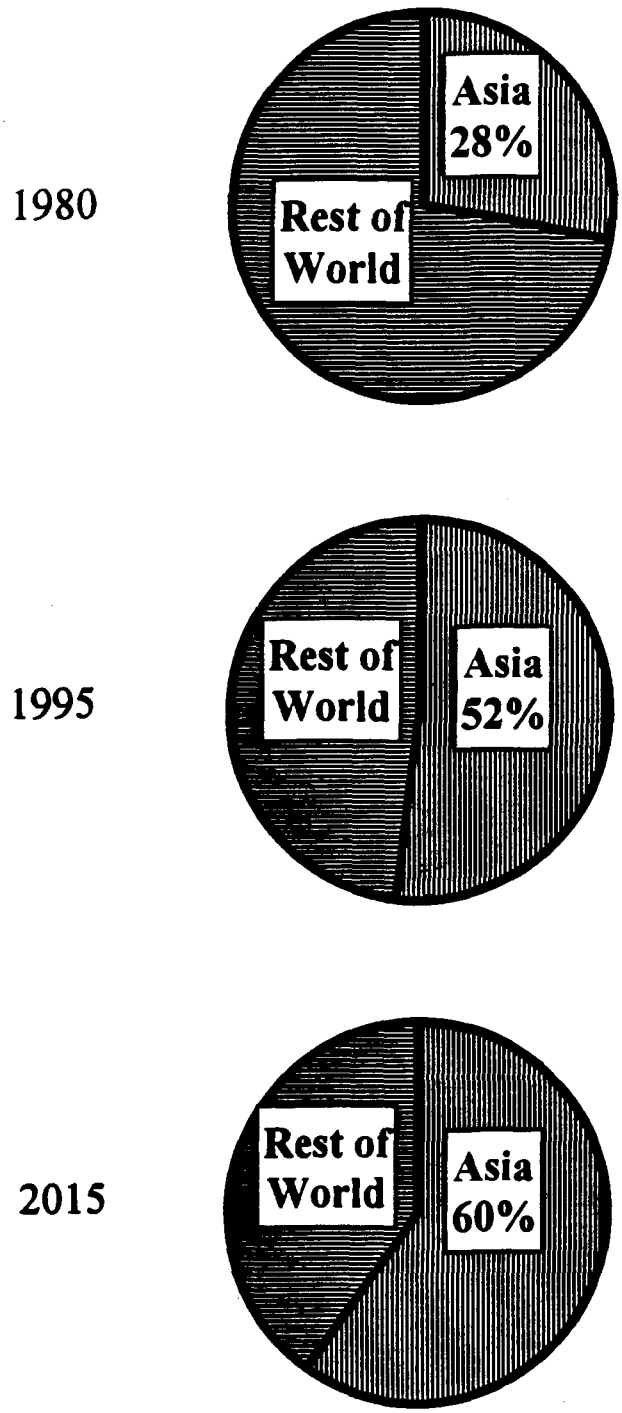

Figure 5. Asia's Growing Percent of World Coal Consumption

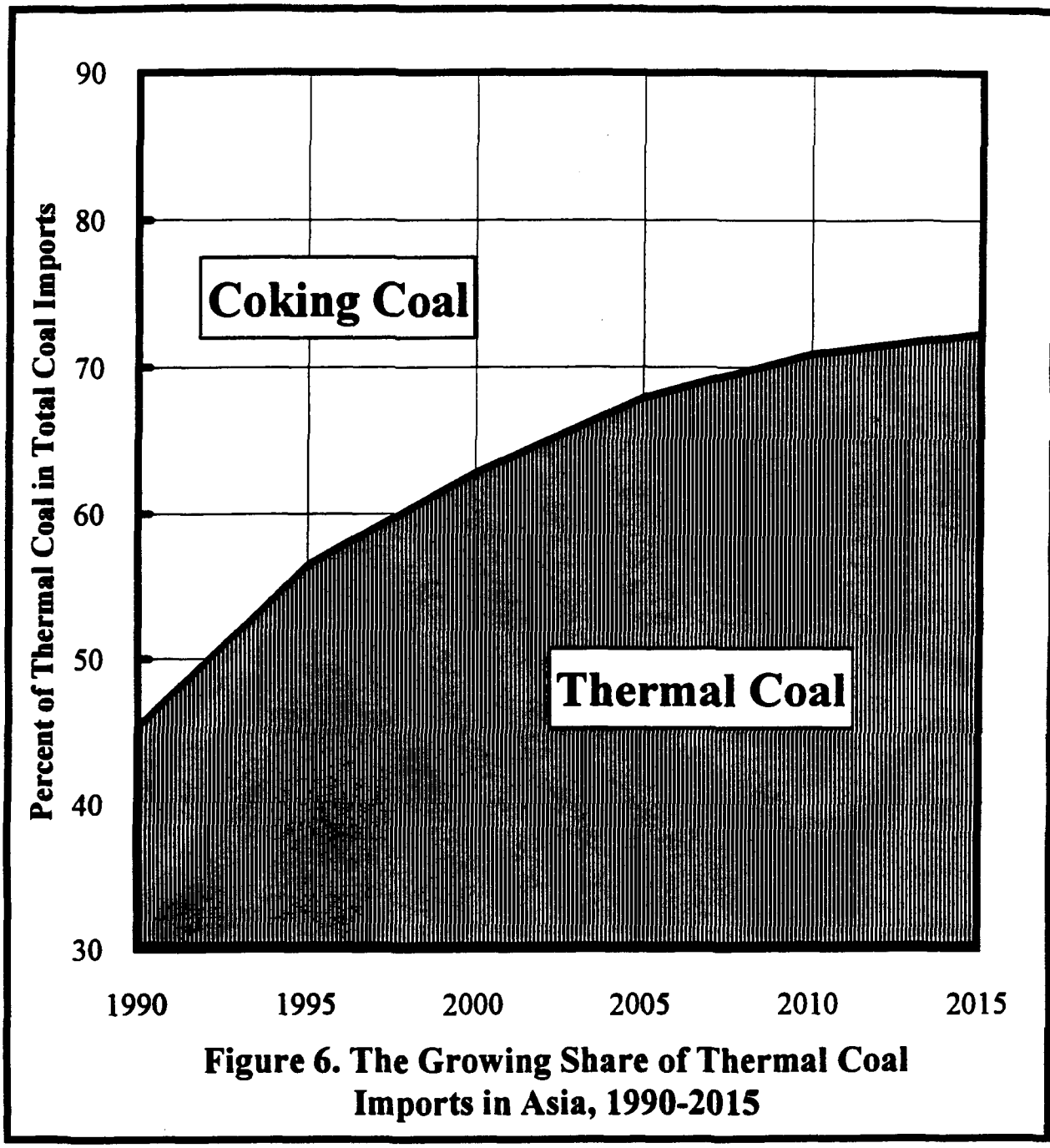

Figure 6. The Growing Share of Thermal Coal Imports in Asia, 1990-2015

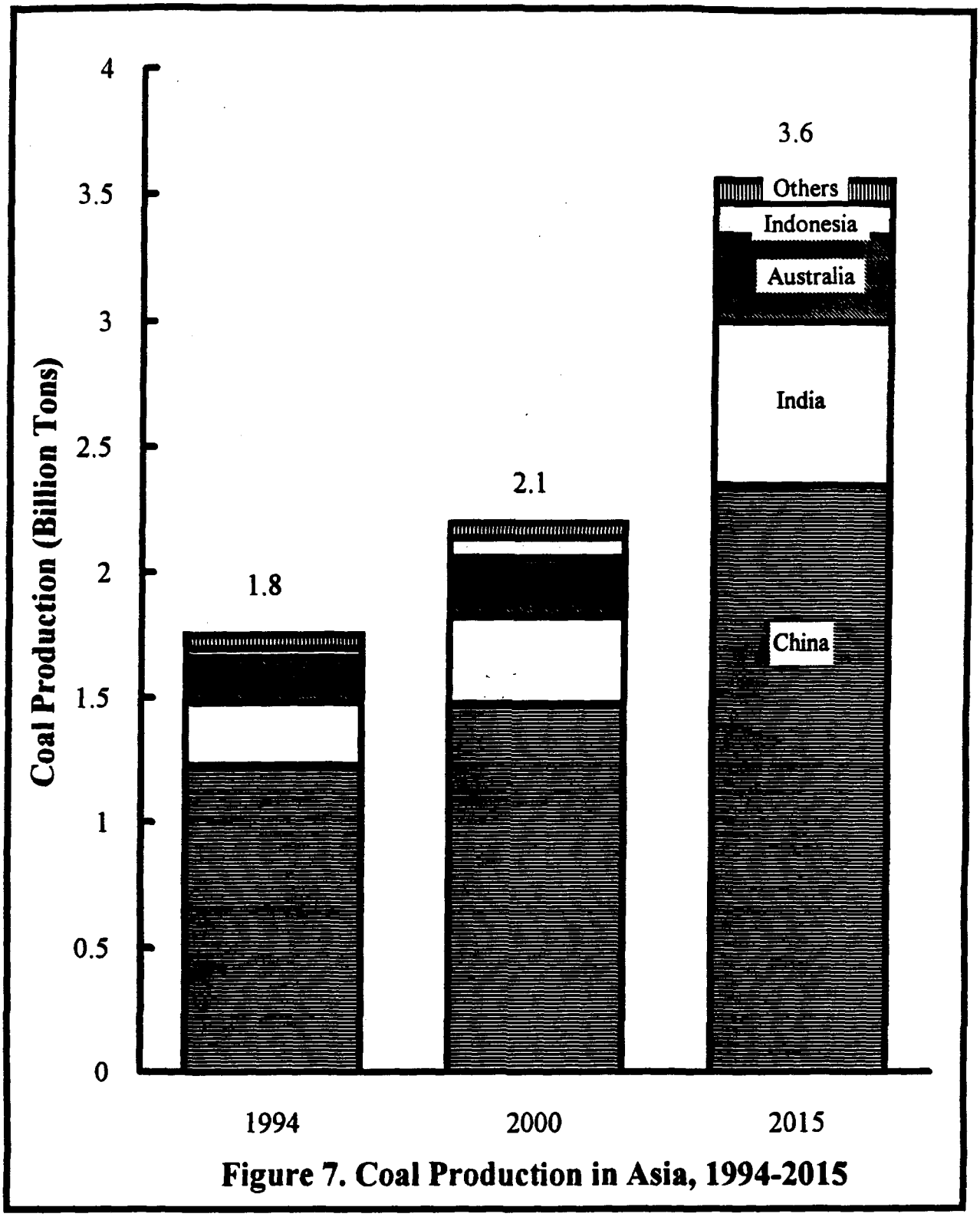

Figure 7. Coal Production in Asia, 1994-2015

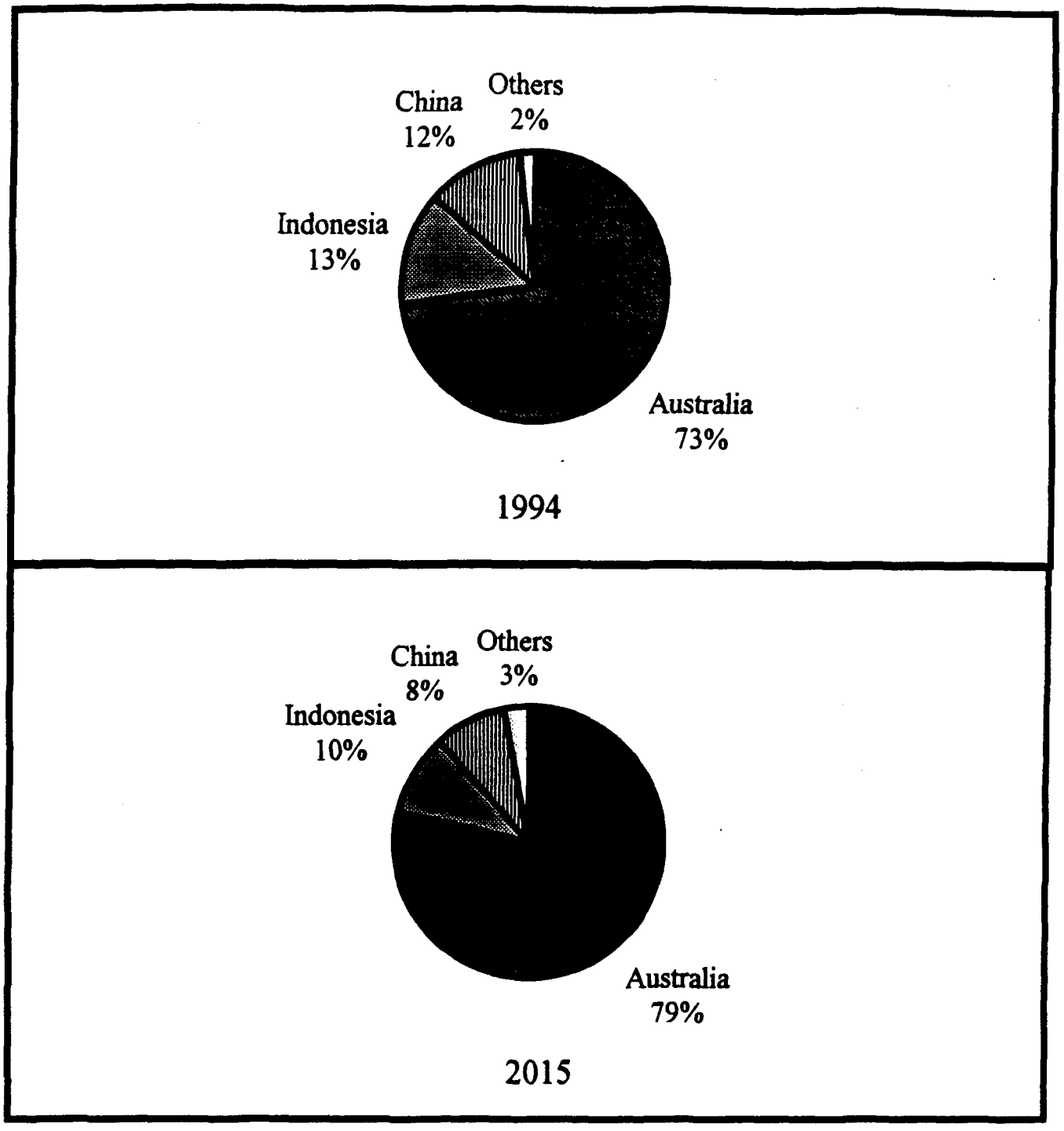

Figure 8. Net Coal Export Shares Among Asian Economies in 1994 and 2015

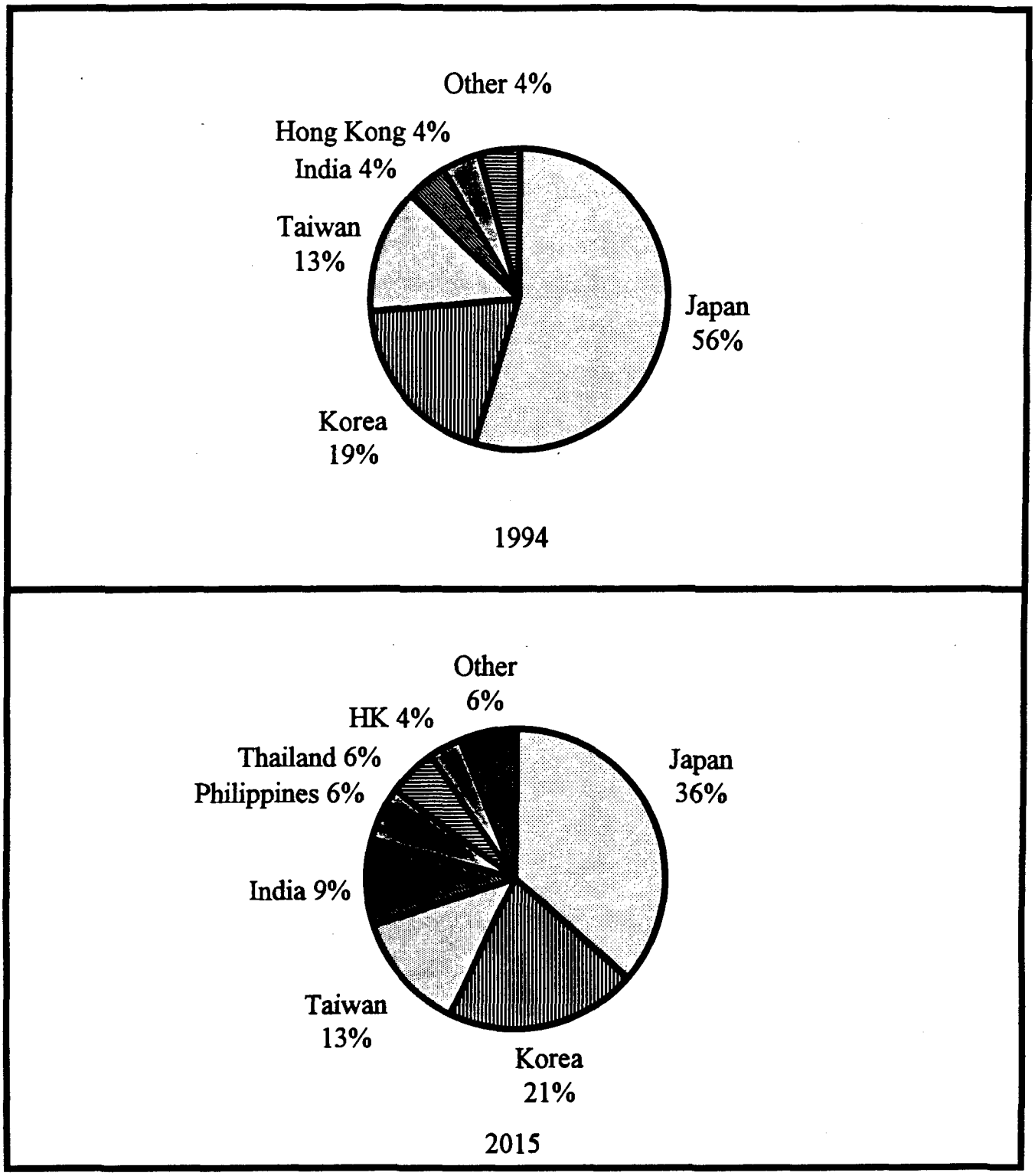

Figure 9. Percent of Net Coal Imports to Asian Economies in 1994 and Projected in 2015

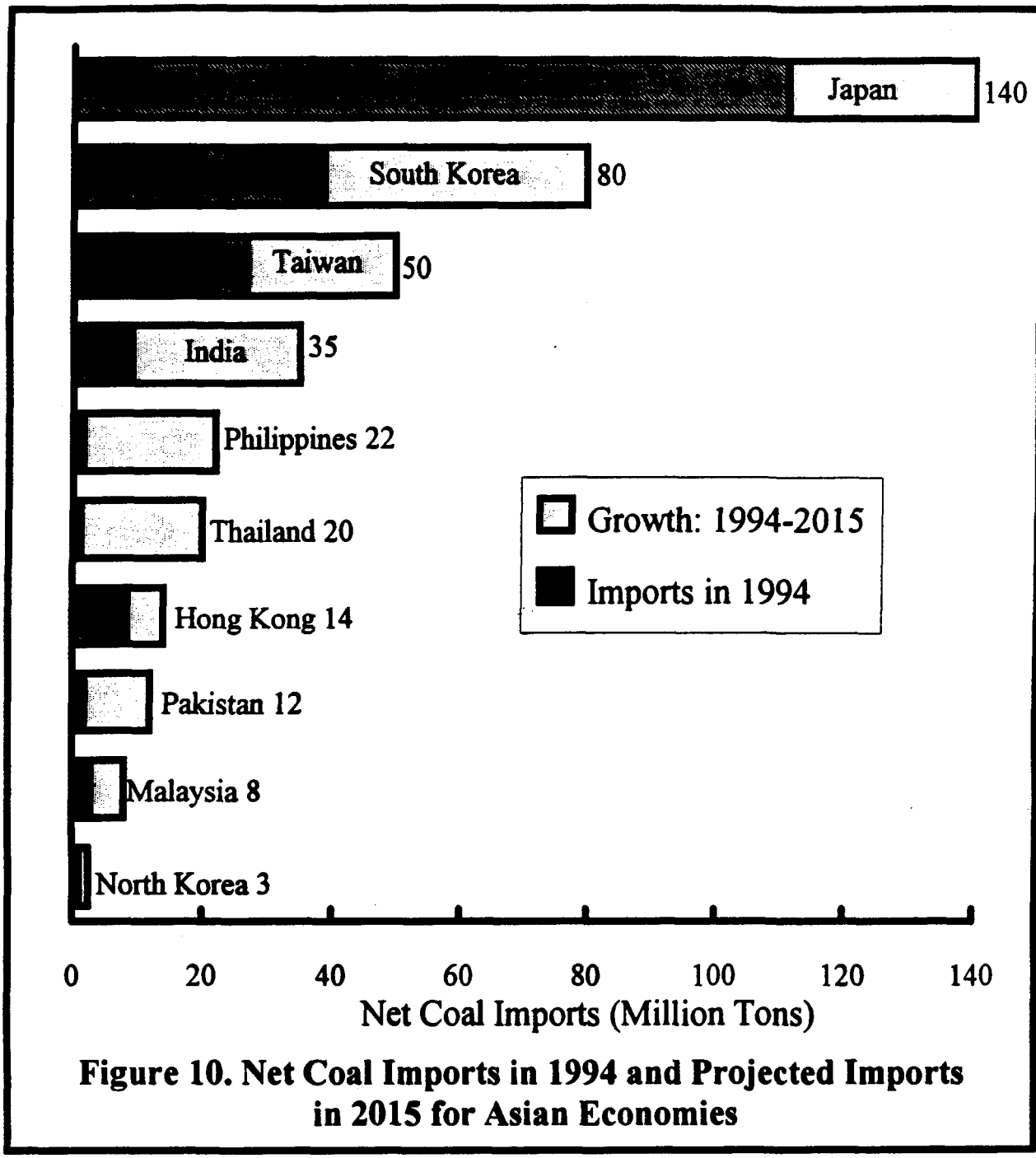

Figure 10. Net Coal Imports in 1994 and Projected Imports in 2015 for Asian Economies

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