THE IMPACT OF TECHNOLOGICAL TRANSFORMATION
ON HISTORICAL TRENDS IN INCOME DISTRIBUTION
OF ASIA AND THE WEST

HARRY T. OSHIMA

THIS paper focuses on the effect of the technological transformations that underlie Simon Kuznets's stylized, inverted U curve for the West and for a similar curve that I worked out for Asia, published in the *Hitotsubashi Journal of Economics*, June 1992 [25]. After returning to the United States in mid-1992 I began to study the literature on the tendency for Western inequality to rise in recent years, this being attributed to the influence of electronic technologies. The question arose of the possibility of the end of the falling portion of the Kuznets's inverted U curve. This further raised the possibility that the Asian curve would turn up in the near future. This paper is an attempt to look into these issues by exploring the impact of technological change on income distribution, first in the West and then in Asia. The discussion is on trends and not on levels. Asian levels tend to be higher than in the West but this is due to the less developed nature of Asian countries with lower farm income per worker and in the urban areas more unskilled workers and low-income proprietors [33, 1989 and 1990 editions]. But with further development, farm income per worker and income per proprietor should rise and the size of the unskilled working class should fall.

We begin with a summary of the derivation of the Asian inverted U curve which is discussed at length in my Hitotsubashi paper cited above.

I. KUZNETS'S CURVE FOR THE WEST

The term, inverted U curve, is a misnomer. It was not Kuznets who so designated the trend, since he thought of the Western curve as long swings, underlying which were long swings in the growth rate of population, urbanization, migration, and national savings.[1]

Although the data for the 19th century were scanty, Kuznets found that the income share of the highest 20 per cent of taxpayers rose from 58 per cent in 1880 to 59 per cent in 1913 in the United Kingdom; from 21 per cent in 1854 for the

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[1] According to Kuznets in private conversation on his visit to Manila in the 1970s. Also he worked with family instead of individual income, because even though it is the latter who participated directly in production, much of income (especially in the case of property and proprietors' income) is generated collectively by members of the family on the farm, stores, restaurants, and workshops; besides the fact that the family, being the basic consuming unit, is appropriate for the various welfare uses to which income distribution data are used.

top 5 per cent in Prussia to 26 per cent in 1875 and 30 per cent in 1913; Saxony's top 20 per cent rose from 56 per cent in 1880 to 57 per cent in 1896 [15, pp. 208–9]. Kuznets noted that the proportion of property income in the total national income rose from the nineteenth century to around World War I for the United Kingdom, France, and Germany and to around World War II for the United States [15, pp. 168–69]. In Japan, inequality rose from the late nineteenth century and fell after World War II [19]. Kuznets could cite much more data for the downward swing, especially after World War II and into the 1960s. The decline was widespread and clear-cut for the United States, United Kingdom, West Germany, Netherlands, Denmark, Norway, Sweden, and other industrialized countries [15, pp. 208–11]. The share of incomes in the top 5 per cent of U.S. families dropped from 24 per cent in 1917–19 to 20 per cent in 1955–59 while the incomes of the lowest 60 per cent rose from 26 per cent in 1929 to 32 per cent in 1955–59. In the United Kingdom, the top 20 per cent share declined from 58 per cent in 1880 to 42 per cent in 1957 [15, pp. 208, 211].

For the 1970s, inequality in the United States began to rise, slowly at first from a Gini coefficient averaging 0.35 in the later 1960s to 0.36 in the 1970s, then accelerating to 0.38 in the 1980s and 0.40 in the early 1990s [29]. Inequality of earnings of men heading families rose in West Germany, Canada, Sweden, and Australia [10, pp. 6–7]. Overall inequality of wages (including those of women) rose not only in the foregoing countries but also in the United Kingdom and the United States although it was stable in France and the Netherlands [6] [10].

II. ASIAN INCOME DISTRIBUTION TRENDS

Based on the Ginis of family income distribution data of the Republic of Korea, Taiwan, Hong Kong, Singapore, Thailand, Malaysia, Philippines, and Indonesia over a period of two or three decades, it is possible to detect an upward movement in inequality during the early period and then a downward movement.[2] (See Table I). As in the case of the Western industrialized countries before World War I, the data are scanty for the period prior to the peaking of the curves which is around a per capita income level of $500 to $1,000 (in 1972 prices). This compares with the peaking of Western curves at per capita incomes of $1,500 to $2,000 (in 1972 prices). The peak for Korea was in 1976 when the Gini rose to 0.39; for Taiwan in 1953 with the Gini reaching 0.56; Hong Kong in 1963/64 at 0.50; Singapore in 1966 at 0.50; in Thailand in 1992 at 0.52; Malaysia in 1973 at 0.52; Philippines in 1961 at 0.49; and Indonesia in 1976 at 0.49.

Although data are not available for the pre–World War II decades, it is possible to speculate that inequality was very low at the time when the Asian economies were premodern, traditional economies with very little industrialization and farm commercialization. Data for Thailand at this early stage for 1962 indicate a Gini

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[2] The stylized curve with the Gini coefficient on the vertical axis and per capita dollar incomes on the horizontal axis is shown in my book [26, p. 200] and also in my paper [25, p. 99]. It is reproduced in Figure 1 in this paper.

TABLE I

GINI TRENDS IN ASIAN COUNTRIES

East Asia		Southeast Asia		South Asia	
Year	Gini	Year	Gini	Year	Gini
Japan:		Singapore:		Bangladesh:	
1962	.37	1966	.50	1963/64	.36
1965	.34	1972	.44	1966/67	.34
1970	.41	1974	.43	1968/69	.29
1975	.36	1979	.42	1973/74	.36
1980	.33	1984	.47	1976/77	.45
1985	.35	1989	.39	1981/82	.39
1990	.35			1983/84	.35
				1988	.39
Republic of Korea:		Thailand:		Sri Lanka:	
1965	.34	1962	.41	1953	.50
1970	.33	1969	.43	1963	.49
1976	.39	1975	.42	1969/70	.43
1982	.36	1981	.43	1973	.41
1985	.34	1986	.47	1981	.31
1988	.34	1988	.47	1985	.43
1991	.35	1990	.49	1989	.37
		1992	.52		
Taiwan:		Malaysia:		India (Rural):	
1953	.56	1957/58	.45	1956/57	.34
1959/60	.44	1967/68	.48	1964/65	.42
1964	.32	1970	.51	1967/68	.48
1970	.29	1973	.52	1975/76	.41
1974	.29	1979	.49	1986	.42
1980	.28	1984	.48		
1985	.29	1988	.44		
1990	.31				
1992	.31				
Hong Kong:		Philippines:			
1957	.48	1961	.49		
1963/64	.50	1965	.49		
1966	.49	1971	.48		
1971	.44	1985	.45		
1973/74	.42	1988	.45		
1976	.44	1991	.45		
1979/80	.40				
1981	.45				
1986	.42				
1991	.45	Indonesia:			
		1976	.49		
		1982	.45		
		1987	.37		
		1990	.43		

TABLE I (Continued)

Sources:

Japan:

Toshiyuki Mizoguchi, "Economic, Sociological and Institutional Factors Related to Changes in the Size Distribution of Household Income: Japan's Experience in a Century," unpublished paper (Tokyo, 1989). According to Mizoguchi, the Gini coefficient for 1970 is somewhat irregular, reflecting the characteristics of the sample that year. The figure for 1990 is from World Economic Information Services (WEIS), a research foundation affiliated with the Ministry of International Trade and Industry of Japan.

Republic of Korea:

Choo Hakchung, "Estimation of Size Distribution of Income and Its Sources of Change in Korea, 1982," *Korean Social Science Journal,* Vol. 12 (1985), p. 95 for 1965 to 1982 data. Figures for 1985 and 1988 are from National Statistical Office, *Social Indicators in Korea, 1993* (Seoul, 1993), p. 60. The figure for 1991 is from WEIS.

Taiwan:

Figures for 1953 and 1959/60 are from Shirley W. Y. Kuo, *The Taiwan Economy in Transition* (Boulder, Colo.: Westview Press, 1983), pp. 96–97. Figures for 1964 to 1992 are from *Report on the Survey of Personal Income Distribution in Taiwan Area of the Republic of China, 1992,* published by the Directorate-General of Budget, Accounting and Statistics, Executive Yuan, Republic of China (Taipei, 1993), p. 15.

Hong Kong:

Laurence L. C. Chau, "Economic Growth and Income Distribution of Hong Kong since the Early 1950's," University of Hong Kong, Department of Economics, Discussion Paper No. 38 (1984) for 1957 to 1979/80 data. Figures for 1981, 1986, and 1991 are from Tzong-biau Lin, "De-industrialization, Integration and Great U Turn in Hong Kong," paper presented at Conference on Growth, Justice, and Income Distribution, July 27–28, 1994, Honolulu.

Singapore:

Figures for 1966 to 1974 are from V. V. Bhanoji Rao and M. K. Ramakrishnan, "Economic Growth, Structural Change and Income Inequality, Singapore, 1966–1975," *Malayan Economic Review,* Vol. 21, No. 2 (October 1976), p. 107. Figures for 1979 and 1984 are from V. V. Bhanoji Rao, "Income Distribution in East Asian Developing Countries," *Asian-Pacific Economic Literature,* Vol. 2, No. 1 (March 1988), p. 28. The 1989 data is from WEIS.

Thailand:

Yukio Ikemoto, *Income Distribution in Thailand: Its Changes, Causes, and Structure* (Tokyo: Institute of Developing Economies, 1991), p. 11. Figures for 1981 to 1992 are from Yukio Ikemoto, "Income Distribution and Malnutrition in Thailand," unpublished paper (Center for Southeast Asian Studies, Kyoto University, 1994).

Malaysia:

Yukio Ikemoto, "Income Distribution in Malaysia: 1957–80," *Developing Economies,* Vol. 23, No. 4 (December 1985), p. 353 for 1957/58, 1970, and 1979 data. Lim Lin Lean, "Income Distribution in West Malaysia, 1967–68," in *Income Distribution, Employment and Economic Development in Southeast and East Asia,* Vol. 1 (Tokyo: Japan Economic Research Center; Manila: Council for Asian Manpower Studies, 1975), p. 181 for 1967/68 data. V. V. Bhanoji Rao, "Income Distribution in East Asian Developing Countries," *Asian-Pacific Economic Literature,* Vol. 2, No. 1 (March 1988), p. 35 for 1973 data. *Fifth Malaysia Plan, 1986–1990* (Kuala Lumpur, 1986), p. 100 for 1984 data. The 1988 data is from WEIS.

Philippines:

Arsenio M. Balisacan, "Rural Poverty in the Philippines: Incidence, Determinants

TABLE I (Continued)

and Policies," *Asian Development Review,* Vol. 10, No. 1 (1992), p. 131. The data for 1991 is from WEIS.

Indonesia:

Figures for 1976 and 1982 are from Abuzar Asra, "Distributional Impacts of Economic Growth: The Case of Indonesia, 1969–70 to 1981" (Ph.D. diss., Griffith University, 1988), p. 130. The 1987 data is from the Central Bureau of Statistics. The data for 1990 is from WEIS.

Bangladesh:

S. R. Osmani and Atiq Rahman, *Income Distribution in Bangladesh,* BIDS Research Report No. 53 (Dhaka: Bangladesh Institute of Development Studies, 1986) for 1963/64 and 1966/67 data. Atiq Rahman, Simeen Mahmud, and Trina Haque, *A Critical Review of the Poverty Situation in Bangladesh in the Eighties,* BIDS Research Report No. 66 (Dhaka: BIDS, 1988), Vol. 1, p. 6, for 1968/69 to 1983/84 data. The 1988 data is from WEIS.

Sri Lanka:

Figures for 1953 to 1973 from Neville S. Karunatilake, "Changes in Income Distribution in Sri Lanka," in *Income Distribution, Employment and Economic Development in Southeast and East Asia* (Tokyo: JERC; Manila: CAMS, 1975), Vol. 2, p. 716. Figures for 1981 and 1985 from *Labour Force and Socio-Economic Survey—1985/86, Sri Lanka, Preliminary Report* (Department of Census and Statistics, 1987), p. 60. The 1989 data is from WEIS.

India:

Changes in Rural Income in India, 1968–69, 1969–70, 1970–71 (New Delhi: National Council of Applied Economic Research, 1975). *Household Income and Its Disposition* (New Delhi: NCAER, 1980). *Changes in Household Income, Inter-Class Mobility and Income Distribution in Rural India, 1970–71 to 1981–82* (New Delhi: NCAER, 1986), p. 55. The 1986 data is from WEIS, but it pertains to the urban as well as the rural sector.

Fig. 1. Stylized Income Distribution Trends: Asia and the West
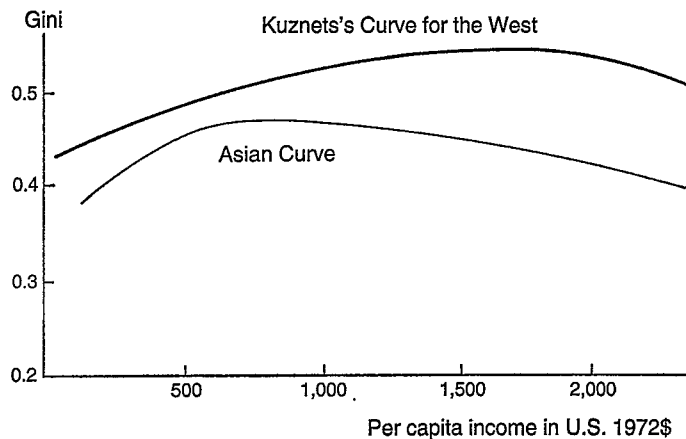
of 0.41, later steadily rising to 0.52 in 1992. The Gini averaged 0.34 in Bangladesh in the 1960s and India, 0.34 in 1956/57, but it is difficult to detect a trend in the figures of the two countries in subsequent decades.[3]

In the traditional premodern economy, small self-subsistent peasant farming predominates, alongside small numbers of large peasants and landlord farms which produce for the small urban sector with its crafts and cottage industries, small stores, and stalls. The higher income groups consist of merchants, moneylenders, rural and urban landlords, professionals, and public officials. The Thai census of 1937 reports nearly 90 per cent of the labor force in agriculture, forestry, and fishing, 3 per cent in industry, and 7 per cent in commerce, personal and public services. The low level of inequality is due to the multitude of small peasant farms whose incomes dominate the distribution of income in traditional monsoon economies.[4]

III.   FORCES CONTRIBUTING TO THE UPWARD TRENDS IN THE WEST: STEAM-BASED TECHNOLOGIES

Kuznets remarked that for the nineteenth century: "It seems plausible to assume that in the process of growth, the earlier periods are characterized by a balance of counteracting forces that may have widened the inequality in the size distribution of total income for a while because of the rapid growth of the non-A [agriculture] sector and wider inequality within it" [15, p. 217]. Elsewhere he added that the rise in inequality was also due to the increase in the growth rate of population, the rise in migration and the expansion of urbanization, and the low rate of national savings. But for some reason, he did not pay much attention to the nature of nineteenth century steam-driven technology as a major source of income disparity.[5]

The steam-driven technology, compared to that of the later electric-driven technology, was crude and cumbersome, lacking in precision, flexibility, and versatility, and costly, not affordable by most firms. To generate steam, large, coal-fed boilers were required and for steam to be distributed throughout the factory, a complex maze of shafts, pulleys, and pipes had to be built overhead. This infrastructure was too costly for most of the smaller firms which were owned and operated by families with insufficient capital.

Cheaper were the water wheels run by water power, but firms had to be located near rivers. Often far from urban centers and being less powerful than steam

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[3] The Gini for Sri Lanka declines from 0.50 in 1953 to 0.31 in 1981, largely due to the adoption of extensive welfare measures. With the abandonment of these measures the Gini rises. Similarly in China, the Ginis are low during the egalitarian Mao period but rise in the 1980s [20].

[4] Details on this point are found in my *Economic Growth in Monsoon Asia* [24, chaps. 1 and 2].

[5] Kuznets [14]. Steam engines in the nineteenth century, electric motors in most of the twentieth century, and computers in the recent decades may be thought of as general purpose technologies serving as "engines of growth" in driving technological progress and economic growth since the nineteenth century. See Bresnahan and Trajtenberg [3].

engines, only smaller numbers of machines could be handled by water wheels. The vast majority of craft shops and domestic industries had to operate machines and other equipment by hand.

Thus, major differences in labor productivity and earnings prevailed in late nineteenth century England among the hodgepodge of large factories with steam engines, medium factories with water mills, and craft shops and domestic industries based on muscle power in each industry. With the exception of textiles, most firms were small, averaging about ten workers. Even in the metal-working industries, small furnaces with simple, hand-operated equipment were found in the home-based shops.

Not only did nineteenth century technologies fail to mechanize most firms in the various industries but within each firm the extent of mechanization was limited. This is so even in the textile factory where skilled operatives work side by side with even larger numbers of poorly paid women and children, most of whom were involved in menial tasks such as handling, hauling, cleaning, sweeping, and so on. The iron industry looked more like construction works, with most of the workers shoveling, digging, hauling, and pounding. Even in the most highly mechanized industry, textiles, only six of the production operations were mechanized, compared to twenty-five mechanized operations in the electric-powered factories of the twentieth century. In 1851 modern industry employed 1.7 million workers compared to 2.5 million in traditional industry.[6] Patents issued in the United States averaged 20,000 in the 1880s compared to 60,000 in the 1960s [30, pp. 957–59].

Nor did nineteenth century technology succeed in mechanizing the agricultural and services sectors. The steam engines with their elaborate infrastructures were too expensive for the wide-open fields and were irrelevant to the small shops, stores, and offices, although they quickly replaced horses in construction and on the railroads.

Organizationally, the variations in size were considerable in agriculture. There were large estates of big landlords, large and medium-sized capitalistic farms, freeholders, and tenanted farmers, besides farm laborers without land. In retailing, department stores began to emerge toward the end of the century amidst a sea of small stores. In transportation, alongside the steam-engine railroads were the innumerable one- and two-horse-driven carriages, wagons, and carts.[7]

In sum, in such a heterogeneous structure, per worker productivity and earnings probably ranged widely not only between industries, i.e., between the partially mechanized manufacturing, mining, and transport industries, and unmechanized agriculture, construction, and services, but also within industries, i.e., between mechanized factories, mines, railroads, and medium and small craft shops and domestic industries.[8]

All this meant that the middle class, whose families occupied the middle deciles in the distribution of income and were the main contributors to income equali-

6 Crouzet [4, chap. 4] for data and descriptions in the above paragraphs.
7 For the United States, see paper by Tenim [27] and Du Boff [9].
8 See wage data in Williamson and Lindert [32].

zation, was a small group relative to the upper-income class of landlords, capitalist farmers, industrialists, merchants, and bankers and the lower-income working families of smallholders, tenants, craftsmen, laborers, and domestic servants.[9] The simple technology of the nineteenth century did not call for the large group of professional, technical, clerical, and public workers which the twentieth century technologies required. Instead, it created a large group of unskilled workers who filled the nineteenth century workshops, plus the *Lumpenproletariat* of Karl Marx composed of casual workers with intermittent jobs, the technologically unemployed, and the beggars.

In such a stratified society, property incomes and proprietors' profits of the highest decile of families were large relative to the salaries of white collar workers and wages of technicians, skilled workers, and farmers in the middle deciles and to the share of wages of the farm laborers, unskilled laborers, casual workers, and servants in the lowest deciles. As noted by Kuznets, the share of property income in the national income rose from the nineteenth century to around world wars I and II in the United Kingdom, United States, France, and Germany.

IV. DOWNWARD TRENDS IN THE WEST: ELECTRIC-POWERED TECHNOLOGIES

In 1900, 80 per cent of machines were driven by steam engines, but by 1929, 78 per cent were driven by electric motors while horses were replaced by internal combustion engines on farm and road. And the weird array of shafts, pulleys, and pipes on the factory ceilings was replaced by wires on the factory floor [8, p. 349]. The rapid spread of electric power was due to its superiority over steam power—in speed, convenience, versatility, flexibility, precision, and cost. Electric power became affordable not only by owners of small factories but also by owners of stores, offices, shops, and homes. More important, its versatility, flexibility, and precision spawned innumerable machines, especially small ones, superior to the cumbersome, steam-driven machines. Mechanization spread across and within industries. Small electric motors were inserted into each machine hitherto manually operated, while the internal combustion engines revolutionized transportation by replacing horses, bicycles, carts, and steam engines.

The productivity gap between and within industries narrowed, and variability in earnings fell. Productivity in agriculture rose as internal combustion engines replaced horses in plows and carts, and electric wires were connected to farm equipment. This made it possible for small farm families to operate larger farms (or reduce farm workforce per acre), thereby raising output per worker. Earnings in agriculture moved closer to industrial earnings.

More important, the development of many varieties of machines and other equipment succeeded in the mechanization of most factory operations (as noted

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[9] Because of the failure to mechanize household operations, a large class of domestic servants, comprising 7.3 per cent of the labor force in the U.S. census of 1900 and probably much larger in the United Kingdom, were employed in the households; in the 1960 census the share fell to 3.0 per cent [15, p. 192].

above with respect to the textile industry) and the number of unskilled jobs (such as handling, hauling, cleaning, drying, packing) were sharply reduced. Machine operators and tenders replaced the unskilled workers and laborers, and earning differentials within factories were cut down.[10]

Cheaper and more flexible machinery eliminated handicraft and domestic industries together with the reduction of small farmers, and the spread of department stores and supermarkets shrank the size of the proprietor class and narrowed its hitherto wide-ranging spread of incomes. In the United States, the share of entrepreneurs and self-employed in the labor force fell from 21 per cent in 1929 to 15 per cent in 1954–60, in the United Kingdom from 13 per cent in 1905–14 to 6 per cent in 1954–60, in France from 33 per cent in 1913 to 27 per cent in 1954–60, in Germany from 21 per cent in 1913 to 16 per cent in 1954–60, and in Canada from 28 per cent in 1926–29 to 18 per cent in 1954–60.[11]

With the availability of small, light-handed equipment, job opportunities for females in factories opened up, especially for wives freed from much housework with the advent of electric appliances and automobiles. More jobs became available in department stores and supermarkets and in the mechanized offices. The number of earners in medium and lower-income households rose. Female workers were 22.7 per cent of the total number of employees in 1900 and 34.3 per cent in 1960, with most of the increases taking place among clerical and sales workers [15, p. 192].

These forces gave rise to a middle class which became much larger than in the nineteenth century. Many more engineers, architects, scientists, technicians, officials, clerks, and sales workers were needed for the more varied and complex technologies of the twentieth century factories, stores, and offices; more managers, supervisors, accountants, lawyers, and other professionals had to be employed to handle the functions of the corporations and their capital-intensive, mass-producing factories. A larger bureaucracy had to be recruited to regulate public utilities and large corporations, to construct and manage roads and other physical infrastructure, and to educate and train a skilled labor force.

In the United States the number of white collar workers (professionals, technicians, managers, officials, clerks, and sales workers) rose sevenfold from 1900 to 1929 while laborers and farm and household workers dropped by one-half. From 1920 industrial laborers fell from 4.9 million to 3.5 million in 1960 and machine operatives rose from 6.6 million to 12.8 million.[12]

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[10] Jerome [12]. While laborers fell from 16.6 per cent of the total labor force in 1900 to 5.9 per cent in 1960, craftsmen, operatives, and tenders rose from 31.2 per cent to 36.9 per cent. See Kuznets [15, p. 192].

[11] Kuznets [15, pp. 168–69]. Kuznets notes that entrepreneurial incomes vary more than incomes of employees [15, p. 214].

[12] See Oshima [23]; *Historical Statistics of the United States* [30]; and *Statistical Abstract of the United States* [31, 1975 and 1993 editions]. As shares of the labor force, white collar workers rose from 16.6 per cent in 1900 to 42.0 per cent in 1960, while manual workers, household and other service workers fell from 83.4 per cent to 58 per cent. See Kuznets [15, p. 192].

In short, it was the replacement of the Marxian proletariat and the unskilled laborers of the steam-driven factories by the middle-class white collar and skilled workers of the electric-driven factories, offices, and stores in the twentieth century which brought down the high inequalities of the nineteenth century to average levels of about 0.35 Gini by the 1960s [29]. As noted above, it is somewhat of a mystery that the most outstanding student of income distribution (Kuznets) should have ignored the technological factor and put so much weight on population, urbanization, and savings growth. It may be that at the time he wrote, historical research had not arrived at a clear distinction between differences in steam- and electric-powered technologies. In 1955 he was puzzled by the clear-cut decline in inequality in so many countries, and even a decade later in his concluding paragraph on income distribution in *Modern Economic Growth* he noted that "the findings and analysis were limited because the available data fail to cover some important structural divisions within the economy. In consequence, the account is incomplete and in many ways it is only a bare beginning" [15, p. 219].

V. THE EMERGING ELECTRONIC TECHNOLOGIES: A NEW RISING TREND?

The shift to the predominance of electronic technologies of automation, computers, and robots has recently started. A survey of 500 manufacturers showed that by 1992 American firms have spent $800 billion in automation. This shift is said to have a greater potential of revolutionizing the economy than the previous technological transformations, with extensive ramifications in the ways of working and living. When completely integrated control by computers of all production processes in the factories (including designing, engineering, transporting, packing, and storing) is installed, the labor-saving can amount to a ratio of 30 to 1.[13] As firms began to install automation, manufacturing productivity in the United States has been rising by 3 or 4 per cent from the mid-1980s.

Technological changes are accompanied by changes in production processes. For example, middle managers, one of whose tasks was to gather and transmit information, became redundant when computers took over the job of collecting and transmitting information. Further, when this information became readily available to all workers on the factory floor, the workers cooperating with managers, engineers, designers, and others in teams were able to solve problems as they came up and thus took over the problem-solving function of middle managers. From the 1980s middle managers began to lose their jobs and hundreds of thousands became unemployed in the United States. Working in teams and empowered to make decisions, workers were motivated with greater incentives and have raised productivity.

Moreover, electronic technologies may produce changes in the mechanism by which productivity and growth have occurred. In particular, capital in the form of machines, conveyer belts, motorized and other equipment was the main agent

[13] "A New Industrial Revolution Is on the Way," *Fortune,* October 5, 1981.

of labor productivity gains in the past. Productivity was raised directly through the more advanced technologies embodied in the new machinery, and indirectly through the skills of workers in handling and the experience of firms in organizing modern technologies.[14] The technology embodied in the electric, mechanical machines is being replaced as the prime engine of growth by the power, speed, and versatility of computers, the agility of electronic-driven machines, vehicles, assembly lines, and other equipment. Capital in the form of machines and other equipment (and its ability to substitute for labor) will then take a backseat to information gathered and dispensed through computers and telecommunication devices.[15]

Specifically, the impact of electronic technologies affected income distribution in various ways. The demand for manual workers to operate machines, to transport materials, parts, and products, to assemble parts and components, began to decline as systems of machines and vehicles were controlled and monitored by computers, as robots were brought in to handle objects and assemble parts and components, and as automated warehouses and transportation forward them through the various processes. In a typical automated plant, it is said that only 5 per cent of the total employees were needed [5]. The complexity of the electronic technologies called for problem-solving, cognitive capabilities instead of physical, manual skills. The demand for college-educated workers with backgrounds in science and mathematics rose [11, chap. 3] [1, chaps 2 and 3]. Their earnings rose, particularly in the 1980s when there was a slowdown in the growth of the supply of college graduates [13, pp. 10–15]. A robust correlation was found between the hiring of well-educated workers and investment in computers.[16]

The new technology is making headway in the back offices of industrial enterprises as well as in the front offices of banks, insurance companies, professionals, hospitals, governments, and department stores. As in the factory, offices mechanized with electric, mechanical equipment are being atuomated and computerized. Computers and information systems for handling data, invoicing, accounting, and inventory control, and facsimile, word processors, portable printers, laser scanners, etc., are reducing the need for clerks, secretaries, typists, and supervisors. By ordering through computers and by using laser scanners, retailers reduce the length of time, quantity of inventory (with just-in-time retailing), and the number of middlemen. Sam Walton of Wal-Mart, by investing in computers, got rid of many wholesalers, mom-and-pop stores, and other middlemen.[17]

[14] De Long [7]. This kind of mechanism is said to be assumed in the growth models of Robert Solow and more recently Paul Romer.

[15] See articles by Peter Drucker on "Post-Capitalism." And it will be impossible to disentangle each factor of production and allocate the sources of growth in the automated, integrated plants of the future, as Denison did in his well-known Brookings study on growth accounting.

[16] Berman, Bound, and Griliches [2]. It is reported that workers using computers are paid 15 to 30 per cent more than workers not using them even though they are doing the same work.

[17] "What Sam Walton Taught America," *Fortune,* May 4, 1992.

Moreover, also constraining the rise of wages of blue collar workers was the shift of American firms producing labor-intensive goods to developing countries in the 1970s and 1980s, together with increased immigration from low-wage countries such as Mexico.

There were other forces contributing to income inequality. There was the tendency of families to shift from husband and wife to single-person units, although this shift slowed down in the 1980s. Also, families headed by retired, elderly persons rose. And finally, there were more two-earner families in the higher income groups than in the lower-income families in 1987 which was not the case in the previous period. This may have been due to well-educated wives taking on high-income work using electronic technologies. In 1987, only 13 per cent of families with incomes of less than $15,000 reported that their wives were employed, compared to 65 per cent of families with more than $50,000 [31, 1989 edition, p. 448].

Workers losing jobs in manufacturing moved into lower-paying jobs in retailing and personal serviecs. In 1988 annual earnings in manufacturing averaged $31,000 compared to $15,000 in retailing. Occupation-wise, machine operatives, tenders, fabricators, and assemblers earned $15,000 as against $6,000 for service occupations.[18] Also during the 1980s the gap between college-educated and high-school-educated wages widened sharply [13, p. 11].

For the economy as a whole, the proportion of men earning less than $20,000 and earning more than $40,000 increased, while those in the middle (namely, 25–34 year old men with twelve years of education who had earnings above $20,000) decreased from 57 per cent in 1979 to 46 per cent in 1987 [16] [10]. Evidently the large middle class (the product of electrically-powered technologies) responsible for the lower income inequalities from the early decades of the twentieth century, is being squeezed by the electronic technologies, as the better-educated families move into the higher deciles while the less-educated middle class fall into the lower deciles. With the jobs in the mass production industries and in the offices becoming scarcer, those in the lower middle class will have to turn to the lower-paying service occupations. If this continues into the next century, we are likely to see the falling portion of Kuznets's inverted U curve turning upwards for some time to come.[19]

Even though there is likely to be an increase in the growth rate of college graduates in the coming decades, it may not be able to catch up with the escalating demand for the well-educated since the electronic revolution has gained momentum only in the 1980s and may be expected to accelerate as costs of electronic technologies fall sharply and global competition intensifies.

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[18] Estimated from data in the *Statistical Abstract of the United States* [31, 1990 edition] and *Survey of Current Business* [28, August 1990 edition].

[19] Kuznets died in the early 1980s before the acceleration of the electronic revolution, and before the trend toward inequality became conspicuous.

VI. UPWARD AND DOWNWARD TRENDS IN JAPAN

As Professor T. Mizoguchi of Hitotsubashi University points out, income inequality began to rise in Japan around the time when industrialization began in the late nineteenth century and into the 1940s. There was a widening gap of average income between the agricultural and nonagricultural sectors, and within the latter wage differentials between skilled and unskilled workers increased [19].

In the mid-1880s only 3.6 per cent of factories used steam engines, 47 per cent had water wheels, while 44 per cent had no motive power [18, p. 301]. The factories using steam engines were the large factories which could afford the heavy cost of installing the infrastructure for generating and distributing steam power. By 1900 factories using steam power, electric power, water power, and muscle power coexisted; as a result wage differentials were larger in the prewar period. Wage differentials widened also between the agriculture, industry, and services sectors in the prewar period and declined in the postwar period.[20]

Since the 1920s income inequality rose with the stagnation in agricultural production, loss of land by farmers and increase in tenancy in the rural sector, and a rise in unemployment and underemployment in the urban sector, besides wage differentials between and within sectors as a consequence of a mix of general purpose technologies underlying productivity differentials, as noted. Unlike in the United States, income inequalities persisted throughout the 1920s and 1930s despite the rapid spread of electric motors in factories: from around 60 per cent of the horsepower of prime movers in 1919 to more than 80 per cent in the 1930s (compared to around 90 per cent in the United States).[21]

However, horsepower per worker was only 0.97 in the 1930s (no higher than that of the United States in 1889 or Taiwan in 1954 when both were predominantly agrarian) in smaller size factories which accounted for more than 90 per cent of the total number of powered factories, an indication that most workers in manufacturing were still working inefficiently. But by 1970 horsepower per worker rose tenfold to 10.7 and this was the outcome of changes in the employment and wage system, management practices, worker participation, teamwork, cooperation, and so on.[22] Another important factor pertaining to the postwar income distribution was the highly intensive use of electric motors in the smaller factories which enabled them to raise productivity and wages by the extensive use of machines.[23]

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[20] See Minami [17, pp. 314–17]. The discussions of these wage differentials in Japan were conducted under the topic "dual structure," dual referring to a technologically modern sector and a technologically backward sector. See Yasuba [34, pp. 254–85].

[21] See Minami [18, pp. 300–306]. U.S. data from Du Boff [9] and Devine [8].

[22] These figures are from Chapter 4, entitled "Contrasting the Economic Growth of Prewar and Postwar Japan," in my Economic Growth in Monsoon Asia [24, pp. 105, 109].

[23] See Minami [17]. See also Ono and Watanabe [22] on the reduction of wage differentials by size of firms in the postwar decades.

Land reform was the major change in raising farm incomes. The higher incomes earned made possible purchases of machines for plowing, transplanting, and harvesting which, in turn, freed members of farm families to take off-farm jobs, income from which began to exceed on-farm incomes by the mid-1960s. In monsoon economies farms are too small and the dry (and cold) seasons too long to provide enough work for the farm families so off-farm work is a major factor in raising incomes to levels comparable to those of urban workers.[24]

These and other changes led to productivity increases and global competitive strength so economic growth accelerated to nearly double-digit levels. Full employment was attained by the late 1950s, followed by labor shortages as full employment was sustained into the subsequent decades. Wages in the lower range of the distribution rose and together with institutions such as labor unions, seniority wage increases, and profit sharing through bonuses, there was generated one of the most equal distributions of earnings in the industrialized world. A large middle class was created and the share of the middle class (of professionals, managers, clerical, sales, and operatives) in the total labor force rose from 46 per cent in 1920 to 95 per cent in 1971, and the share of the lower class of fishermen, farmers, and laborers fell from 54 per cent to 5 per cent [24, p. 131].

Unlike the situation in the United States and other Western countries, the spread of electronic technologies in Japan thus far has failed to raise the Gini (which remains at 0.35 in 1990). This may be due to the rapid expansion of exports in industries such as machinery, automobiles, semiconductors, and consumer electronics, which together with the slow growth of the labor force meant that labor continued to be in short supply throughout the 1980s. Unlike in the Western countries the shortage of labor enabled workers to find good jobs in the tight labor market. Job opportunities for housewives opened up in the retail and service industries so that two-earner families in the lower deciles became common.

Nevertheless, in the early 1990s there appear to be signs of slackening with the unemployment rate rising from a low of 2.1 per cent in 1991 to 2.2 per cent in 1992 and 2.5 per cent in 1993.[25] This is in part due to the exodus of exporting firms to produce abroad in order to circumvent the high and rising exchange value of the yen. But it may also be due to the spread of the electronic revolution across industries and services, especially computerized and robotized ones with automation beginning to eliminate jobs in the factories and offices.

Important also were signs of revitalization of American steel, automobile, semiconductor, computer, and other industries which in the early 1990s began to be sufficiently competitive to reduce the imports from Japan, and in the case of microprocessors and computers, competitive enough to invade and sell in Japan. Also it seems that the old formula by which Japanese firms climbed to the top of competition was no longer working well in the face of the slow growth of GDP, and because of the demand of the new technologies for slimming down and

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[24] See details in Oshima [26, chap. 7]. Also democratization of institutions, of bureaucracy, schools, police system, mass media, etc., improved their efficiency over prewar authoritarian institutions and contributed to income equalization. See Oshima [24, chap. 4].

[25] Japan, Management and Coordination Agency, Statistics Bureau, *Annual Report on the Labour Force Survey, 1993.*

flattening out, institutions such as lifetime employment and seniority wage payment were being abandoned. Consequently, it will not be surprising that Japanese income distribution may begin to widen in the near future [21].

As noted, data for the other Asian countries for the pre–World War II decades are not available. They exist only for Japan. The latter's experience may not be relevant for the other Asian countries which were prevented from becoming industrialized by colonial powers. Hence, water wheels and steam engines (except in railroads) were not of consequence but what was important was the electric-powered technologies in labor-intensive industries (food, textile, wood, small machinery industries) as against capital-intensive industries (iron, steel, perto-chemicals, cement, paper and pulp, chemical, automobiles, aluminum industries).

Colonial policies tended to raise income inequalities, in particular the establishment of plantations took away land from the peasants, leaving them with little or no land. The technology of the plantations required managers, supervisors, scientists, and clerical staff with high incomes and unskilled laborers with low incomes. The influx of manufactured goods from the colonial countries wiped out many of the traditional crafts, leaving many of the workers underemployed.[26]

After World War II these countries were able to raise tariffs to protect import-substituting industries such as textiles whose incomes rose faster than that of the traditional industries, and the incomes of indigenous proprietors, merchants, moneylenders, professionals, and others in commerce and services increased with the loss of privileges and positions of foreign counterparts. In the rural sector, the rise in demand for agricultural products due to expanding urbanization benefited mainly the farms near the cities and their incomes rose faster than that of the hinterland farms which lacked the roads, means of transport, and finances to market their produce.[27] Later, with the development of higher yielding varieties of rice, farms with irrigation were able to raise their yields by planting new varieties but not the others without irrigation, further worsening income distribution in the rural sector.

With the passage of time, infrastructure for modernization became available. Roads were built for motorized transport and electricity became widely available to operate machines for smaller industries and services in the urban sector and to operate farm equipment.

The timing of the downward turning point of the Gini varied with countries. There was a tendency for countries coming into modern economic growth early in the postwar era to generate lower Ginis first. Thus it was in Taiwan which

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[26] Before the coming of the colonial powers, income distribution in Asian countries was domi-
nated by the agricultural sector which employed about three-fourths to four-fifths of the
labor force. (See Japan's 1872 census and Thailand's 1937 census.) Because of the
scarcity of land relative to population, most of the farms clustered around the 1–3 hectare
size, with limited numbers of landlords and landless laborers. In the small urban sector
were the craftsmen with their apprentices, domestic manufacturers with family helpers,
merchants, moneylenders, retailers, professionals, public servants, and others whose incomes
were not widely dispersed. Overall inequality was probably low in the traditional monsoon
economies of Asia.

[27] Cf. 1962/63 and 1968/69 income distribution curves for Thai rural and urban sectors in
my paper [25, pp. 103–4].

modernized its agriculture first with land reform, irrigation, multiple cropping, mechanization, etc., and mechanized its industries in food, textiles, garment, and other labor-intensive sectors where there was a decline in the Gini in the early 1950s. The attainment and sustenance of full employment from the early 1950s speeded up the spread of mechanization in the 1960s, 1970s, and into the 1980s which in turn reduced the size of the unskilled factory workers, of marginal and menial service workers (such as domestics) and raised the wages of construction and service workers, besides enabling housewives to find jobs [24, chap. 4]. But in the early 1980s inequality began to rise with the introduction of capital-intensive industries (cement, iron and steel, petrochemicals) and the expansion of the high-wage services such as banks, real estate, and business services.[28]

In the case of Korea which also started early with land reform and labor-intensive industrialization, the Gini began to rise earlier than in Taiwan as it began capital-intensive industrialization in the 1970s. The Philippines also started industrialization early and the Gini peaked in the early 1960s. But its fall was moderate, only to the 0.4 level, never falling to the levels of 0.3 of Taiwan or Korea. This is due to the failure to undertake effective land reform and initiate labor-intensive industrialization.

Ginis of the city states of Hong Kong and Singapore began to fall in the late 1960s after full employment was reached with the rapid growth of labor-intensive industrialization which attracted labor from the low-paying marginal services such as domestic services, peddling, stalls, and traditional crafts. With full employment, housewives came out of the homes and took jobs in labor-intensive industries and services.

Malaysia's Gini began to fall in the early 1970s with the reversal of agricultural policies from supporting the development of large plantations to the development of small farms. New farm lands were hacked out of forests and distributed to the Malay peasants and a number of industrial estates and export zones were established to attract labor-intensive industries from abroad.

The two countries which were latecomers to industrialization in Southeast Asia were Thailand and Indonesia. Their Ginis began to fall in the mid-1980s and late 1970s, respectively. In both cases the rise in the Ginis was due to the slow growth of modern industries, constrained by the lack of infrastructures such as roads, transport, electricity, etc. But as these began to be put in place nationwide instead of being concentrated in Bangkok and Jakarta, the impact on inequality was favorable. Of course, coming late into industrialization, the agricultural sector was predominant so that the decline in regional disparities in agricultural income was important for both countries as in Malaysia and the Philippines.

The latest to enter into modernization and industrialization were the South Asian countries. With the industrial sector so small, the agricultural sector contained 70 per cent or more of the workforce in India and Bangladesh and 50 per cent in Sri Lanka, and was overwhelmingly traditional with hardly any

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[28] These changes raised the demand for professional, technical, and executive personnel, whose earnings rose twofold in the past ten years compared to 1.7-fold for service workers and 1.5-fold for agricultural workers.

mechanization. The absence of clear trends in the Gini may be due to the fluctuations in farm output due to the influence of changing weather conditions.

CONCLUDING REMARKS

Since our interest was in the impact of technological transformation on very long-term trends in income distribution, the foregoing discussion neglected to mention other long-term forces and processes which had major impact—such as population growth, structural shifts, migration, spread of education, and so on. In a sense, these forces may be thought of as proximate forces behind which lie deeper and more distal ones—such as technology. It is the latter which may be responsible in large part for the rapid growth of population in the nineteenth century by creating a large demand for unskilled labor; and in the twentieth century, it may be a major factor in slowing down population growth by lowering the demand for labor through replacing unskilled labor with electric-powered technologies and by raising the demand for educated labor. Nor would the massive shift of population from agriculture have been possible without the mechanization of farming, and without the creation of urban jobs through reduced prices as a result of industrial mechanization.

As to prospects, tendencies toward inequality may continue into the future in the West as electronic technologies continue to reduce employment in factories and offices with those losing jobs moving into the low-paying retail, restaurants, and personal service occupations. This may also be the situation for Japan and the NIEs. But the prospects may be different for Southeast Asia where wages are not high enough to induce widespread adoption of costly robotized and computerized automation. The spread of electric-powered/internal-combustion technologies is far from completion and their equalizing impact in agriculture and industry is likely to lower the Gini for some years to come. Greater mechanization of farming will raise wages and lower labor requirements while the rapid expansion of modern industry and services will increase higher-paying jobs in the urban sector.

As to South Asia, technological forces may be too weak to have much impact on income distribution trends since the traditional technologies still dominate production in the rural and urban sectors. It is likely that institutional changes such as agrarian reform in the agricultural sector and policies to promote small industries and employment are likely to affect equity more than technology. The introduction of modern technology has just begun and it is likely to contribute to greater inequality.[29]

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[29] Likewise for socialist countries like China, starting out in the transition from planned/command to market economies, inequality is likely to increase as the market forces wages and other incomes to conform to the dictates of costs and prices. Unlike the planners of the command economy, technological demands will not be ignored by market forces, and the mandated egalitarianism of the planners will have to give way to disparities in line with market costs and prices.

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