Education, Development, and Wage Inequality: The Case of Taiwan

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I. Introduction

Changes in income inequality over time have been a subject of long-standing interest among economists, particularly in a development context. The first theory proposing a relationship between the two was Kuznets's (1955) hypothesis that the expansion of an industrial sector will cause per capita income inequality to rise until the industrial sector begins to dominate the agricultural sector, at which point inequality will fall again. Since then, a flood of research has examined the relationship not only between inequality and industrialization but also between inequality and a number of processes also associated with development. These processes include changes in industrial structure, factor-specific technical change, educational expansion, population aging and the feminization of the labor force. Yet, since these processes are often concurrent, their relative importance at different stages of an economy's development is rarely obvious.

Kuznets's hypothesis was grounded in the early experiences of England, Germany, and the United States, all of which started to industrialize well before the other processes mentioned began to take root. For example, Kuznets notes that inequality in the United States started to rise from 1870 onward; this preceded the expansion of secondary school education in the United States by nearly 4 decades. Women did not start entering the U.S. labor force in earnest until the 1970s, and the effects of the postwar decline in fertility on the population's age structure will not be fully felt until well into the twenty-first century. The effects of the first three of these processes on the U.S. wage structure have been well documented (Kuznets 1955; Goldin and Katz 1999; Juhn and Kim 1999), and if the United States follows Japan's example, the fourth is but a matter of time (Ohtake and Saito 1998).

In the experience of more recently developing countries, however, these

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processes have tended to occur within a much narrower time frame and with a greater degree of simultaneity. This is particularly true of the East Asian newly industrialized countries. For example, Taiwan's expansion of secondary education was initiated in the 1950s, and the country started to shift its exports from agricultural products to industrial manufactured goods about a decade later. In the 1970s and 1980s, manufacturing production shifted from labor-intensive to largely capital-intensive methods; women started to enter the labor force in considerable numbers in the latter half of this period. South Korea's development experience was even more compressed, with its first concerted efforts to expand primary education taking place in the early 1960s.

Because of the simultaneity of these processes, the simple relationships that were evident in earlier examples of development are much more difficult to see in later ones. For example, Fields (1980) notes that, while educational expansion seems to have reduced wage inequality in countries that undertook it prior to World War II, more recently developing countries have not seen comparable reductions in their own levels of wage inequality. This is true not only of East Asian countries but also of countries in other regions. A likely explanation is that, while educational expansion did reduce wage inequality in these countries, other factors, like industrial expansion or factor-specific technical change, worked to increase wage inequality at the same time. Therefore, a decomposition is necessary to separate the effects of these factors on wage inequality as a whole.

One popular method to decompose these effects has been to use a regression equation to model the dependent variable of interest (often wages) and then derive the effect of changes in the explanatory variables or the coefficients of the model on the variance of that dependent variable (or, conceivably, some other moment of interest, like a Theil or Gini index). The advantage of such models is that, when correctly specified, they are useful in developing counterfactuals or making predictions about the future. However, correctly specifying these models is difficult, since the same problems that potentially plague the underlying regression equation will also invalidate the decomposition results.

The primary contributions of this article are twofold. First, this article presents, and applies to Taiwan, a multiple-stage Theil decomposition that easily nests multiple explanations for the time path of wage inequality over time. The advantage of this method is that it does not require a correctly specified regression equation to consistently estimate the relative contribution of each. The limitation is that, unlike a well-specified regression model—where changes in the exogenous, right-hand-side variables can be thought to cause changes in the dependent variable—the Theil decomposition simply sum-

marizes features of the data and says nothing about the direction of causality. An additional point is that the results from this decomposition can change depending on which variables are included; the results for any particular variable must be interpreted in light of others present. Multivariate inequality decompositions in the literature so far have focused on the regression approach virtually exclusively.

Second, this article sheds new light on the debate on wage inequality for Taiwan itself. It is no secret that Taiwan's development experience has been exceptional, and Taiwan is certainly not an example of a typical developing country. However, the presence of a large number of potential explanations for changes in Taiwan's wage structure has prevented consensus as to which of these explanations are the most important.

From the perspective of labor supply, the literature has identified a number of factors that would be expected to reduce wage inequality. Most of these factors are related to Taiwan's educational expansion. For example, using data from the May supplements of Taiwan's Labor Force Surveys through 1991, Gindling, Goldfarb, and Chang (1995) observe a generalized decline in the wage return to education for graduates with a lower secondary qualification or higher. Clark and Hsieh (2000) study Taiwan's compulsory education policy with similar data and an eye toward using year of birth as an instrument to measure the return to a year of schooling in Taiwan. They find that doing so generates instrumental variables (IV) estimates of the return to education that are significantly lower than the corresponding OLS estimates. They argue that this is because of the significantly greater supply of educated graduates in Taiwan after the compulsory education policy in Taiwan took effect. Finally, Gindling and Sun (2002) use Katz and Murphy's (1992) methodology to explicitly test whether changes in the supply of educated graduates, in the absence of any shifts in demand, are sufficient to explain changes in Taiwan's wage structure and conclude that they are.

Population aging and the entry of women into the labor force, however, have worked to increase inequality in Taiwan. While the effects of population aging have received little attention from the perspective of wage inequality, Deaton and Paxson (1994) find a slight increase in inequality of consumption across households between 1976 and 1990 and attribute it to the aging of Taiwan's population, and Schultz (1999) finds an analogous result for income inequality. Moreover, since women tended to enter Taiwan's labor force at the low end of the skill distribution, particularly in the 1980s, their increased labor force participation can also be expected to increase wage inequality (Zveglich, Rodgers, and Rodgers 1997).

From a demand perspective, increases in the demand for skilled labor are

often thought to increase wage inequality. There are two mechanisms through which this can be thought to occur: changes in industrial composition and changes in the mix of workers employed within industries. Although production in Taiwan became more skill intensive through both of these mechanisms throughout the 1980s and 1990s, few researchers have found definitive evidence of the effects of these changes on the premium paid to skilled labor, perhaps because of the large increases in the supply of skilled labor occurring at the same time (see, e.g., Gindling and Sun 2002). Nevertheless, the potential demand-side pressures on Taiwanese wages are unmistakable.

There has been some previous work seeking to explain the pattern of Taiwanese wage inequality over time. Unfortunately, it has not yielded any consensus on the relative contributions of these factors. Using a linear regression method, Fields and Mitchell (1999) decompose changes between 1980 and 1995 among a number of covariates and find that changes in the distribution of education reduced income inequality during this time, though changes in the return to education increased it. However, other researchers, using different years, have come to the opposite conclusion (e.g., Jiang [1992], in examining 1978 and 1986), suggesting that analyzing these changes over a wider time frame would be useful. Another reason for the different conclusions may be different choices of control variables to be included in the decompositions. For example, Jiang (1992) includes industry dummy variables in the wage regression, while Fields and Mitchell (1999) do not. Finally, there has not been much exploration of wage structure changes after 1995, though this is an interesting time due to the accelerating expansion of the service sector.

This article is organized as follows. Section II surveys factors likely to affect Taiwan's wage structure through the supply side. The rapid expansion of secondary and tertiary education dramatically increased the supply of educated labor. On the other hand, factors related to labor demand, such as factor-specific technical change within industries and changes in industrial structure over time, also intensified. Section III explores these factors. Section IV examines relative returns to education and wage inequality within cohorts. At the cohort level, age-relative earnings profiles are remarkably stable over time; consequently, distributing education to younger cohorts tends to reduce between-cohort wage inequality. However, within industries that underwent more intense technical change, the relative returns to education are higher for younger cohorts. Since the supply of skilled labor is greater within younger cohorts, the increases in relative wages, which tend to increase inequality, can be attributed to shifts in demand. Therefore, though supply-related factors tended to reduce wage inequality between cohorts overall, demand-related factors tended to increase it between cohorts within industries. Section V uses

a multiple-stage Theil decomposition to formalize these points, separating wage inequality into components that capture the effects of the entry of increasingly educated younger cohorts, changes in industrial composition, factor-specific technical change, and the entry of women into the labor force. Of these, the first and third are the most important, with the entry of increasingly educated younger cohorts explaining much of the inequality decline in the 1980s and factor-specific technical change accounting for a significant portion of the rise in inequality in the 1990s. Section VI concludes.

II. Taiwan's Educational Expansion

A. Historical Background and Implementation

By the middle of the 1950s, it became evident in Taiwan that the structure of the educational system, in which a very high proportion of school-age children attended primary school but far fewer went beyond that, was in need of reform. For example, for the cohort born in 1944, 88.4% of these Taiwanese completed primary school but only 34.7% went on to complete any higher level.[1] Although opportunities for attending lower secondary school were relatively few at the time, the demand for such education had accelerated to the point where the stresses imposed on children by the competitive entrance examination system had begun to reach an extreme level. To have a chance at one of the coveted places in lower secondary meant, at the very least, long hours of private supplementary classes and even longer hours of extra study.

In the face of such strong demand by parents for more education for their children, the Taiwanese Ministry of Education responded by constructing large numbers of lower secondary schools with the overarching goal of removing the examination requirement. The intent was to provide a place in the local lower secondary school for all students who wished to attend. Although the Ministry of Education had hoped to construct enough schools by 1955, and it kept up its school construction project until well past then, by 1965 the widely criticized examination system for lower secondary places still persisted. At the same time, membership requirements of the International Labor Organization forbade the use of workers under the age of 14, so what to do with the island's children aged 12–14 had become a growing social problem.

In this climate, the Taiwanese government under Chiang Kai-shek ordered the Ministry of Education to continue its school-building project with the goal of implementing 9 years of compulsory education by 1970. This date

[1] Figures are from the author's calculations, using data from the May supplements of Taiwan's Labor Force Surveys.

TABLE 1
PERCENT PRIMARY SCHOOL STUDENTS PROMOTED TO LOWER SECONDARY SCHOOL, BY YEAR

Year	Percent Promoted
1950	31.78
1956	47.75
1961	53.79
1966	59.04
1971*	80.85
1976	90.41
1981	96.77
1986	99.04
1991	99.28
1996	98.89

Source. Education Statistical Indicators, Republic of China, Ministry of Education, Taiwan, April 1999.
* First measured year under the compulsory education policy.

was later revised to 2 years earlier, and the extension of compulsory education from 6 to 9 years became law in 1968.

B. Outcomes

Effects on educational attainment. The Taiwanese education policy had dramatic effects on the educational composition of Taiwan's population. The most direct indication of the policy's effects is a dramatic increase in the proportion of primary school students advancing to a place in lower secondary school over time, as table 1 indicates. Although there is a substantial spike in promotion levels immediately after implementation of compulsory education, enrollment in lower secondary schools did not truly become universal in Taiwan until about 1986.

The effects of this policy on the educational composition of Taiwan's population become immediately apparent when examining the proportions of people in Taiwan with the required level of compulsory education (lower secondary) or more by year of birth. Figure 1 shows these proportions for all of Taiwan. Labor force surveys taken from 1979 to 1998 allow observation of the educational attainment of cohorts born from 1879 through those born in 1985. The vertical line on the right is drawn for the year 1956, the year of birth for the first cohort to be affected by the compulsory education law. Students turning 12 in 1968 would have graduated from primary school that year and then been the first compelled to attend lower secondary under the new regulation. The vertical line on the left is drawn for 1938; students turning 12 in 1950 were the first to benefit from the Ministry of Education's

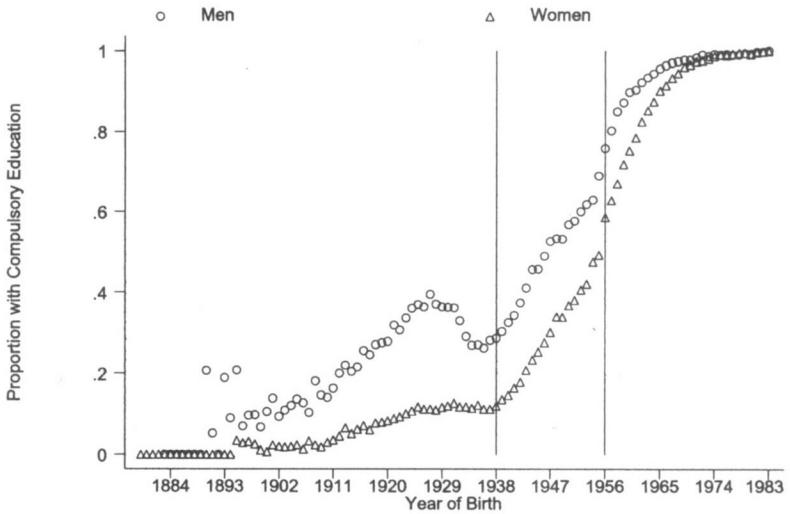

Figure 1. Proportion of men and women in Taiwan with 9 years of education or more, by year of birth

continuing school construction plan. It should be noted that since these estimates were constructed from a currently living population, and mortality diminishes with educational attainment, the early figures may have some upward bias.

It is clear that educational attainment in Taiwan had been on the rise even before the compulsory education policy. The rising trend in educational attainment before then is a result of policies of Japanization undertaken during Japan's colonial rule of the island from 1895 to 1945. It had been the view of the Japanese colonial government that using the educational system to improve literacy and promote cultural assimilation would be the best strategy for the colony's long-term stability and economic success (Tsurumi 1977; Hermalin, Liu, and Freedman 1994). The dip in educational attainment immediately to the left of the 1938 line is attributable to chaos caused by World War II and the Nationalists' closing of Japanese schools and repatriating Japanese teachers upon taking power in 1945. Some of the bulge immediately prior, however, represents immigration from the mainland with the arrival of the Nationalist army, members of which tended to be born in the 1920s. About a million in number, and many of them soldiers and officials, they had more education than the local Taiwanese who were born at about the same time (Zimmer et al. 1998).

Effects on labor force composition. Table 2 summarizes changes in the composition of Taiwan's labor force between a number of different demographic groups, both over time and by birth cohort. The quantities given are the

TABLE 2
GENDER AND EDUCATIONAL COMPOSITION OF TAIWAN'S LABOR FORCE, BY YEAR AND BIRTH COHORT (PERCENTAGES)

	Percent of Total by Year				
	1979	1984	1989	1994	1998
Men	67.20	63.86	62.40	61.63	60.38
Women	32.80	36.14	37.60	38.37	39.62
Education:					
Illiterate	7.97	6.09	4.11	2.59	2.11
Self-educated	3.07	2.36	1.75	1.02	.49
Primary	42.96	36.14	30.43	24.55	18.86
Lower secondary	17.96	19.28	19.80	20.68	19.05
Upper secondary	6.58	7.24	8.11	8.90	9.27
Senior vocational	11.69	16.78	20.76	23.53	25.61
Vocational/technical college	4.84	6.42	8.33	10.94	13.98
University and higher	4.92	5.70	6.71	7.80	10.64
	Percent of Total, by Birth Cohort				
	1929–32	1933–36	1937–40	1941–44	1945–48
Illiterate	15.15	13.72	13.00	8.77	4.04
Self-educated	6.08	5.62	7.02	4.11	1.27
Primary	52.54	58.23	55.39	53.62	50.62
Lower secondary	10.52	8.75	7.97	10.91	12.84
Upper secondary	4.76	4.16	3.51	4.88	6.50
Senior vocational	4.26	4.04	5.94	8.13	10.50
Vocational/technical college	3.30	2.74	3.25	4.14	5.93
University and higher	3.39	2.75	3.92	5.45	8.31
	1949–52	1953–56	1957–60	1961–64	1965–68
Illiterate	2.25	.85	.08	.00	.00
Self-educated	.48	.17	.17	.00	.00
Primary	45.67	37.05	18.60	8.90	3.40
Lower secondary	13.82	15.04	25.65	28.44	23.59
Upper secondary	7.30	9.07	9.90	9.35	9.97
Senior vocational	12.99	18.72	24.27	28.03	32.07
Vocational/technical college	8.63	10.32	11.68	13.83	17.96
University and higher	8.85	8.78	9.81	11.45	13.02

Source. Taiwanese Labor Force Survey, Directorate-General of Budget, Accounting, and Statistics, Taiwan, Taipei, various years.

percentage each group represents of the total number of people in the labor force. A number of trends are apparent: the labor force became both more highly educated and more gender balanced. Taiwan's labor force also became older over this time period, with the age of the median worker rising from 32 years in 1979 to 37 years in 1998.

The relative proportion of workers with only a primary education declines sharply over time, accounting for 43% of the total labor force in 1979 but only 19% of the labor force in 1998. This is to be expected, since most

[illegible] calculated using data from Taiwan's Labor Force Survey.

entrants to the labor force over this time period were young people completing their schooling and most of those exiting were older retirees.

Most of the new workers entering the labor force, however, did not stop at merely the level of education they were required to attain. The proportion of lower secondary workers entering the labor force increased in successive birth cohorts through 1961 and then decreased in favor of workers opting either for vocational training (representing at least 12 years of education) or a university degree. As a result, the proportions of workers in the labor force from higher educational groups all posted strong increases over time, with the proportion of workers graduating from vocational and technical colleges increasing the most swiftly from 1979 to 1989. From 1994 to 1998, however, the proportion of workers with university degrees and higher qualifications grew the most rapidly.

In summary, there were profound and rapid changes in the educational attainment of Taiwan's population across birth cohorts. While less than half of students born between 1945 and 1948 went on to any education past primary school, for the cohort born 20 years later, 3 years of secondary education had become universal and almost three-quarters of students exceeded this mark. Accordingly, the supply of educated graduates, particularly young educated graduates, in Taiwan's labor force increased rapidly from 1979 through 1998. To put these changes into perspective, the educational composition of the U.S. labor force underwent a similar change from the late 1940s to the late 1970s.

III. Taiwan's Industrialization and Technology Upgrading

A. Industrial Policy and Development after 1979

In addition to Taiwan's labor force, the industrial sector also underwent significant changes over the 1980s and 1990s. Before 1979, Taiwan's industrial strategy was highly export oriented, seeking to capitalize on its extremely inexpensive, yet highly educated, labor force. Competition between the United States and Japan was intense, especially in plastics, electronics, and textiles. This forced U.S. manufacturers to look overseas for ways to cut costs, especially for skilled labor. Japan's Ministry of Trade and Industry also encouraged industries to invest abroad, especially those that were more labor intensive or technologically simple. Taiwan, seeking to benefit from these new flows of American and Japanese investment, took steps to adjust its industrial base accordingly (Gold 1986).

Unfortunately, this strategy started to falter in the mid-1970s. Rising protectionism increasingly hindered Taiwan's exports, especially in the United States. In addition, other newly industrializing countries were starting to compete in the same product markets. Exporters' profit margins were eroded

by rising local wages, and, in the political sphere, Taiwan lost diplomatic recognition from Japan and the United Nations. This unnerved foreign firms further, leading to capital flight and the emigration of skilled personnel to the United States (Wade 1990).

In this environment, the Taiwanese government in 1979 launched a new policy to shift the focus of Taiwan's industrial development from capital-intensive, heavy industries to technology-intensive, nonpolluting, and non-energy-intensive industries. To provide the necessary infrastructure, the government instituted and funded research and development institutes and provided a number of incentives for the development of high-tech industries (van Hoesel 1999). It also actively sought to promote industrial automation and technology transfer, sometimes even providing venture capital for joint local-foreign enterprises. Some policy levers, such as import tariffs and export incentives, ran afoul of World Trade Organization (WTO) regulations and were abandoned by the 1990s. Nevertheless, the government remained highly involved in research and development; in the 1980s, government-sponsored research made up nearly half of all industrial research spending, and in the 1990s the proportion was about a third (Amsden and Chu 2003).

B. Outcomes

Effects on production. Taiwan's technology policy had substantial effects, particularly in the manufacturing sector. One way to assess technical change in production is by examining the capital-labor ratio. In manufacturing, fixed assets per employee for Taiwanese firms more than doubled from US$7,150 in 1976 to US$14,610 in 1986. For foreign firms, the difference was even greater. In these firms, fixed assets per employee more than tripled over the same time period, from US$6,490 in 1976 to US$19,680 in 1986 (Schive and Tu 1991).

Anecdotal evidence from more specific industry studies also indicate substantial changes in the character of production in Taiwanese manufacturing. For example, in the garment industry, Gereffi and Pan (1994) note that Taiwanese apparel firms shifted from largely manufacturing the garments themselves to providing raw materials and machinery to garment factories in places where labor was much less expensive.

Taiwanese bicycle producers took a similar tack, locating assembly facilities in China and focusing marketing efforts in developed countries. The role of the government was to subsidize the design of ever higher quality bicycles, which, in turn, required progressively more sophisticated parts. Most of these parts were manufactured in Taiwan, and local producers continually upgraded their capacity in order to meet the demands of ever more advanced designs.

However, lags between these designs and local producers' capacity to meet the specifications sometimes required importing high-end parts from Japan, particularly in the early 1990s (Amsden and Chu 2003).

This pattern of industrial upgrading was repeated in many industries, particularly in electronics and information technology. In each one, Taiwanese firms sought to exploit low-cost labor overseas, realize economies of scale through automation and mass production, and focus on core competencies of project execution, production engineering, and integrative design.

Although the service sector was not an active focus of government policy, it nevertheless developed in step with the manufacturing sector. This occurred because large business groups frequently sought to enter services as a way to diversify their revenue, especially those in industries where technological change was less swift. For example, the President Group, foreseeing that competition with China would threaten its core food-processing business, extended its operations into distribution and retailing (Amsden and Chu 2003).

Effects on labor force composition. One of the most remarkable aspects of Taiwan's industrial development in the late 1980s and 1990s is the reversal of the "brain drain" that occurred 2 decades earlier. In 1965, the U.S. adoption of skills-based immigration criteria resulted in a flood of Taiwanese college graduates migrating to the United States for further study and then remaining for employment. By the 1980s, Taiwan sent more candidates for PhD engineering study than any other country. Stunningly, these candidates sometimes made up entire graduating classes in these fields from Taiwan's top three universities. Not finding any employment opportunities at home, most did not return after completing their degrees, to the considerable embitterment of Taiwanese policy makers (Saxenian and Hsu 2001). In this respect, some felt that Taiwan's investment in higher education had been a colossal policy mistake, with much of the benefit being reaped by Silicon Valley.

By the late 1980s and early 1990s, however, a number of these overseas Taiwanese had started to return, bringing their acquired knowledge of production methods with them. Local demand for their talents was much greater; where before there had been a dearth of employment opportunities, now they were actively sought after, and many were enticed back with offers of high-ranking positions or venture capital to found their own firms (Li 1995). Numbering about 1,000 annually, these returnees represented only a small part of the total labor force in these industries (in 1989, the manufacturing sector employed about 2.7 million people, 100,000 of whom had a college degree or higher). Nevertheless, their experience highlights a tremendous shift in the demand for workers at the highest skill levels.

Aggregate statistics also suggest changes in the demand for skill within

TABLE 3
INDUSTRIAL COMPOSITION OF TAIWAN'S LABOR FORCE, BY YEAR

	Percent of Total, by Year				
	1979	1984	1989	1994	1998
Agriculture and mining	17.9	14.3	10.5	8.5	6.8
Construction	8.8	7.6	8.2	11.9	10.3
Manufacturing	35.3	36.7	36.4	29.3	29.8
Communications, transport, and utilities	6.9	6.5	6.1	6.0	5.8
Wholesale and retail trade	13.6	15.8	17.9	19.3	19.9
Finance, insurance, real estate	1.3	1.6	2.4	3.5	4.3
Business services	.9	1.0	1.5	2.4	2.9
Social and personal services	11.0	12.3	13.1	15.3	16.4
Public administration	4.4	4.3	4.1	3.8	3.7
	Average Years of Education, by Year				
Agriculture and mining	5.0	5.5	5.7	6.5	6.9
Construction	6.8	7.7	7.9	8.9	9.5
Manufacturing	8.2	8.7	9.4	9.9	10.6
Communications, transport, and utilities	9.3	9.8	10.1	10.6	11.2
Wholesale and retail trade	8.2	9.1	9.8	10.5	10.9
Finance, insurance, real estate	12.4	12.7	12.6	12.9	13.4
Business services	11.7	12.0	12.4	12.6	13.1
Social and personal services	10.3	10.7	11.2	11.5	12.0
Public administration	11.3	11.7	12.1	12.9	13.3
All workers	8.0	8.8	9.5	10.2	10.9

Note. Taiwanese Labor Force Surveys, Directorate-General of Budget, Accounting, and Statistics, Taiwan, Taipei, various years.

the manufacturing sector. Some statistics relating to employment in manufacturing and other industries are presented in table 3. While the overall size of the manufacturing sector did not change very much between 1979 and 1998, and in fact it yielded employment to the service sector in the 1990s, the characteristics of workers employed in manufacturing changed substantially. In 1979, the average manufacturing worker had 8.2 years of education, and nearly half of manufacturing workers had 6 years of education or less. Those with 12 years of education or more amounted to only about a fifth of the total. By contrast, by 1998, nearly half the manufacturing labor force had 12 years of education or more and only a fifth had 6 or fewer. Although the average education of workers in all industries increased between 1979 and 1998, the fastest increases took place in manufacturing and construction.

Within-industry shifts, however, were not the only factor contributing to increases in the demand for skilled labor. One interesting fact presented by table 3 is that the average number of years of education for all Taiwanese workers increased by 2.9 years, which is greater than the increase for any single industry. This is possible because the employment share of more skill-intensive industries, particularly services, increased over time, absorbing many of the more educated workers in the process.

In summary, these changes suggest a large increase in the demand for skilled labor with two primary, driving causes: factor-specific technical change within the manufacturing sector and the expansion of the service sector.

IV. Returns to Education and Wage Inequality within Cohorts

In order to measure differences in returns to education and wage inequality across cohorts, data are used from the May supplements of Taiwan's monthly Labor Force Survey, which has been administered by Taiwan's Directorate-General of Budgeting, Accounting, and Statistics every year since 1979. The survey is a household survey and asks detailed questions on wages earned, hours worked, and jobs held in addition to demographic information such as highest level of education attained and place of residence. The survey is limited to those age 15 and higher. Every year, the survey is given to approximately 19,000 households, which, at an average household size of slightly more than three members over 15 years of age, translates into approximately 60,000 observed people each year, of whom about half participate in the labor force. In all, the data sets from 1979 to 1998 make up a substantial merged data set, with 1,144,471 individuals observed in total.

Throughout this analysis, four cohorts are examined in detail, consisting of Taiwanese born from 1929 to 1938, 1939 to 1948, 1949 to 1958, and 1959 to 1968. Taiwanese from earlier or later cohorts generally did not spend enough of their working life between 1979 and 1998 to be useful as a basis for comparison. This section does not seek to provide a set of robust explanations for differences in returns to education and wage inequality across cohorts but merely to present a series of suggestive, stylized facts. The phrase "return to education" refers to a ratio of educated workers' wages to less educated workers' wages within cohorts. In most cases, the ratio is that of university graduates' wages to lower secondary graduates' wages, though for robustness others are also examined.

There are two ways to compare differences in the return to education across cohorts without imposing parametric assumptions on earnings—by holding time fixed or by holding age fixed. Figure 2 adopts the first method and shows the ratio of wages of men with a university degree or higher to those with a lower secondary qualification for each of the four cohorts over time.[5] It indicates that workers with a university education from older cohorts systematically received more of a return to their education than those from younger cohorts.

[5] Too few women from the earliest two cohorts attended university for a corresponding comparison to be sensible. For the later two cohorts, however, the results are qualitatively the same, though women from those cohorts in general received higher returns to a university education than men from the same cohort.

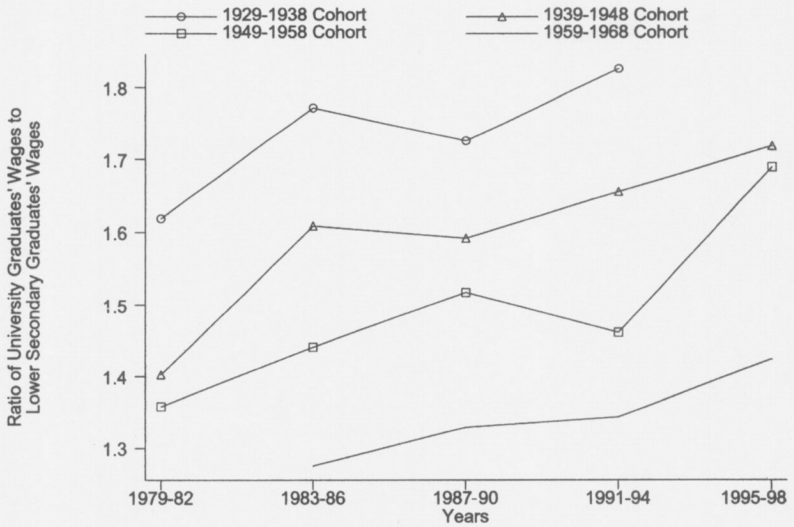

Figure 2. Relative return to education over time, by cohort (men)

There are two possible explanations for this phenomenon. The first is based on the fact that earlier cohorts are simply older; if the return to education increases with age, it makes sense that older cohorts will have higher returns to education than younger cohorts. The second explanation is cohort specific, that there is something about older cohorts that makes an educated worker from such a cohort relatively more valuable. Providing that educated workers from older and younger cohorts are not perfect substitutes, this might be the case if older cohorts are in general less educated, making educated workers from those cohorts more scarce. Figure 3 sheds light on these possibilities, comparing the returns to education across cohorts when age is held fixed.

Figure 3 indicates that, for all four cohorts, the relative return to a university qualification increases steeply with age. Moreover, the age–relative earnings profile is remarkably similar for all four cohorts; the variation in relative earnings is attributable more to variation in age than it is to differences in the cohorts themselves. In fact, the hypothesis that the age–relative earnings profile is identical for all four cohorts cannot be rejected at the 1% level ($F = 1.98$; $P = .031$). While a surprising finding for a country undergoing rapid technical and industrial change, it is consistent with the work of other researchers' findings on the pattern of changes in Taiwan's wage structure (e.g., Gindling and Sun 2002). The most common explanation for the lack of change in the wage premium for education is the coincident large increase in the supply of educated graduates, which mitigated the wage effects of Taiwan's ongoing industrial development.

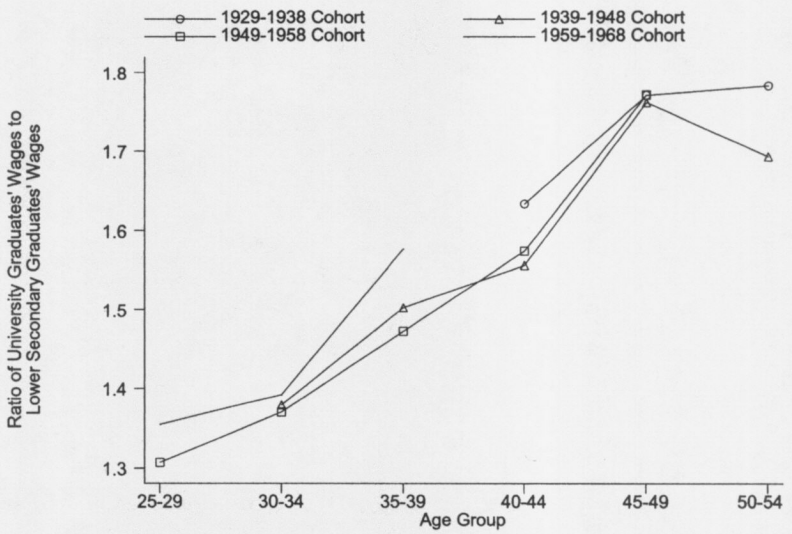

Figure 3. Relative return to education by cohort and age (men)

An alternate reading of figure 3 is that the relative return to a university qualification increases sharply with experience. It is worth pointing out that, within cohorts, common methods of imputing experience do not permit identifying an "experience effect" separately from an "age effect" in the preceding analysis. This is because, within cohorts, imputed experience is typically a linear combination of age and an education-specific constant (the age of leaving school). Therefore, controlling for age and education effectively controls for experience as well.

One of the puzzles presented by figure 3 is that it suggests that demand-side factors had no influence on the wages paid to skilled labor in Taiwan, despite the significant changes in Taiwanese industry detailed earlier. A plausible explanation for this phenomenon is that there were demand-side effects on wages but that they were neutralized at the cohort level by large increases in the supply of skilled labor. One way to separate these two effects is to examine the relative return to skill within industries. Since it is costly to switch industries, particularly after accumulating several years' experience, the supply of skill within cohort-industry groups tends to remain constant over time. However, switching firms within the same industry is a simpler matter, so wages should still be competitively determined within industries. Therefore, changes in the skill premium within cohort-industry groups reflect factor-specific technical change within that industry.

One obvious place to look for factor-specific technical change is the high technology manufacturing sector, which, following Katz and Murphy (1992),

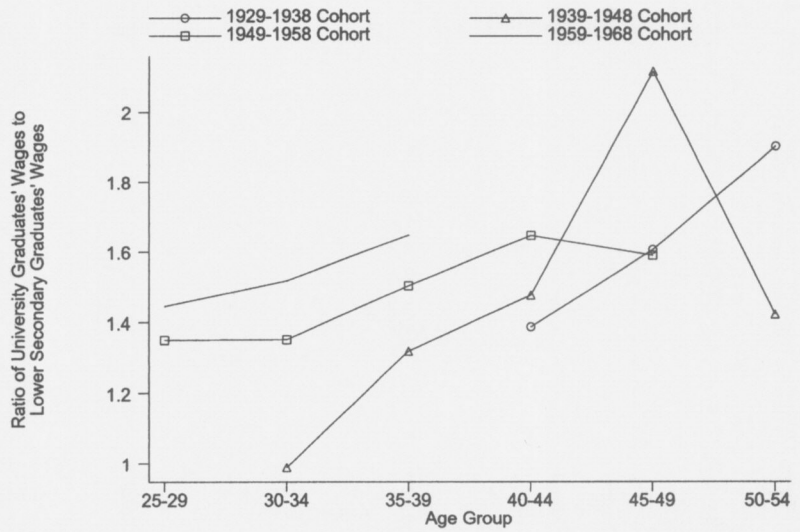

Figure 4. Relative return to education by cohort and age within high-technology manufacturing (men)

includes the chemicals, petroleum, plastics, and precision instruments industries. In 1989, these industries employed about 350,000 people, or about 13% of the total manufacturing labor force. Figure 4 displays, for the four cohorts examined earlier, the relative return to a university education within this subset of manufacturing. For all cohorts, the age-relative earnings profile increases fairly steeply over time. Moreover, younger cohorts receive higher skill premiums than older ones, despite the fact that they are relatively more educated. This suggests that the demand for skilled labor has increased substantially over time in this sector.

Figure 5 examines low-technology industries that we know a priori not to have undergone rapid technical change. Again, using Katz and Murphy's (1992) definition, these industries include apparel, textiles, and food. Amsden and Chu (2003) note that firms in these industries tended to focus more on diversifying their products offered rather than upgrading their manufacturing processes. These industries employed about 28% of the total manufacturing labor force in 1989. Here, the age-relative earnings profile is much flatter for each cohort, which suggests that factor-specific technical change proceeded much more slowly in these industries. In addition, younger cohorts received lower skill premiums than older ones, which is the reverse of the trend depicted in figure 4.

What this suggests is that, though increases in the supply of skilled labor tended to be cancelled out by increases in demand across industries, imbalances between these factors still drove wage structure changes within industries.

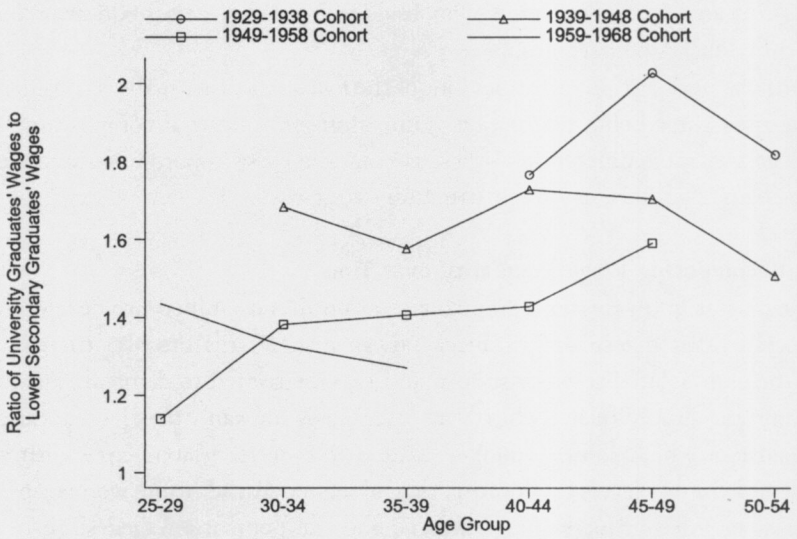

Figure 5. Relative return to education by cohort and age within low-technology manufacturing (men)

Within cohorts, returns to skill rise in industries where factor-specific technical change is more rapid and remain stagnant in others. Across cohorts, the dimension along which the supply of skill varies, returns to skill fall in more basic industries, though they rise in more advanced ones. Overall, these factors balance to produce the result in figure 3.

When other levels of education are examined, the conclusions are qualitatively similar. Examining the wage ratio of upper secondary to lower secondary graduates, or that of secondary to primary graduates, differences between age-relative earnings profiles across cohorts are of about the same order of magnitude as those shown in figure 3. The differences are, however, statistically significant, and to the extent they exist, younger cohorts tend to receive lesser returns to education than older ones. Examining these profiles within industries yields findings analogous to those shown in figures 4 and 5.

In summary, these two sets of figures highlight two forces pushing inequality in Taiwan's wage structure in opposite directions. As shown by figures 2 and 3, even though older cohorts receive greater returns to education than younger cohorts at any point in time, the age–relative earnings profiles faced by these cohorts have remained remarkably stable. However, since younger cohorts are more educated, wage inequality across cohorts declines as they enter the labor force.

By contrast, as figures 4 and 5 show, within-cohort age–relative earnings profiles have not remained stable within industries. As factor-specific technical change progresses in some, but not others, the relative earnings of more- and

less-educated workers diverge. This leads to inequality across education levels within cohort-industry groups.

As the next section quantifies, out of the five factors this analysis considers—the other three being population aging, shifts in industrial composition, and the gender wage differential—these two are the most important in accounting for changes in Taiwan's wage structure over time.

V. Decomposing Wage Inequality over Time

The discussion in the preceding three sections has examined five development processes that may plausibly affect Taiwan's wage structure over time. Three of these are related to labor supply, and two are related to demand. The most important supply-related shift that occurred is Taiwan's massive educational expansion, which caused younger cohorts to enter the labor force with considerably higher levels of education than older ones. In addition, women entered the labor force in increasing numbers, and the population aged slightly. On the demand side, factor-specific technical change increased the demand for skilled labor within industries, especially high-level manufacturing. At the same time, the employment share of the service sector increased, which also tended to increase the demand for skilled labor.

The effects of these factors on the wage structure can be separated by decomposing the Theil index in the following way:

$$
\begin{aligned}
T = & \sum_{c=1}^{C} \frac{n_c}{n} \cdot \frac{\mu_c}{\mu} \ln\left(\frac{\mu_c}{\mu}\right) + \sum_{c=1}^{C} \sum_{s=1}^{S} \frac{n_{cs}}{n} \cdot \frac{\mu_{cs}}{\mu_c} \ln\left(\frac{\mu_{sc}}{\mu_c}\right) \\
& + \sum_{c=1}^{C} \sum_{s=1}^{S} \sum_{e=1}^{E} \frac{n_{cse}}{n} \cdot \frac{\mu_{cse}}{\mu_{cs}} \ln\left(\frac{\mu_{cse}}{\mu_{cs}}\right) + \sum_{c=1}^{C} \sum_{s=1}^{S} \sum_{e=1}^{E} \sum_{g=1}^{G} \frac{n_{cseg}}{n} \cdot \frac{\mu_{cseg}}{\mu_{cse}} \ln\left(\frac{\mu_{cseg}}{\mu_{cse}}\right) \qquad (1) \\
& + \frac{1}{n} \sum_{c=1}^{C} \sum_{s=1}^{S} \sum_{e=1}^{E} \sum_{g=1}^{G} \sum_{i=1}^{n_{cseg}} \frac{y_{csegi}}{\mu_{cseg}} \ln\left(\frac{y_{csegi}}{\mu_{cseg}}\right).
\end{aligned}
$$

In this expression, c indexes cohorts, s indicates sectors or industries, e represents education groups, and g indexes genders. Further, n, n_c, n_{cs}, n_{cse}, and n_{cseg} refer to the number of people in the population, the number of people in cohort c, the number of people in cohort c within sector s, the number of people in cohort c within sector s of education level e, and the number of people in cohort c within sector s of education level e and gender g, respectively. Similarly, μ, μ_c, μ_{cs}, μ_{cse}, and μ_{cseg} refer to the mean wage in the population and the corresponding conditional means. Note that consistent estimation of none of these parameters requires a correctly specified wage equation. Expression

y_{csegi} refers to the wage of individual i belonging to that cohort-sector-education-gender group.

There are some general caveats to be made regarding the interpretation of results from this type of decomposition. First of all, (1) is not a structural model of wages. Since this is the case, the results do not have a causal interpretation. While they can show that the data are consistent with certain explanations of the path of inequality over time, conclusions about the most plausible direction of causality depend on prior knowledge of Taiwan's labor market. Second, each term is a function of a particular variable and all prior variables in the decomposition. For example, the second term measures between-sector wage inequality within cohorts. If cohorts were not included in the decomposition, this term would represent only between-sector wage inequality and have a very different interpretation. Because of this, adding more factors to the model could, in principle, change the results, and they must be interpreted very carefully with this in mind.

The first term in (1) quantifies wage inequality attributable to differences in wages between cohorts. As younger, more educated cohorts become more well represented in the labor force, inequality measured by this term should decline over time. This occurs because the effect of increasing the education of the youngest cohorts is to raise the average wages of a group with typically below-median earnings. That this will reduce the inequality index follows because the Theil index obeys the Dalton transfer principle.

The second term quantifies wage inequality attributable to differences in relative wages between industries within cohorts. This term captures the traditional Kuznets effect of the expansion of the industrial sector on inequality (only here the focus is on wage inequality, not income inequality as in Kuznets's original hypothesis). Industries are measured at the one-digit level. Although it may seem that industry has long overtaken agriculture in Taiwan, Ikemoto and Uehara (2000) point out that the upward portion of the Kuznets curve can reappear as successively higher productivity industries enter the economy. Therefore, the expansion of the service sector and the replacement of lower-technology industries by more advanced ones may cause inequality to increase.

The third term measures inequality due to differences in earnings across educational levels within cohort-sector groups. There are two factors that can cause earnings differentials within cohorts and industries to increase—factor-specific technical change, as described in the preceding section, and population aging as cohorts move up the age-relative earnings profile. It should be noted that, since both aging and factor-specific technical change result in increases in relative earnings over time, the effects of these processes cannot be separately identified. However, as population aging in Taiwan was not that intense (its

TABLE 4
THEIL DECOMPOSITION OF WAGE INEQUALITY IN TAIWAN OVER TIME

	Theil Index	Between Cohort	Between Sector
1979	.155	.032	.01
	(.004)	(.001)	(.001)
1984	.143	.02	.019
	(.002)	(.001)	(.001)
1989	.123	.009	.015
	(.001)	(.000)	(.001)
1994	.143	.00	.017
	(.005)	(.000)	(.001)
1998	.155	.00	.018
	(.005)	(.000)	(.001)
	Between Education	Between Gender	Within
1979	.029	.014	.06
	(.002)	(.001)	(.003)
1984	.032	.016	.055
	(.001)	(.001)	(.001)
1989	.030	.017	.051
	(.001)	(.000)	(.001)
1994	.041	.020	.061
	(.002)	(.002)	(.002)
1998	.052	.016	.066
	(.002)	(.001)	(.002)

Note. Standard errors are in parentheses.

experience is similar to that in the United States between 1980 and the early 1990s and it was spread out over an interval nearly twice as long), it is reasonable to surmise that factor-specific technical change makes up most of the effect identified by this term.

Finally, the fourth term captures wage inequality due to differences in relative wages of men and women within cohort-sector-education cells. Since women entered the labor force at all educational levels, but the gender wage differential did not move in the same direction for all of these, the direction of change of this term is unclear. However, most women entering the labor force until 1992 were relatively unskilled, and the gender wage differential worsened for less-skilled women over time (in the early 1980s, the skilled women were, for the most part, already in the labor force [Zveglich et al. 1997]). Therefore, the influx of these women, since their wages declined even as their numbers increased, should cause inequality to increase.

Table 4 presents the results of this decomposition over time for workers in Taiwan born between 1939 and 1968.[1] The between cohort, between sector, between education, between gender, and within columns refer to the first,

[1] The oldest cohort, born between 1929 and 1938, is excluded to avoid selection problems with those remaining in the labor force after their sixtieth birthday.

TABLE 5
PERCENT CONTRIBUTION OF BETWEEN-COHORT, BETWEEN-SECTOR, BETWEEN-EDUCATION, BETWEEN-GENDER, AND WITHIN CHANGES TO OVERALL CHANGES IN WAGE INEQUALITY

	Theil Index	Between Cohort	Between Sector
1979–89:			
Absolute Change	−.032	−.023	−.002
Percent Change	100.0	71.5	6.0
1989–98:			
Absolute Change	.032	−.007	.003
Percent Change	100.0	−21.8	9.6
	Between Education	Between Gender	Within
1979–89:			
Absolute Change	.001	.003	−.012
Percent Change	−3.8	−10.9	37.2
1989–98:			
Absolute Change	.022	−.001	.015
Percent Change	68.1	−4.2	48.2

second, third, fourth, and fifth terms in (1). Overall, as measured by the Theil index, wage inequality decreased between 1979 and 1989 and then increased thereafter, until by 1998 it was at nearly exactly the same level it was in 1979. Underlying this U-shaped trend, however, are two important factors. The between sector and between gender columns, representing the effects of changes in industrial composition and the feminization of the labor force, turn out not to be that significant. However, the educational expansion contributed substantially to the decline in wage inequality in the 1980s, and factor-specific technical change accounts for a large portion of the increase in the 1990s.

To clarify this point, table 5 shows the percentage contribution of each of these components to the 1979–89 decrease and the 1989–98 increase in wage inequality. It can be seen that the contribution of between-cohort shifts to the decline in inequality in the 1980s is considerable, exceeding 70%; the contributions of other factors are relatively minor. As for the increase in inequality in the 1990s, between-education shifts are the most important factor, accounting for nearly 70% of the total change. This suggests that Taiwan's educational expansion was the most important factor compressing wages in the 1980 and that factor-specific technical change was the most important factor dispersing wages in the 1990s. However, for reasons to be outlined below, these measures may understate the effects of changes in industrial composition.

Even after examining all of these factors, the within component still accounts for a fair amount of the total trend in wage inequality in the 1980s and 1990s. Therefore, it is useful to think carefully about what the within component constitutes. By the nature of the Theil decomposition, the magnitude of the

within component depends on the fineness of the groups used to measure the between components. It will, mechanically, shrink if more variables are added to the decomposition or existing variables are broken up into finer categories. In this way, it is analogous to the sum of squared residuals in an ordinary least squares regression.

One limitation of the data is that, since Taiwan's industrial classification system has undergone a number of changes between 1979 and 1998, the industry codes across years are comparable only at the single-digit level. Expansion of skill-intensive categories within these categories will go unmeasured by the Theil decomposition. Moreover, it is fairly likely that at least some displacement of this type occurred. One example is the expansion of the cellular phone industry in the 1990s, which tended to displace the manufacture of notebook computers (Amsden and Chu 2003). If these products were in different single-digit industries, the between-sector measure would capture the effects of this expansion on the wage structure. But since both of them fall within the same single-digit industry, within inequality is the result. Therefore, part of the change due to the within component may reflect finer changes in industrial composition, especially in later years.

VI. Conclusion

One of the difficulties in explaining changes in wage inequality, especially in more recently developing countries, has been the existence of many potential reasons for these changes. While these factors tended to be successive in the experience of the United States and Western Europe, they were more simultaneous in countries that started to industrialize after World War II. As a result, the literature has been divided as to whether the experience of earlier developing countries is still relevant, and if so, how. For example, Fields (1980) observes that the postwar educational expansion in a number of countries was not followed by reductions in wage inequality. At the same time, expected increases in wage inequality have not always occurred either; studying Taiwan, Gindling and Sun (2002) find virtually no evidence for demand-driven changes in the wage structure, despite a manifest sea change in the character of local industries.

One clear possibility is that these processes have tended to neutralize each other, thereby making the effect of any one difficult to discern in isolation. The seemingly unchanging relationship between age and returns to education across cohorts in figure 3 is consistent with and underscores Gindling and Sun's (2002) findings. But although one interpretation of figure 3 is that neither the supply of nor the demand for skilled labor in Taiwan changed appreciably over time, a more likely interpretation is that they moved in lock

step with one another, at least at the cohort level. Due to this stability, the higher educational attainment of younger cohorts increases their earnings relative to older ones and causes between-cohort inequality to decline over time.

When relative returns to education within cohorts are examined at the industry level, however, mismatches start to occur. Within cohort-industry groups, these returns rise quickly in industries undergoing rapid technical change and remain stagnant in others. If, as seems probable, these increases are the result of factor-specific technical change, the implication is that factor-specific technical change increases between-education inequality within cohort-industry groups. Similarly, the expansion of high-wage industries can be expected to increase between-industry inequality within cohorts, and the feminization of the labor force may affect between-gender wage differences within cohort-industry education groups.

Since these development processes intuitively correspond with nested measures of between-group inequality, a multiple-stage Theil decomposition is a sensible way to measure the relative contribution of each. It should be stressed that, although the Theil decomposition is useful in examining whether the data are consistent with one hypothesis or another, the results cannot establish causality in and of themselves. Moreover, results for a particular factor must be interpreted very carefully in light of the fact that they are dependent on, and can change with, the other factors included in the decomposition. The results are consistent with the assertion that, while Taiwan's educational expansion was an important factor reducing wage inequality in the 1980s, factor-specific technical change accounted for a significant portion of the increase in the 1990s. The other factors were less important, though, since industries could only be measured at the one-digit level, the importance of the expansion of high-wage industries may be understated.

Taiwan's experience suggests that the relationships between wage inequality and development processes established before World War II are still relevant to developing countries today. But since supply- and demand-related factors tend to cancel one another out, their relative importance is difficult to determine, at least where prices are concerned. The multiple-stage Theil decomposition avoids this problem by implicitly holding supply fixed within cohort-industry groups, which allows these effects to be separated. Therefore, future researchers may find it useful in identifying the effects of these processes on a country's wage structure.

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